# Improving Livestock Management in Wilderness

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**Abstract**—Recreation livestock (horses, mules, llamas, and goats) use accounts for 11% of all wilderness visits, and production livestock (cattle and sheep) use occurs in 37% of all wilderness areas. Recreation use is expected to increase at the same rate as total wilderness use, but production use will change little. Managers should recognize that the relationship between the severity of impacts and the intensity of livestock use can be linear or curvilinear because different management approaches will be effective for each type of relationship. Improved livestock management will occur with greater coordination of knowledge and staff in range and wilderness management.

Recreation and production livestock in wilderness are authorized under different provisions in the Wilderness Act, and distinct tools and criteria are prescribed to manage their impacts. Recreation livestock use conforms to the recreational mission of the Act and is subject to full discretionary interpretation by agencies to manage that use within levels consistent with a goal of maintaining the wilderness character of an area. In contrast, production livestock use is one of five uses (mining, aircraft & motorboats, control of fire, disease & insects, water resources facilities, and livestock grazing) that were granted special status to continue in wilderness if they existed prior to designation. Further, some provisions for production livestock management explicitly ignore the wilderness character goal of an area, leaving little room for discretionary interpretation by the agencies.

Each type of livestock use produces impacts from defoliation, trampling, concentration of animal waste, reduction of wildlife, conflicts with other users, and as vectors for the spread of noxious species. However, the expression of these impacts can be quite different between recreation and production livestock use. Both the relationships among the intensity, timing and type of use, and their spatial arrangement and impacts differ between types of livestock. Recognizing these similarities and differences, can assist in improving livestock management in wilderness. To this end, this state-of-knowledge review of livestock use in wilderness will (1) describe the extent of occurrence and managers' concerns about the two livestock uses, (2) compare the nature and management implications of impacts caused by the types of livestock, (3) compare the legal framework and administrative tools applied to management of recreation and production livestock in wilderness, and (4) outline the challenges to management, and the research and development that can improve livestock management in wilderness.

Recreation livestock in wilderness are the horses mules, burros, llamas, and goats that are used as beasts-of-burden to carry people or their belongings. Production livestock in wilderness are sheep and cattle raised for meat, wool, and leather products. Packstock is a common synonym for recreation livestock (for example, McClaran 1989), and domestic livestock is a synonym for livestock grazing on federal lands (36 Code of Federal Regulations 222.1 (1998); 43 Code of Federal Regulations 4100.5 (1998). This paper uses the terms recreation livestock and production livestock because the shared noun stresses the similarities of the impacts and management principles for these two groups of animals, and "production" is used rather than domestic because all these animals are domesticated. Finally, the term recreation livestock is consistent with regulations promulgated by the USDA Forest Service and USDI Bureau of Land Management (36 Code of Federal Regulations 293.3 (1998); 43 Code of Federal Regulations 8560.1 (1998).

Wilderness areas that receive either of these two types of livestock use are most common west of the Mississippi River including Alaska and Hawaii (McClaran and Cole 1993; Washburne and Cole 1983). Recreation livestock use occurs most frequently in areas administered by the Forest Service (FS) and Bureau of Land Management (BLM), to a lesser degree in USDI National Park Service (NPS) areas, and rarely in USDI Fish and Wildlife Service (FWS) areas. In general, production livestock use in wilderness follows a very similar pattern of occurrence among agencies, except for a lower frequency in NPS areas.

Beyond the practical matters of where, when, and how livestock use occurs in wilderness, it has played a role in the evolution of important wilderness concepts and in the articulation of congressional guidelines for wilderness management. Leopold's (1921) original definition of wilderness proposed that the minimum size of wilderness be large enough to allow for a two-week recreation livestock trip. The first studies of recreation impacts in wilderness focused on recreation livestock in Sequoia and Kings Canyon National Parks in the 1940s, where Sumner (1942) devised the precursor to the concept of recreational carrying capacity as a tool to set use limits that would not impair "the essential qualities of the area." Production livestock grazing was included as an accepted use in the first wilderness established in 1924, and that status has not faced serious challenge (McClaran 1990). To some, the inclusion of production livestock grazing privileges was a simple exchange for rancher acceptance of wilderness designation (Roth 1984). To the contrary, Leopold (1921) suggested that benefits would accrue to both recreationists and ranchers because livestock production under frontier conditions

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would hold some fascination to visitors, and the exclusion of roads and the ensuing "settlers and hordes of visitors" would benefit ranchers. Further, Wallace Stegner (1961) felt the presence of production livestock would "emphasize a man's feeling of belonging in the natural world." Despite these early opinions, it is the detailed congressional guidelines for the administration of the facilities and motorized vehicle use associated with production livestock in wilderness (McClaran 1990) that most influence production livestock and management in wilderness. These directives allow agencies to make very little distinction between production livestock management inside and outside of wilderness, which is in sharp contrast to the broad discretion available for recreation livestock management.

## Extent of Use and Managers' Concerns

### Recreation Livestock

In 1990, recreation livestock use occurred in about 55% of FS and BLM areas, 35% of NPS areas, 7% of FWS areas, and about 50% of all wilderness areas (McClaran and Cole 1993). Overnight visits with recreation livestock accounted for about 20% of total overnight visits to all wilderness areas; 36% of visits in the Rocky Mountain region and 15% of visits in the Pacific region used recreation livestock. Among agencies, the proportion of overnight visits with recreation livestock range from nearly 30% for FS areas to 1% for BLM areas. In general, about 30% of recreation livestock use was by commercial enterprises such a outfitters, pack stations and other concessioners, about 60% of recreation livestock use was by private parties, and about 10% was by the agencies for administrative purposes such as trail maintenance and ranger patrols. Commercial and administrative uses were proportionately higher in NPS areas and in the Western states. Private use was proportionately greatest in BLM areas and in the Southeast and Midwest regions.

In both 1980 and 1990, the proportion of all wilderness area visitation (overnight and day use) by people with recreation livestock was 11% (McClaran and Cole 1993; Washburne and Cole 1983). This contrasts with the change from 1960 to 1980, when it recreation livestock use declined from the dominant to a secondary use behind backpacking. This occurred even though absolute levels of livestock use were steady or increased during that period (Lucas 1985; McClaran 1989; McClaran and Cole 1993). The recent stability in proportion of recreation livestock use is important because it occurred when wilderness visitation continued to increase in all but a few high-use wilderness areas (Cole 1996). This suggests that there has been a steady and comparable increase in demand for a wilderness experience by backpackers and groups using recreation livestock. The popularity of wilderness visits using recreation livestock is illustrated by feature articles in the travel sections of prominent newspapers (Tannen 1999). Furthermore, a majority of wilderness managers expect this increase in recreation livestock use to continue in the near future (Watson and others 1998).

Use of llamas and goats began in earnest during the 1980s in some wilderness areas, and by 1990, about half of all areas had received some amount of use by these alternative types of recreation livestock (McClaran and Cole 1993). Between 1985 and 1990, llamas use had occurred in over half of all wilderness areas, seven wilderness areas reported more than 10 visits with llamas, and llama use accounted for more than 20% of recreation livestock use in four areas. Only 5% of all wilderness areas reported goat use between 1985 and 1990. Llama and goat use was most frequent in the Pacific region and in areas administered by the FS or NPS. Future use levels of these alternative recreation livestock will depend on the cost of obtaining and maintaining animals, creating less impact than traditional recreation livestock (Cole and Spildie 1998; DeLuca and others 1998; and Watson and others 1998), changing visitor preference from riding animals to leading animals, and developing the practice of combining animals such as riding horses and pack llamas into single strings of animals to transport both people and supplies.

In 1980, recreational livestock impacts to trails, campsites and lakeshores were considered to be a problem by about a third of all wilderness managers: nearly 30% reported impacts to trails, 45% reported impacts to campsites and about 30% reported impacts to lakeshores (Washburne and Cole 1983). These problems were most common in FS areas, and in the Rocky Mountain and Pacific regions where use was greatest. In 1989, about 60% of FS managers reported at least some moderate level of impact and about 15% reported at least a great level of impact, to trails by recreation livestock (General Accounting Office 1989). By 1990, about 45% of all managers felt that ecological impacts from recreational livestock were not adequately controlled by existing regulations (McClaran and Cole 1993). There was relatively little variation among agencies and regions in the perception of inadequacy of regulations. Although these are not exactly comparable measures of concern, they suggest a growing concern about recreational livestock impacts that are consistent with the increased amount of use during the 1980s.

### Production Livestock

In 1980, about 30% of all wilderness areas had some amount of production livestock use, and that proportion rose to 35% in 1987, probably as a result of newly designated wilderness areas that had preexisting production livestock use (McClaran 1990; Reed and others 1989; Washburne and Cole 1983). In the Rocky Mountain and Pacific regions, at least half of the FS and BLM areas experienced some level of production livestock use, and, surprisingly, about 10% of NPS areas received some production livestock use (Washburne and Cole 1983). In the FS areas, sheep use was about three times more common than cattle use (General Accounting Office 1989), but cattle were more common on BLM areas. Production livestock use in wilderness has been stable over the past decade. It is extremely rare for use to commence in previously unused areas, and the termination of use is also rare (General Accounting Office 1989; McClaran 1991), but there has been a modest trend of reduced numbers of animals in these grazed areas (McClaran 1991; Reed and others 1989). This stable amount of production livestock use is in sharp contrast to the increasing use of recreation livestock, which suggests a need to extend the management expertise and attention from production livestock (range management personnel) to recreation livestock use (recreation management personnel).

Among managers in wilderness areas with production livestock use in 1980, 10% felt that the existence of these animals contributed to management problems; and these perceptions were most common in FS and BLM areas in the Rocky Mountain and Pacific regions (Washburne and Cole 1983). Furthermore, illegal production livestock use was on a list of most significant problems in wilderness areas by five or more wilderness managers (Washburne and Cole 1983). In 1989, about 25% of FS wilderness managers stated that overgrazing by production livestock created moderate or greater impacts (General Accounting Office 1989).

Natural resource managers in Montana rated threats from production livestock impacts fifth behind fire suppression, atmospheric pollutants, recreation, and adjacent land use (Cole 1994). Cole and Landres (1996) suggested that threats to wilderness from the impacts of production livestock, fire suppression, nonnative species, and adjacent land uses were more extensive than threats from the impacts of mining, atmospheric pollutants, recreation, and water projects. Livestock impacts were considered most severe in aquatic ecosystems and riparian vegetation, especially in arid regions where these ecosystems were most rare.

Even though these measures of production livestock use and concerns are not perfectly matched with those for recreation livestock, the stable amount of production livestock use is in sharp contrast to the increasing use of recreation livestock. Managers also seem to have a more intense and pervasive concern about recreation livestock impacts than production livestock impacts. It is possible that the differences in perceived impacts reflect the managers' greater concern about impacts to recreation areas such as trails and campsites compared to the more dispersed impacts from production livestock. Nonetheless, the different trends in the amount of use between these types of livestock should stimulate increased attention to recreation livestock management. Assistance from existing personnel with production livestock management expertise can help meet this refocused attention.

## Livestock Impacts and Implications for Management

Recreation and production livestock impacts to wilderness share the same agents of defoliation, trampling, concentration of animal waste products, reduction of wildlife, conflicts with other users, and vectors for noxious species. The severity of these impacts can vary in relation to the intensity, timing, and type of livestock use. The structure of these relationships between use and impact is sometimes curvilinear.

Recognizing curvilinear relationships where the severity of impact varies between each additional level of use can be valuable for resource managers (fig. 1). For example, a convex curvilinear relationship is where impacts are greatest with the initial increments of use. A convex curvilinear relationship shows that preventing the initial impacts will minimize impacts more than reducing use levels when use is already high. In contrast, the concave curvilinear relationship indicates that the greatest change in impact severity occurs when intensity of use is already high. Recognizing a concave curvilinear relationship is important when use levels are increasing toward a threshold where the next increment of use will create more severe impacts than all the previous increments of increased use.

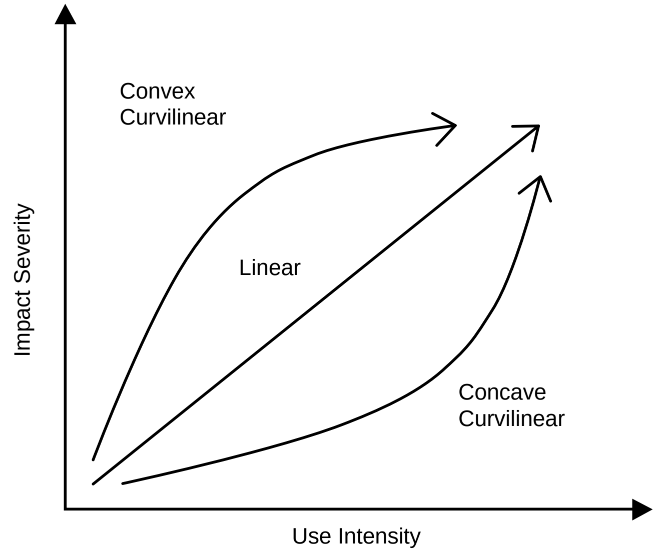


**Figure 1**—Comparison of linear, convex curvilinear, and concave curvilinear responses of impact severity to increasing levels of use intensity. The linear response shows equal amounts of impact with each additional increment of use. The convex curvilinear response shows unequal amounts of impact for each increment of use, and the greatest levels of impact occur with the initial amounts of use intensity. The concave curvilinear response shows unequal amounts of impact for each increment of use, and the greatest levels of impact occur with increasingly larger amounts of use intensity.

The spatial distribution of impacts can be very different between these classes of livestock. Compared to production livestock, recreation livestock use is more concentrated along trails and in camps, and is more common in areas with little forage production. The patterns of impact severity can have important implications for the primacy of different livestock management tools. For example, if impact severity is most sensitive to intensity of use, managers should focus efforts to control the length of time and number of animals allowed in an area.

### Defoliation

Defoliation of vegetation occurs when animals eat or otherwise remove plant biomass. Defoliation initially reduces leaf area, root activity, and the rate of photosynthesis; more lasting impacts are reductions in regrowth potential and the inability to persist among less heavily defoliated plants. The likelihood of defoliation is dependent on the density of livestock, availability of plant biomass, and diet preference of livestock.

In general, the intensity of defoliation limits the rate and extent of regrowth because nearly all the energy used for regrowth is generated by the remaining ungrazed leaf tissue (see Briske 1996; Briske and Richards 1995). The timing of defoliation limits regrowth if meristems (locations of cell differentiation and elongation) are removed or environmental conditions (temperature, light, and nutrients) are limiting. Community-level impacts result from differential selection of plant species by herbivores and differential resistance to defoliation among plant species. Total plant cover decreases with increasing defoliation pressure. This pattern of reduced cover is more quickly apparent in preferred forage species and species with meristems that are easily defoliated because they are elevated or they all develop at one time (synchronized development). Eventually, reduced growth of these selected or less resistant species will result in changes in the vegetation composition.

Impacts to plant productivity appear to be more sensitive to changes in grazing intensity (animals/area/time or percent utilization of available plant biomass) than the timing of grazing. Van Poolen and Lacey's (1979) meta-analysis of 32 grazing studies in the western U.S., showed that reducing grazing intensity produced a greater response in increased plant production than implementing a seasonal rotation grazing system.

The structure of the relationship between change in species composition and grazing intensity differs from that for the relationship between change in plant productivity and grazing intensity. Based on a meta-analysis of over 250 grazing impact studies from around the world, Milchunas and Lauenroth (1993) found that changes in species composition, measured as departure from ungrazed comparisons, were linearly related to grazing intensity, site productivity, and the length of exposure (evolutionary time-frame) to grazing pressures. Changes in biomass productivity, measured as departure from ungrazed comparisons were convex curvilinearly related to grazing intensity, and linearly related to total plant productivity in the area.

The convex curvilinear relationship between impacts and grazing intensity is partly a function of decreasing intake of forage (defoliations) by animals as continued defoliation reduces the amount of available forage. This pattern is consistent among large herbivores (Huston and Pinchak 1991). For example, defoliation by recreation livestock increased, in a convex curvilinear manner as grazing time increased; decreases in plant cover after eight hours of use on a picket pin were less than double the impact after only four hours (Olson-Rutz and others 1996a,b).

Management guidelines for allowable intensity of grazing pressure (utilization levels) have become more conservative, but the emphasis on intensity over timing has been consistent. Guidelines in the early 1910s were set to prevent utilization from exceeding 75-90% of current year production; by the 1940s, they were reduced to 75%, and current guidelines are 30-45% and occasionally as high as 50% (Holechek and others 1998; Sampson 1952). There is also a trend to move from grazing intensity standards based on utilization of current-year growth to standards based on remaining plant biomass. The rationale for this shift is that regrowth is the result of the amount of leaf area remaining after defoliation, and remaining biomass is more easily and accurately measured (Heady and Child 1994). The median utilization values in the studies included in the meta-analysis by Milchunas and Lauenroth (1993) were about 45%.

Management implications for these patterns of plant response to defoliation start with the proposition that there has been a short length of exposure (evolutionary time-frame) to grazing pressures in western U.S. wilderness areas (Milchunas and others 1988), and that these areas can be classified as low productivity sites. Given this, we should expect grazing intensity to have greater influence on plant productivity than on species composition. In wilderness areas, one can expect the impacts from production livestock to be more widely dispersed than recreation livestock, which do not venture far from camps. Actions to manage the defoliation impacts from recreation livestock can rely more on controlling the location of grazing and requiring pack-in feed compared to the management of production livestock, which will rely more on control of animal numbers. Because of a possible convex curvilinear relationship, the initial defoliation increments created by moving recreation livestock to new areas will create many new areas where there are significant impacts to productivity.

## Trampling

Trampling of vegetation and soil occurs when the hooves of livestock strike the vegetation and soil during travel, grazing, or confinement, and when animals lie or roll on the ground. In general, the severity of these impacts exhibit a convex curvilinear pattern, where the initial trampling produces more severe impacts than later trampling (Cole 1995a,b; Cole and Spildie 1998; DeLuca and others 1998).

The trampling impact to vegetation (cover and height) and to soil erosion is between two and 10 times greater from horse travel (along trails or not) than from hikers or llamas doing the same amount of travel (Cole and Spildie 1998; DeLuca and others 1998; Weaver and Dale 1978; Wilson and Seney 1994). These greater impacts from horses are probably the result of both more weight per surface area contacting the ground and the metal shoes on their hooves. Apparently, these traits create a greater shearing potential, which increases the likelihood of direct plant damage and soil erosion by both compaction and loosening of soil particles. It is likely that these same patterns hold for trampling impacts in camps, because soil compaction and reduced plant cover are positively associated with camps used by recreation livestock compared with those used by hikers (Cole 1983). The severity of impacts to vegetation, for both horse and llama, varies in relation to the life form of the vegetation: graminoid (grass and grass-like plants) vegetation is the most resistant and resilient, erect forb (nongrass and nongrass-like herbaceous plants) vegetation is least resistant, and woody shrub vegetation is the least resilient (Cole 1995a,b; Cole and Spildie 1998). As a result, the convex curvilinear pattern is less pronounced in graminoid vegetation, but it is most pronounced in forb-dominated vegetation with high species diversity (Cole 1995a,b).

Production livestock trampling in corrals and locations near drinking water and forage supplements (salt, minerals, and protein) provides the closest analogy to recreation livestock trampling impact to trails and campsites. Although a direct comparison has not been reported, one would expect the trampling impact from production cattle to be less than horses and mules because they have no metal shoes, but greater than llamas because they have greater weight per surface area contacting the soil. The impact from production sheep should be slightly greater than llamas because the hooves of sheep are less padded than llamas.

The concentration of trampling impacts is less common in grazed areas than along travel routes and in camps because animals are more likely to venture widely for forage than follow the same path. Given the choice, animals try to avoid wet areas (Platts and Nelson 1985), and the more resistant and resilient graminoid vegetation is more common in grazed areas than forb or shrub vegetation. In general, when cattle are grazing, the severity of impacts to vegetation and soil are positively associated with soil wetness and negatively associated with the length of growing season (for example, Clary 1995). The worst scenario for trampling impacts from grazing cattle is areas with wet soils and short growing seasons because compaction is more severe and the time for recovery of vegetation is shorter. In the earliest range management guidelines, Jardine and Anderson (1919) warned of trampling impacts that happen if use occurs on soils that are too wet to support the animal's weight. One must assume that this impact pattern was well accepted by managers because later guidelines (for example, Heady and Child 1994; Stoddart and Smith 1955) largely ignore the trampling impacts of early season use and focus instead on the impacts of defoliation.

Cattle appear to avoid trampling bunchgrass vegetation while grazing, and this behavior is expressed even at a high animal density, albeit at lower avoidance rates (Balph and Malechek 1985; Balph and others 1989).

Damage to trees and tree death are trampling impacts unique to recreation livestock. They result from animals being tied to trees in camps and popular day use areas (Cole 1989c). This type of tree damage is cumulative; for example, tree damage increased over a 12-year period, even when absolute use of these camps declined during that time (Cole 1993).

The implications of these patterns of trampling impact are different for high use areas and grazed areas. In high-use areas (trails, camps, corrals, water, and supplemental feed sites) where use is concentrated, the type of animal, the type of vegetation, and the history of use are the primary influences on the severity of trampling impact. Managers should attempt to prevent unintentional use in areas previously undisturbed by horses and mules, particularly where the vegetation is dominated by forbs and low shrubs. This is most critical when considering the relocation of use facilities like trails, camps, and corrals. Furthermore, active measures that prevent tying to trees should be applied in all areas, independent of use levels. For grazed areas, where use is more dispersed, intensity and season of use are most critical. Managers should attempt to minimize grazing in areas that are wet and have a short growing season.

## Concentration of Animal Wastes

Fecal and urine wastes from livestock have important influences on water quality, soil nutrient status, defoliation patterns, and insect and odor concentrations. The severity of the impacts from wastes appeared to be related first to the distribution of animals, second to their concentration, and less importantly to the aridity of the area and type of animal.

Fecal coliform (FC) contamination in surface waters is used to indicate the likely presence of such pathogens as *Salmonella* and *Giardia* (Tiedemann and others 1987). FC contamination is most likely if feces are deposited directly in surface waters, but this is relatively rare (around 5%) for free-roaming animals (Gary and others 1983; Larson and others 1988). However, the likelihood of contamination increases exponentially as the proportion of animal use within a few meters of surface waters increases, because bacteria are carried to water as runoff during precipitation events. For example, increased FC contamination was more strongly influenced by the cattle use of meadows near streams than the stocking density in the entire pasture (Tiedemann and others 1987). These patterns result from a logarithmic decline in the FC concentration with distance and age of feces: significant contaminations are largely restricted to a one meter radius of feces (Buckhouse and Gifford 1976). Although FC concentration in cattle feces remains high after 30 days, it is several orders of magnitude less then the concentration found at one to two days (Kress and Gifford 1984; Thelin and Gifford 1983). Because drying strongly reduces the probability of contamination, contamination will be more likely in mesic than arid areas, and from cattle feces because they are more moist than feces from horses and sheep.

Urine deposits create patches of high nitrogen concentration in soil and plants, because urine contains the majority of nitrogen in animal wastes (Archer and Smeins 1991), even though the majority of this nitrogen is volatilized (Woodmansee 1978). This high concentration of nitrogen is followed by increased intensity of defoliation by grazing animals in the growing season subsequent to urination (Jamarillo and Detling 1992).

The relationships between waste concentration and increased number of insects and intensity of odor are not clear. They probably have a convex curvilinear structure, where the initial amounts of waste generate more of an increase in insects and odors than similar additions of wastes would generate if wastes were already very abundant.

The implications of these patterns of impact from animal wastes center on the type of livestock and the ability to prevent animal use near bodies of water. Impacts from recreation livestock may be more easily controlled if camps and holding areas are away from streams, and because horse and mule feces are drier than cattle feces. Further, the significance of dry feces in reducing contamination implies that activities to break up fecal mounds will hasten drying and reduce the probability of contamination, particularly in areas near water. Reducing production livestock use near streams may be more difficult than recreation livestock because their use is more dispersed, but efforts to fence riparian areas and develop drinking water sources away from streams can be effective. Finally, a convex curvilinear structure to insect and odor problems suggests that efforts to concentrate fecal deposits in existing areas that are far from streams should take precedence over moving use to new areas.

## Reduction of Wildlife

In wilderness, livestock can reduce the abundance and occurrence of wildlife species, directly through displacement and transmission of disease, and indirectly through habitat change and reduction of forage.

Displacement has been described primarily where the presence of livestock can alter the location and movement of large mammals. Displacement by cattle and sheep is most common (see Krausman 1996). Observations of displacement by horses is limited to pronghorn antelope and wild horses (Miller 1983); no studies have described displacement by llamas. Theoretically, the seasonal or yearly ungrazed pastures in multi-pasture rotational grazing systems for production livestock rather than the alternative, continuously grazed pastures, should provide preferred areas for these wild ungulates. However, observations of wildlife preference in areas managed under rotational grazing systems have recorded mixed results. Mule deer (Peek and Krausman 1996) and white-tailed deer (Teer 1996) appear to favor these grazing systems over continuously grazed areas, but there were inconsistent results in the studies for elk (Wisdom and Thomas 1996).

Bighorn sheep are the most sensitive species to diseases transmitted by livestock, and pronghorn antelope also exhibit sufficient susceptibility to warrant concern (Jessup and Boyce 1996). Pneumonia transmission from production sheep to bighorn sheep has been repeatedly documented, and transmission by cattle is suspected. Llamas are known carriers of paratuberculosis (Jessup and Boyce 1996), but there appear to be no known cases of transmission to wild animals. For these diseases, the only effective management is complete isolation of livestock from bighorn sheep.

Defoliation and trampling by livestock can create immediate and more long-lasting changes in vegetation structure and composition that can indirectly influence the habitat quality for wildlife species. Immediate changes include reduction of herbaceous plant abundance, most particularly plant height, and these changes can greatly alter the abundance of upland birds (Knopf 1996). The significance of these short-term changes are primarily a function of the season of use because the habitat requirement of many upland birds is not year-long and the vegetation will regrow. Aquatic life, particularly cold-water fish, are also susceptible to these short-term changes in plant height because tall vegetation shades the water, modifying temperatures, and contributing detritus that supports insect that are prey (Platts and Nelson 1985). Current livestock management recommendations prescribe minimum plant heights that should remain in areas grazed by livestock (Clary 1995; Knopf 1996). Longer-term changes in structure and composition caused by livestock use include the increase of woody species and reduction of herbaceous species, and a general loss of plant cover (Archer and Smeins 1991). Livestock grazing intensity has more influence on the severity of these long-term changes than season of grazing.

Finally, the impacts of insufficient forage for wildlife species is largely a function of the intensity of livestock use. The dietary overlap between livestock and wildlife species will largely determine the relative susceptibility of wildlife species. Cattle and horse diets generally overlap most with elk, and bison; while sheep (and presumably llamas) diets generally overlap most with deer, bighorn sheep, and pronghorn antelope (Vallentine 1990). However, feral horse diets can be quite similar to pronghorn antelopes (McInnis and Vavra 1987).

These general patterns of impacts to wildlife suggest that displacement by production livestock will be greater than by recreation livestock because the former are more widely dispersed. Therefore, seasonal rotation of livestock among pastures may be beneficial because the availability of ungrazed areas will reduced displacement problems. Production livestock, especially sheep, can transmit disease to wildlife, and the prevention of transmission by any livestock species should be taken seriously. Controlling the timing of both production and recreation livestock use will best address short-term impacts to the vegetation structure of wildlife habitat, whereas, controlling livestock numbers is more critical in minimizing long-term changes in habitat. Finally, controlling the number and type of livestock will best address the problems of reduced forage for wildlife.

## Conflicts With Other Users

Conflicts between livestock and other wilderness users come in two forms: conflicts with firmly held attitudes of appropriateness that can be considered a predisposition to conflict, and conflicts with activities encountered during a visit to wilderness that can be considered situational conflicts (Ivy and others. 1992). In general, the severity of both types of conflicts with hikers is greater with production than recreation livestock.

About 40% of hikers in five FS wilderness areas were predisposed to conflict with production livestock in wilderness (Johnson and others 1997), and the severity of that conflict is greater for visitors that reside in urban versus rural areas (Mitchell and others 1996). Furthermore, that conflict is greater for production livestock in wilderness than in nonwilderness camping areas (Mitchell and Wallace 1998). The severity of conflicts with production livestock declines as the hikers' expectation of encountering livestock increases (Johnson and others 1997), but the structure (linear or curvilinear) of this relationship is unknown. Situational conflicts center on encountering manure and livestock-related structures such as fences (Johnson and others 1997). The quality of the wilderness visit was diminished for about two-thirds of hikers when they encountered cattle and sheep, compared to nearly 75% of visitors when encountering fences, and about 50% of visitors when encountering recreation livestock or any type of visitor. Observing these animals near water and camps was the most sensitive encounter for hikers. Finally, perception of overgrazing or excessive defoliation of plant biomass was the foremost indicator of the visitor perceiving improper livestock management by the FS.

A predisposition to believe that horses are inappropriate in wilderness was the most consistent contribution to severe hiker conflict with recreation livestock in wilderness, but most hikers did not express conflicts (Watson and others 1993). Manure on trails, large group size, and litter were the most irritating recreation livestock situations encountered by hikers, but hikers were most sensitive to a general impression of overcrowding from all visitor types. At least one study suggests that the severity of these conflicts is inversely related to the intensity of recreation livestock use (Stankey 1979): conflicts were less severe in areas with higher amounts of livestock use. The level of wilderness manager's acceptance of recreation livestock increased with their level of experience using these animals in wilderness (Moore and McClaran 1991). Predisposition appears to play a role in greater acceptance of encounters with llama than horses and mules (Blahna and others 1995). Interestingly, hikers are more accepting of llamas than horse and mule users, and acceptance by wilderness managers is between that of hikers and traditional livestock users (Blahna and others 1995; Watson and others 1998). Transmission of disease to wild animals and encouraging the introduction of nonnative plants by llamas were the situations of greatest concern to all wilderness users (Watson and others 1998).

The management implications of these patterns of users conflicts focus on two areas: predisposition to conflict and on-site reduction of negative encounters. Several authors suggest that increasing hikers' awareness of encountering production or recreation livestock may help relieve conflicts by discouraging visits by those with the greatest predisposition against these uses (Blahna and others 1995; Johnson and others 1997; Watson and others 1993). Zoning wilderness areas to separate recreation livestock from sensitive visitors has also been discussed (Blahna and others 1995; Watson and others 1993). Onsite reduction of animals and manure near water and camps may help relieve the severity of situational conflicts, but the use of fences to achieve these goals may be counterproductive because 75% of hikers reported that fences detracted from the quality of their visit. Reducing the level of defoliation by livestock may reduce conflicts. Finally, encouraging greater familiarity with a wilderness experience that includes recreation livestock may encourage greater acceptance of these uses and their unique impacts, but it may not reverse strongly held predispositions.

### Vectors for Noxious Species

Livestock have long been labeled as vectors that encourage the spread of noxious (unwanted native and nonnative species), either directly through the spread of seed or indirectly through disturbance (Elton 1958). In wilderness areas, it is common to find a greater abundance of nonnative plants in recreation livestock camps than backpacker camps, a difference that has increased over time (Cole and Hall 1992). To control this problem, managers must understand whether actions that prevent seed introduction will be more effective than efforts to prevent disturbance.

Contrary to most suggestions (see review in D'Antonio and Vistousek 1992), livestock grazing is not a prerequisite for the presence or abundance of nonnative plant species. Recent work in the western United States suggests that the abundance of nonnative plant species is no different in grazed and ungrazed areas (Lacy 1989; Stohlgren and others 1999), and that the rate of spread is not associated with the intensity of livestock grazing (McClaran and Anable 1992). The pattern is different for camps: recreation livestock camps have a higher abundance of nonnative species than hiker camps (Cole and Hall 1992). However, although the extent and intensity of disturbance are greater in livestock camps, the role of livestock use as a vector for the transport of these plants must also be considered. Recent calls for weed-free feed certification led Cash and others (1998) to assess the viability of weed seed following the feed pelleting process. They found seed viability dropped dramatically with increasing hammering and dying applications in the pelleting process, but no treatment completely eliminated viable weed seeds.

In relation to the spread of animal species, increasing abundance of the brown-headed cowbird, a native brood parasite, with livestock movements can be detrimental to some bird species. Furthermore, the relationship between cowbird abundance and livestock is probably convex curvilinear. Because of their association with bison, cowbirds were probably common throughout the Rocky Mountain region and the Great Plains (Chance and Cruz 1998), but the spread of cowbirds is a historical event in the Pacific and Great Basin regions where bison were absent (Rothstein 1994).

Because the spread of nonnative plants is loosely correlated with the presence of livestock, management efforts should focus on preventing livestock from transporting seed into wilderness areas by requiring the most aggressive weed-free feed and animal handling. Pelleted feed may not be aggressive enough, and more attention should be paid to quarantining animals for one or two days before admission into wilderness to prevent transport of ingested seed. Impacts from cowbirds are more likely from production livestock than recreation livestock because the former are more widely dispersed.

## Legal and Administrative Frameworks for Recreation Livestock Management in Wilderness

The legal framework for livestock management defines the discretion given to agencies by Congress and the formal regulations that the agencies have developed to meet the directives from Congress. The discretion available to develop unique management programs is much greater for recreation livestock than for production livestock.

Administration of livestock use includes the establishment of impact standards and monitoring, the application of management tools, and the assignment of personnel to these responsibilities. There is more variation in the administration of recreation than production livestock, and this is expected considering the smaller amount of discretion for managing the latter.

### Legal and Regulatory Framework

The legal framework for recreation livestock use and management in wilderness is given in the Wilderness Act (16 United States Code 1133b (1998)). Recreation is a public purpose that agencies will provide in wilderness, while at the same time the agencies are responsible for preserving the wilderness character of an area so that "...its community of life [is] untrammeled by man...without permanent improvements... and] the imprint of man's work [is] substantially unnoticeable." (16 United States Code 1131c (1998)). While these two purposes are instantly at odds when agencies permit potentially destructive recreation use, the conflict is even more pronounced for recreation livestock use because it has a greater potential for destruction than hiking. However, the use of recreation livestock can become a practical matter because the prohibition of motor vehicles and mechanical transport (16 United States Code 1133c

(1998)) makes recreation livestock the only non-pedestrian means of transporting people, equipment and supplies on land that fully complies, without exception, with the intent of Congress. (Simple exceptions to this prohibition are emergencies of human health and safety, administrative use, and pre-existing uses grandfathered in statute or congressional guidelines.) In combination, these three elements of the Wilderness Act—visitation, preservation, and transportation—define the latitude and the tension of recreation livestock administration in wilderness.

Overarching directives to BLM, FS and FWS agents stress that recreation use is subordinate to the maintenance of wilderness conditions (36 Code of Federal Regulations 293.2 (1998); 43 Code of Federal Regulations 8560.0-6 (1998); 50 Code of Federal Regulations 35.2 (1998)). In contrast, recreation management regulatory directives for NPS agents do not specify any unusual management for wilderness areas (36 Code of Federal Regulations 2.16 (1998)).

BLM agents are given very detailed regulatory directives for wilderness recreation management compared to the other agencies. BLM agents are directed to use (1) the principles of nondegradation to establish recreation use capacity, (2) the minimum management tool to establish use facilities, (3) the principle of wilderness dependence to resolve conflicts between different recreation uses, and (4) indirect methods to reduce recreation impacts such as trail design, and information and education, rather than direct methods such as regulating the use of saddle horses and or packstock, managing areas strictly for foot or horse use, requiring permits for entry, limiting party size or number of parties during overnight visits, limiting number of users, and restrictions to stock grazing or canoe/boat beaching in popular areas (46 Federal Register 47183-47188 (1981)). Specific to recreation livestock, agents are authorized to (1) issue permits for commercial users, and, (2) require users to carry native feed or pellets, and (3) hobble rather than tether horses (46 Federal Register 47196-47197 (1981)). FS agents are authorized to prohibit entry and grazing (36 Code of Federal Regulations 261.57(1998)) in wilderness areas, and specifically they may limit grazing of recreation livestock (36 Code of Federal Regulations 293.3 (1998)). FWS agents are authorized to limit number of visitors, season of use, kind and location of use, and require permits for access (50 Code of Federal Regulations 35.6(1998)), but there is no specific directive pertaining to recreation livestock management. NPS agents are directed to prohibit loose-herding and use outside of trails or other designated areas; and to enforce any other prohibition established by park superintendents (36 Code of Federal Regulations 2.16 (1998)).

## Administrative Framework

**Impact Standards and Monitoring**—The Limits of Acceptable Change process (Stankey and others 1985) and general wilderness management philosophy (Hendee and others 1990) suggest that the development of impact standards should be part of the wilderness management planning process, where users and administrators interact to set the level of acceptable impacts (standards) and where these standards will be applied. Surprisingly, only 35% of all wilderness areas used public participation to develop impact standards for recreation livestock use in 1990, whereas professional judgement was used in about 61% of areas (McClaran and Cole 1993). Tradition-based standards were the second most common approach (used in 40% of the areas), while existing standards for production livestock and research-based standards were the least common (27% and 22% of areas) approaches to establishing impact standards.

The greater reliance on professional judgement and tradition may be a function of very limited research about recreation livestock impacts and management (Cole 1989a; General Accounting Office 1989), but the low frequency of public participation is antithetical to the principles and legal requirements of public land management. Furthermore, the absence of public involvement is likely to result in conflict between managers and users, and among users. It is unfortunate that more use was not made of production livestock standards because their long history of development and administration could provide a useful perspective when considering impact standards for recreation livestock.

In 1990, about two-thirds of wilderness areas monitored recreation livestock impacts in at least some camps and about one-half monitored impacts to trails, but less than 30% monitored impacts to grazed areas or other visitors (McClaran and Cole 1993). This surprisingly low frequency of monitoring, especially in grazed areas, may be explained by findings that managers have insufficient resources to monitor impacts (General Accounting Office 1989), but it may also reflect insufficient development and training in monitoring methods for grazed areas. Monitoring methods for trails and campsites are outlined in Cole (1989b), and grazed areas methods are outlined in the FS and BLM range management handbooks and in many other sources (see Bonham 1989; McClaran and Cole 1993; Muir and McClaran 1997). The missed opportunities from the infrequent use of traditional range management resources about monitoring impacts, mirrors the infrequent use of production livestock standards to set impact standards. Monitoring efforts that concentrate on measurements of intensity, such as utilization or standing biomass, may be the most robust parameters to measure because intensity of use is important in the severity of many livestock impacts. Simple plant height measures can provide reliable estimates of defoliation intensity.

**Management Tools**—Each agency that is responsible for recreation livestock management in wilderness promotes different management tools, and, moreover, the application of these tools ranges from strictly enforced regulations to guidelines used to promote voluntary behavior. Some have argued that the use of guidelines conforms to a minimum management tool that should be used to least infringe on the visitor's experience (Hendee and others 1990; Lucas 1982, 1983), whereas others suggest that regulations can be viewed as a more equitable approach to visitor management (Dustin and McAvoy 1984).

In practice, the application of regulations versus guidelines for managing recreation livestock is different among the agencies. About 60% of all wilderness areas with overnight recreation livestock use had some form of use regulation in 1990 (McClaran and Cole 1993). NPS agents were most likely (91%) to rely on regulations and BLM agents were least likely (13%). The NPS's greater inclination to regulate reflects an impact prevention philosophy, while the less frequent application of regulations by the FS reflects a philosophy of reducing impacts only after they reach unacceptable levels (see discussion in McClaran and Cole 1993). In addition to these differences among agencies, there appears to be a greater propensity to rely on new regulations to solve problems if some regulations are already in place. On closer examination of responses to the 1990 survey (McClaran and Cole 1993), I found that only 34% of managers in areas without any regulations perceived a need for more regulations to correct excessive impacts compared to 56% of managers in areas with at least one existing regulation.

Less than 5% of wilderness areas with recreation livestock controlled amount of use by regulating total animal numbers or number of groups using livestock in 1990 (McClaran and Cole 1993). The use of regulations was very rare except in NPS areas, where they were present in about 30% of those areas. The infrequent attention to intensity or amount of use neglects the very important influence that intensity has on the severity of impacts from plant defoliation to vegetation and wildlife habitat; it also overlooks the importance of perceptions of overgrazing by other visitors. In addition, this absence of regulations addressing total use stands in contrast to the general concern among managers about overgrazing.

Timing of use was regulated in 5% of all wilderness areas with recreation livestock use in 1990 (McClaran and Cole 1993), a proportion that was unchanged from 1980 (Washburne and Cole 1983). In general, guidelines to control season of use are more popular than regulations, however, no NPS or FWS areas employed guidelines and no BLM area attempted to control timing of use. The infrequent control of timing of use ignores the important influence that time of use can have on the severity of trampling impacts when soils are most wet. Greater attention to controlling the timing of use may address managers' concerns about recreation livestock impacts to trails and camps.

Management tools that address the location of impacts recognize that impact severity is often site-specific. For example, the severity of user conflicts is related to encounters along trails and in camps, and trampling impacts are most severe in areas that have not previously received use and chronically wet areas. These location-oriented tools include efforts to alter the location of use with behavioral rules, site-specific rules, and the construction of facilities that attract use to less sensitive areas.

In 1990, management to alter user behavior were most likely to address length-of-stay and group size limits (about 40% of areas), and most other controls were applied in less than 20% of areas. In comparison, guidelines were applied in 50-65% of areas to reduce off-trail use, prevent tying to trees, and encourage the of use of pack-in feed (McClaran and Cole 1993). The situational (on-site) conflicts among users can be managed with length-of-stay limits in areas with popular campsites and grazing areas, or by prohibiting loose-herding (no ropes tied between animals) in areas with an abundance of hiker use. However, these tools will not address the predispositional conflicts among users. Efforts to prohibit off-trail travel would prevent the formation of new trails, and limits on group size might reduce the probability that existing campsites would expand to accommodate larger groups. Similarly, preventing the tying of stock to trees and encouraging the use of hitchlines (ropes tied between trees on which livestock are tied) can prevent the initial and most severe trampling impacts to trees.

In 1990, the use of pack-in feed was encouraged in nearly two-thirds of all areas and required in 15% (McClaran and Cole 1993). In general, this behavior is encouraged to manage the impacts of grazing in areas that have especially sensitive conditions such as water-logged soils or rare plants, conflicts with other users, or areas that want to limit the amount of grazing. Pack-in feed can be used to maintain animal vigor during a long journey. However, a point of diminishing returns develops when the benefits of reduced impact per animal from pack-in feed is diminished by the greater number of animals that are needed to carry more feed. While encouraging the use of pack-in feed is a worthy practice, there must be some provision to ensure that these feeds do not hasten the spread of nonnative plant species. Therefore, it is essential that all pack-in feed, whether required or recommended, be certified weed-free or processed into pellets to reduce the transport of weed seeds. One to two day quarantine measures before admission to wilderness might be tested as well, and should be considered even without the use of pack-in feed.

In 1990, site-specific rules were most commonly applied as regulations concerning the location of campsites: about 40% of all areas with overnight use required camping a minimum distance (either 100 or 200 feet) from water and nearly 10% limited camping to specifically designated "stock camps." In those few (about 5%) wilderness areas using season of use or total use regulations, about 80% applied them on a site-specific basis (McClaran and Cole 1993). These site-specific controls certainly address animal waste contamination of surface waters and control the location of impacts in high-use areas.

Providing facilities as an indirect approach to modifying user behavior, was implemented in up to 20% of wilderness areas. Facilities included hitchracks, pastures/corrals, drift fences, or water developments were most common in NPS and FS areas (McClaran and Cole 1993). Because these facilities are very effective at attracting use, they can increase the severity of impacts in these areas, but they will reduce impacts to areas without these facilities. These facilities should be evaluated for both the overall reduction in impacts they provide to other areas, and for their compliance with minimum tool directives.

In summary, the application of management tools largely ignores direct controls of intensity and timing of use; and instead focuses on altering use behavior, and, secondarily, on the location of use. This style of management largely ignores the important influence that intensity and timing of use have on the severity of impacts by recreation livestock. One must wonder if regulations on intensity and timing were envisioned by the 45% of managers reporting a need for more regulations in 1990 (McClaran and Cole 1993). The greater application of tools that address behavior and location can prevent initial impacts in new areas and avoid undue regulations in lightly used areas.

**Personnel**—In the vast majority of wilderness areas, recreation livestock use is administered by recreation or wilderness staff rather than range management personnel. Most recreation and wilderness personnel have little technical training in establishing impact standards or monitoring impacts to soils, vegetation, wildlife or other users. Fortunately, in some areas, wilderness management planning is conducted by interdisciplinary teams that include members with more expertise in these areas. However, the implementation of these plans usually resorts to the wilderness and recreation staff, and in the majority of cases, personal judgement forms the basis for recreation livestock impacts standards in wilderness. Administrators should foster a greater involvement from range management staff in the development of these standards and the implementation of monitoring programs.

## Legal and Administrative Frameworks for Production Livestock Management in Wilderness

### Legal and Regulatory Framework

The legal and regulatory directives for production livestock and their management in wilderness are far more specific than for recreation livestock. These directives maintain production livestock use if it was present before wilderness designation, and they stipulate very different impact standards and management tools for increases in livestock use compared to maintenance of existing use levels (McClaran 1990).

Growing tension between Congress and the FS about the administration of production livestock in wilderness climaxed in 1980, when wilderness designation legislation was proposed for wilderness areas with significant amounts of grazing (Roth 1984). In an effort to ensure designations and to standardize livestock administration to conform with congressional intent, a set of grazing guidelines were forged by a group composed of House of Representative Committee members, FS staff, wilderness advocates, and livestock industry representatives. Although these guidelines are not an official amendment to the Wilderness Act, they have been cited as management criteria in every wilderness designation statute since 1980 for FS and BLM areas with any pre-existing grazing, and they have been incorporated into regulatory language (46 Federal Register 47194 (1981)) and agency handbooks (McClaran 1990). McClaran (1990) documents this trend from 1980 through the Arizona Desert Wilderness Act of 1990. Since 1989, the congressional grazing guidelines were explicitly cited in all four statutes designating areas with pre-existing grazing. The four statutes are: Arizona Desert Wilderness Act of 1990 (104 Statutes at Large 4469 Sec. 101.f); Nevada Wilderness Protection Act of 1990 (104 Statutes at Large 1784 Sec. 6.a); Colorado Wilderness Act of 1994 (107 Statutes at Large 756 Sec. 3.2.b); and the California Desert Conservation Act of 1994 (108 Statutes at Large 4471 Sec. 103.c.).

These five congressional grazing guidelines appeared in House Report No. 617 (96th Congress, 1st Session, prepared for the Colorado Wilderness Act of 1980, 94 Statutes at Large 3265 and is codified at 16 United States Code 1133-other provisions). The guidelines address the administration and management of animal numbers, facilities, and mechanized equipment aspects of production livestock use in wilderness (McClaran 1990):

1. Wilderness designation will not be a criteria for reducing animal numbers, and increasing animal numbers is permitted only if wilderness values are not adversely impacted.
2. Using motorized equipment and vehicles to continue to maintain livestock management structures and facilities will follow a rule of practical necessity and reasonableness.
3. Using natural materials is not required when repairing or constructing livestock management structures and facilities, unless it does not result in unreasonable additional cost.
4. Construction of new facilities should be primarily for resource protection and management, not for increasing the amount of livestock use, but replacement of existing facilities is permitted.
5. Using motorized vehicles will be permitted for emergency access to sick animals and emergency placement of supplemental feed.

### Administrative Framework

In essence, the congressional guidelines created two sets of standards for the administration of production livestock use in wilderness; one that applied to use that existed prior to wilderness designation and a second set for any additional animals, facilities, or equipment use after wilderness designation. The impact criteria and management tools for maintaining existing use are the same as those applied outside of wilderness; but for additional use, the impact criteria and management tools are based on preventing impacts to wilderness values.

Whether in wilderness or outside wilderness, livestock administration is organized by grazing allotments, where impact standards, monitoring, and management tools are prescribed in an allotment management plan (36 Code of Federal Regulations 222.2 (1998); 43 Code of Federal Regulations 4120.2 (1998); 46 Federal Register 47195 (1981)). These allotment management plans (AMP) conform to the multiple-use provisions established in the relevant FS Forest Plan or BLM Resource Management Plan (36 Code of Federal Regulations 222.2 (1998), 43 Code of Federal Regulations 4100.0-8 1998), so the types of natural resources and the mix of multiple-uses in each allotment will result in different standards and tools for each grazing allotment. Since the early 1990s, the scheduled revisions of AMPs have conformed with requirements of the National Environmental Policy Act (83 Statutes at Large 852) which include formal public participation procedures. The average AMP is revised either every 10-15 years, or more frequently if ownership of the grazing permit changes or there are new resource conflicts among the multiple uses. All FS AMPs are scheduled for revision using National Environmental Act procedures between 1995-2000 under the Recission Act of 1995 (109 Statutes at Large 212).

**Impact Standards and Monitoring**—Impact standards used for pre-existing livestock use typically prescribe acceptable levels of forage utilization, changes in vegetation composition, and soil erosion. These standards are set to minimize resource deterioration while integrating livestock use with the other ongoing uses and values in an area. In general, utilization standards range from 30-50% use of current season production of biomass, and this is typically measured for the dominant forage species in the area. More conservative utilization standards are applied to support other uses, such as wildlife habitat requirements, or to stimulate changes in vegetation composition. Vegetation composition standards have traditionally been based on the potential natural vegetation in the area before Anglo-American settlement, but there is an increasing trend to establish standards that match the "desired" composition determined in the FS Forest Plan, BLM Resource Management Plan and AMP public participation process because some uses may result in composition that is different from the potential or pristine vegetation (West and Smith 1997). Soil erosion standards are the least articulated of the three, but the general goal is to prevent erosion rates from exceeding natural levels.

In contrast, impact standards are based on preserving the wilderness character of the area when there is a proposal to increase livestock use above the level existing before wilderness designation. For example, standards applied by the BLM (46 Federal Register 47184 (1981)) include minimizing the detection of human work on the land, maximizing potential natural vegetation composition, and minimizing erosion.

It is possible that the difference between wilderness and nonwilderness standards will diminish with the recent implementation of a new impact standard process by the BLM and a possible new direction for standards in the FS. The BLM is beginning the process of applying new Standards and Guidelines (43 Code of Federal Regulations 4180 (1998)) that are likely to stress ecological conditions more than previous standards. The FS solicited a recent review by a group of scientists that concluded with recommendations refocusing attention toward ecological sustainability and less emphasis on multiple use (Johnson and others 1999).

Monitoring grazing allotments to assess the level of impacts with respect to the impact standards is not performed as frequently as one would hope, and "problem" allotments typically are monitored most frequently. Utilization is the impact standard that is most commonly monitored, but it is rarely measured every year. Utilization is typically estimated with a standard height-weight conversion for dominant forage species, or clipping biomass in paired grazed-ungrazed plots (Bonham 1989). Vegetation composition and soil erosion receive cursory attention during efforts to monitor utilization, and the vegetation composition on many allotments has not been formally measured for at least 10 years and often more than 20 years.

**Management Tools**—The management tools used on any allotment are articulated in the AMP and the lease agreement between the agency and the livestock operator. These documents include a grazing schedule that details the amount, season, type of grazing animal, and location. The amount of use is measured in animal unit months (AUM), the amount of forage needed to support a mature cow with small calf for a month (approximately 800-1000 lbs of forage). Theoretically, AUMs can be converted among different types of animals (for example 1 AUM = 5 sheep grazing for a month), but differences in metabolism and diet will distort the accuracy of these conversions (Holechek et al. 1998). Season of use describes the start and finish of grazing in a given year, and location of use describes where the grazing will take place. Taken as a whole, the AMP describes a grazing schedule that can be as simple as one herd of animals in one location (pasture) for a set period of time, or as complicated as several herds of animals moving among many different locations where the length of stay is determined by amount of utilization rather than a set calendar date. These more complicated arrangements are referred to as rotational grazing systems, and they are developed to foster improvement in vegetation composition and/or animal performance. Fences, water developments, herding, and diet supplements (salt, minerals, and protein are most common) are used to control the location of animals.

Certainly, the potential for controlling the severity of production livestock impacts are in place with the availability of these diverse management tools and the planning requirements for AMPs. These tools are capable of addressing the intensity, timing, and location of use. However, it is not easy to know how frequently they are being applied or how effectively they are working. It is important to recognize that while congressional grazing guidelines for livestock administration in wilderness provide the opportunity to construct new facilities to control resource damage (see abbreviated guideline #4); such as fences to exclude livestock from surface water areas, wet areas, or sensitive vegetation (Cole and Landres 1996), new fences are very likely to be a major source of conflict for hikers.

**Personnel**—Most production livestock managers have university-level training in range management or similar disciplines. This training includes monitoring methods, plant and soil identification, and livestock management. Furthermore, most new AMPs are developed using an interdisciplinary team that includes wildlife and recreation specialists. However, the number of range management personnel has declined over the past 15 years in most FS and BLM units, and this may explain the infrequency of monitoring on allotments.

# Management Challenges and Research and Development Needs

## Management Challenges

The challenge to wilderness managers is to control and reduce the livestock impacts that 25-45% of managers find unacceptable, and to accomplish this in the face of increasing recreation livestock use and constrained options for management of production livestock that are defined in the congressional grazing guidelines. The probability of meeting these challenges could be improved with the following changes in livestock administration: (1) develop defensible impact standards, (2) implement reliable and frequently applied monitoring programs, (3) apply needed management tools, and (4) increase the number of personnel working in wilderness that have been trained in range management.

The development of defensible impact standards will require a combination of public input, research findings, use of accepted production livestock standards, and continual validation from repeated monitoring. Resolving differences among users will be difficult, given the high degree of predisposition of hikers against any livestock other than llamas, and the predisposition of traditional recreation livestock users against llamas. Planning tools like Limits of Acceptable Change will be challenged when developing impact standards for production livestock use that must conform to the nonwilderness standards in the congressional grazing guidelines. This challenge will be especially great when many visitors demand less livestock or livestock removal based on impacts to wilderness traits because such criteria are not permitted by the congressional grazing guidelines. Research findings are not plentiful for recreation livestock (Cole 1989c), but production livestock standards can provide a starting point to form the acceptable impact standards.

Increasing the level of monitoring will be essential to keep abreast of the impacts associated with increasing use levels and to help develop defensible impact standards. Using monitoring to both assess impacts and revise management tools and standards is a form of adaptive management, in which monitoring informs managers of conditions and then stimulates continual revision of management. It is critical that managers recognize the utility of monitoring for these dual purposes. It is not always obvious that monitoring can provide valuable information for development of impacts standards by documenting trends in impact severity. For example, long-term monitoring can describe how often any hypothetical impact standard has been exceeded, and if that occurrence has been increasing. Monitoring will help evaluate the effectiveness of different management tools by describing the difference in resource conditions (and user attitudes) before and after the new tools were applied.

Recreation livestock management will need to increase the application of management tools that control the intensity and timing of use, especially as use increases. Some may argue for greater uniformity among agencies in the use of guidelines versus regulations, because visitors are inconvenienced and managers are frustrated when wilderness travel crosses jurisdictions that use different tools (guidelines or regulations) and apply different standards (for example, 20% versus 35% utilization). However, there are some lessons to be learned from this interagency variation that merit perpetuation of these differences. The variation in approaches provide a means to evaluate the effectiveness of different approaches to ensure that erroneous management decisions are not made throughout the wilderness preservation system.

For production livestock, the application of management tools such as fences to control site-specific impacts will face increasing resistance from visitors, even though the congressional grazing guidelines allow for these tools if the main purpose is resource protection. Increased efforts to provide information materials to visitors about the location of fences, the need for fences, and the directives in the congressional guidelines may help increase acceptance of these tools.

More trained personnel will be needed to monitor and manage the impacts from the expected increases in recreation livestock use. One way to meet this challenge would be more cooperation and coordination between wilderness and range management personnel. Range management staff should be encouraged to provide more assistance in recreation livestock monitoring and management, while wilderness staff should be encouraged to provide assistance with production livestock management in wilderness. Any differences in impact standards should not hinder this coordination because monitoring techniques can be the same and only the standards will differ. While there is certainly merit to Cole's (1989a) plea for more range scientists to address wilderness management situations, it seems equally obvious that wilderness management could benefit from better use of the relevant information in the range management discipline. Some means for facilitating this exchange if information include: handbooks, workshops, and wilderness range management courses offered at land grant universities.

## Research and Development

Both basic research and research leading to the development of effective livestock management will help improve livestock management in wilderness. Excellent basic research on the resistance and resilience of vegetation in relation to horse and llama trampling help managers to be more diligent about limiting off-trail and travel in wet areas. Building on this basic research, development of techniques to form horse with llama teams could combine the demand for horses for riding with the opportunity to minimize impacts with llamas. Furthermore, the growing popularity of llamas is justification to expand recent trampling impact studies, and examine the diet and intake rates of these animals.

The increasing recreation livestock use and the perpetuation of production livestock use means that conflicts rooted in predisposition against livestock will not disappear. In fact, given the increase of wilderness users from urban areas, these conflicts will probably increase. Therefore, information and planning tools need to be develop to reduce these conflicts by spatial separation. This separation may be a voluntary behavior induced by information describing the location of livestock in wilderness, or it may come from prescribed behavior required by the designation of livestock-free areas.

Research describing the results of the various management tools being applied throughout the Wilderness Preservation System will help managers understand the variety of available tools and their effectiveness. This type of research is no substitute for the strong inference possible when controls and treatments are replicated in an experimental design. Nonetheless, greater communication of management failures and successes, when joined with the few experiments, can help managers see the possible and understand the impossible.

Finally, research describing the rate of recovery (resilience) when use is reduced will help complete the information managers now have about recovery after use is terminated. This information is critical because the termination of use is rarely an option compared to use reduction. Cole and Hall (1992) described the recovery of vegetation in recreation livestock camps when use was terminated as well as when use was reduced. They noted that while some impacts diminished when use was reduced, damage to trees from the tying of stock is cumulative and actually continued to increase even with reduced use. They also noted that when use was terminated, the rate of recovery was more rapid in mesic than arid areas. Expansion of this type of research will help managers predict the probability and rate of response to use reduction. Specifically, this research would address how much and how rapidly recovery will occur with each increment of

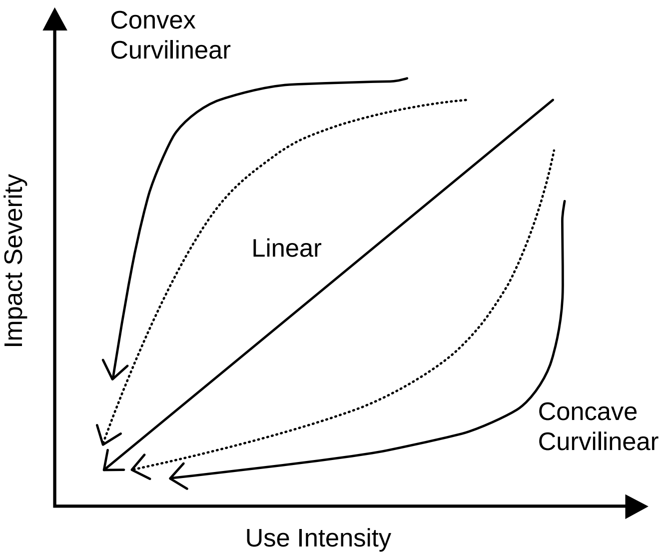


**Figure 2**—The rate of recovery following the reduction in the intensity of use can vary from linear, curvilinear to extreme curvilinear relationships. The linear relationship suggests that each unit of reduction of use will result in equal amounts of reductions in the severity of impacts. The modest convex curvilinear relationship (dashed curve) suggests that the rate of recovery (resilience) will be greatest when use is reduced towards a minimum intensity. The extreme convex curvilinear relationship suggests (solid curve) that recovery will be very minimal with reductions of intensity until use reaches very low intensities. Similarly, the modest concave curvilinear relationship (dashed curve) suggests that the rate of recovery will be greatest with the initial reductions of use, and the extreme concave curvilinear relationship (solid curve) suggests that nearly all recovery will occur with the initial reduction in use.

use reduction (fig. 2). The benefits of this information will be greatest for impacts most strongly controlled by use intensity, such as defoliation in grazed areas, and less useful for trails, where the initial impacts and timing are more important.

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