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Packstock in Wilderness: Use, Impacts, Monitoring, and Management

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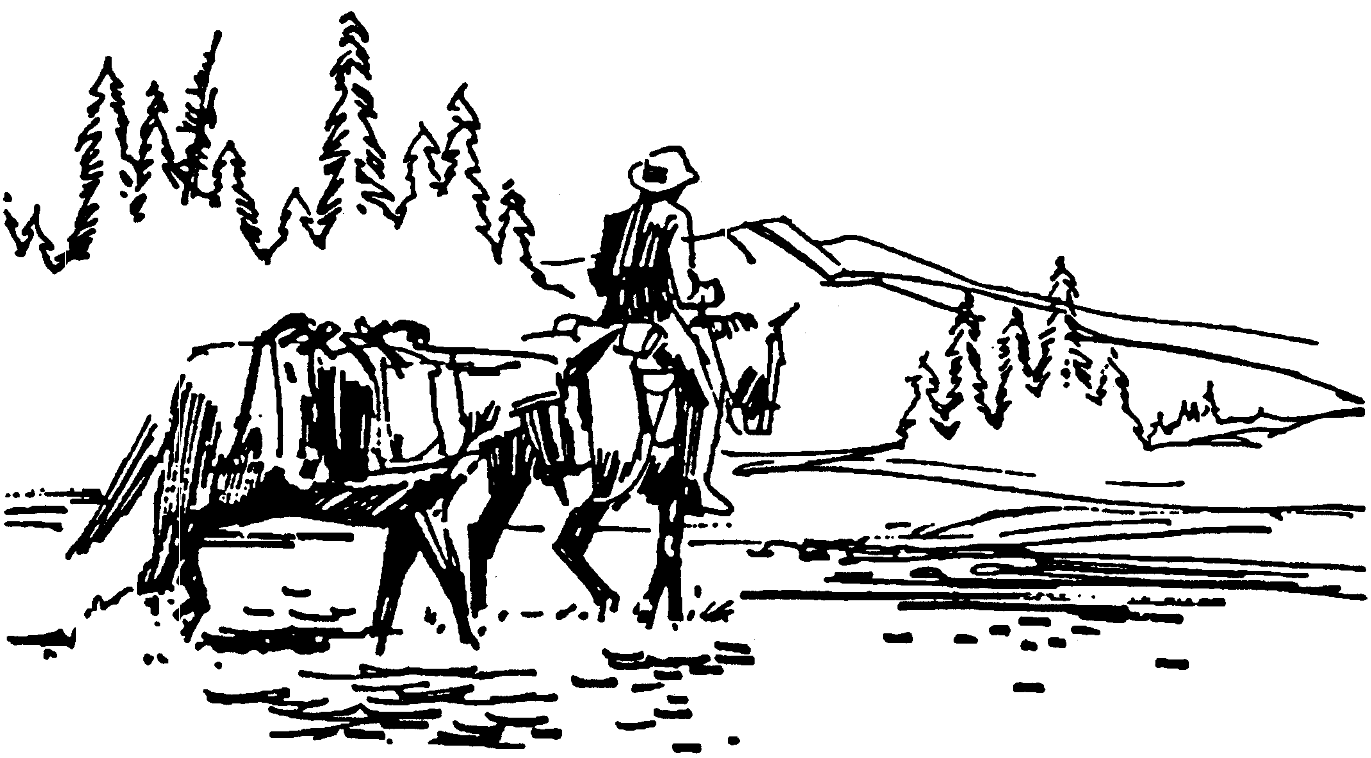

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RESEARCH SUMMARY

This report summarizes information relevant to managing packstock in wilderness. It presents the results of a survey of managers of all areas in the National Wilderness Preservation System, as well as summaries of information from literature reviews. Sections describe: the amount and composition of packstock use in wilderness, impacts associated with packstock use, methods for monitoring impacts caused by pa&stock, techniques for managing packstock in wilderness, examples of packstock management programs, and research needs.

In 1990 about half of all wildernesses had some packstock use. Packstock was prohibited in 14 percent of wildernesses. About 11 percent of wilderness visitation was by parties with stock. Packstock use is minimal in wilderness areas managed by agencies other than the Forest Service and outside of the Pacific and Rocky Mountain regions. Llamas have been used in more than half of the wildernesses with packstock use.

Packstock may harm vegetation, soils, water quality, wildlife, and visitor experiences in wilderness. Monitoring and management of packstock should focus on soil erosion and defoliation near streambanks and popular camping areas. Some methods for monitoring packstock impacts are described.

Wilderness managers are using a wide variety of strategies for managing packstock. However, nearly half of the wildernesses with stock use have no restrictions on their use. The only restrictions commonly applied are limits on party size and the length of stay. Limits on the amount of use and the time of use are particularly rare.

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INTRODUCTION

Packstock are a common mode of travel in wilderness and an important source of impact; however, packstock management has garnered relatively little attention compared to backpacker management. At one time, packstock were the primary mode of transportation in most backcountry settings. Their presence was instrumental in the development of the wilderness concept and wilderness recreation management. For example, in his seminal work on the wilderness concept, Aldo Leopold (1921) defined the minimum size of wilderness as the area that could be covered in a 2-week packstock trip. When Lowell Sumner (1942) introduced the recreation saturation point (carrying capacity) concept to describe the level of use where impacts become excessive, he was referring to large Sierra Club trips using packstock in California's Sierra Nevada.

Despite this tradition, the numbers of backpackers eclipsed pack strings in wilderness during the 1960's and 1970's. This shift followed the development of lighter equipment and freeze-dried foods that became available to a generation hungry for wilderness camping experiences, but with little background in the use of packstock.

Although the proportion of packstock use has declined relative to backpacking, packstock use is still popular in wilderness. Lucas (1985) found that backpackers replaced packstock users as the primary users in the Bob Marshall Wilderness Complex sometime between 1970 and 1982. However, packstock use increased by 20 percent during that period. Similarly, in Sequoia and Kings Canyon National Parks, backpackers replaced stock users as the primary users sometime between 1960 and 1980. The absolute amount of packstock use there remained fairly constant (McClaran 1989). Moreover, use of packstock in wilderness still causes serious problems. Even low levels of packstock use can cause substantial impacts. Compared to impacts caused by backpackers, packstock impacts to trails and campsites are more severe, and packstock impacts to grazing areas have no corollary for backpackers' impacts (Cole 1990a). In 1980, managers of 15 percent of the Forest Service wilderness areas reported packstock impact problems "in many places" (Washburne and Cole 1983); in 1989,X percent of the managers surveyed reported severe impacts and 24 percent reported moderate impacts (United States General Accounting Office 1989).

These accounts of packstock impacts suggest a need for additional information to guide packstock management in wilderness. This report compiles information that can contribute to improved packstock management.

Information Needs

Wilderness managers have struggled to satisfy Congress' seemingly contradictory intents in creating-the National Wilderness Preservation System: to provide areas untrammeled by humans where natural processes are unhindered, and to provide for wilderness-type recreational opportunities (Hammitt and Cole 1987; Hendee and others 1990). Progress has been made on two fronts. Research has helped us learn how the amount and character of recreational use influences levels of impact, and managers have developed experience with practices to control these impacts without infringing on visitors' wilderness experiences.

Interestingly, concern over packstock spurred the initial advances on both these research fronts. Concern over the impacts caused by packstock use in the Sierra Nevada of California during the 1930's and 1940's led to a series of studies of packstock impacts on meadows-the first studies of recreational impact in wilderness-type areas. Several of these studies were conducted by National Park Service biologist Lowell Sumner (19421, who suggested using the carrying capacity concept to describe the maximum number of packstock that can graze in a mountain meadow without impairing "the essential qualities of the area."

Sumner's recognition that recreation was not wholly benevolent and his suggestion to control its impacts by limiting use to an area's carrying capacity were important breakthroughs in wilderness recreation management (McClaran 1989). However,

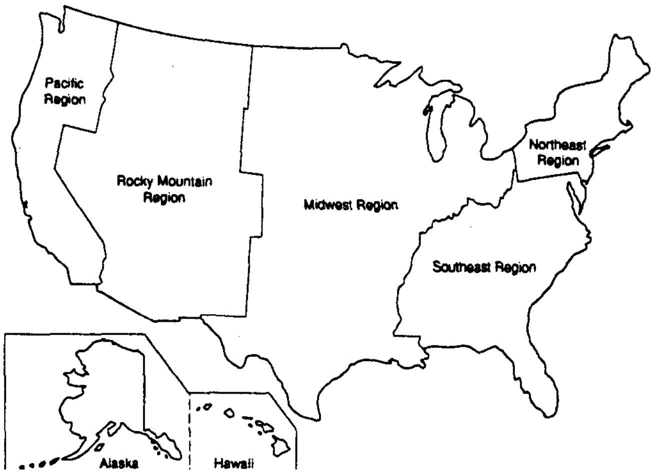

Figure.l -Regions of the United States used when reporting results of the survey of wilderness managers.

Trends in packstock management programs in wilderness can be assessed by comparing the results of this survey with previous surveys. In 1978 (Bury and Fish 1980; Fish and Bury 1981) and 1980 (Washburne and Cole 1983), managers in all National Wilderness Preservation System units and some potential wilderness units were surveyed. The sample size in 1978 was 272 units, with a return rate of 92 percent. All 308 units and potential units surveyed in 1980 returned the mailed questionnaires. The surveys were basically similar in their objectives; however, they differed in the questions they posed to managers and in the conclusions they drew. In general, the 1980 survey reported a greater breadth of management practices and wilderness conditions than did the 1978 survey. The 1978 survey placed more emphasis on the rationales for management decisions and on the differences between the managing agencies. The United States General Accounting Office (1989) surveyed all Forest Service Ranger District offices with wilderness management responsibilities. Questionnaires were returned by about 92 percent of the 587 offices surveyed.

Comparing these earlier surveys to the current survey provides a perspective on changes in the use of specific management techniques and on shifts in agency philosophies over the past decade. However, two developments during the 1970's and 1980's influenced the survey results. First, the wilderness system increased greatly. The size of the National Wilderness Preservation System grew from 20 million acres in 1978 to over 90 million acres in 1990. The number of individual units increased from 188 in 1978 to nearly 500 in 1990. Therefore, quite a few areas included in the later surveys were not included earlier. Second, in 1976 Congress authorized the Bureau of Land Management to manage wilderness areas. By 1987 the Bureau was responsible for over 350,000 acres in 23 wildernesses (McClaran 19901. The use and physical characteristics of these new wilderness units, particularly the smaller units, units located in Alaska, and units managed by the Bureau of Land Management, may be quite different from those units designated before 1980.

EXTENT, INTENSITY, AND COMPOSITION OF PACKSTOCK USE

The likelihood of encountering packstock or traveling with packstock in wilderness has declined since the 1960's, but packstock use appears to have stabilized in the past decade in some areas (McClaran 1989). This section describes the extent of packstock use throughout the National Wilderness Preservation System, changes in use during the past decade, and the extent that nontraditional pack animals, such as llamas and goats are being used in wilderness.

Horses and Mules as Packstock

Packstock use occurred in 49 percent of all wilderness areas. Packstock use was explicitly prohibited in 14 percent of wilderness areas (table 1). Wilderness areas managed by the Forest Service and Bureau of Land Management were most likely to have packstock use: just over half of the wilderness areas managed by these agencies have some packstock use. About one-third of the areas managed by the National Park Service had packstock use, while only 7 percent of Fish and Wildlife Service areas (two units) had packstock use. Packstock were prohibited in more than half the Fish and Wildlife Service areas and in more than one-third of the National Park Service areas. Relatively few Forest Service and Bureau of Land Management units prohibited use. Wilderness areas in the Pocky Mountain and Pacific regions were more likely to have packstock use, but even in the Rocky Mountains more than one-quarter of the wilderness areas had no packstock use. None of the wilderness areas in the Northeast had packstock use; nearly two-thirds of the wilderness areas there prohibited packstock use.

The prevalence of wilderness areas prohibiting stock use has increased since 1980. Washburne and Cole (1983) reported that stock use was prohibited in only six of 308 wilderness and potential wilderness areas (2 percent) in 1980; in 1990, stock use was prohibited in 58 of the 423 areas (14 percent). The number of areas experiencing packstock use decreased from the 231 reported in 1980 to 202 in 1990, even though the number of wilderness areas increased during the decade. Of the 58 areas prohibiting packstock in 1990, 32 were established after

Table 1—Extent, intensity, and type of user visiting wilderness units with packstock

Agency and region	Units with packstock		Units prohibiting packstock	Packstock share of visitation	Packstock share of visitation in units with packstock	Overnight packstock share of overnight visitation	Overnight packstock share of overnight visitation in units with overnight packstock use	Proportion of overnight packstock use		
								Private	Commercial	Administrative
	Number	- - - - - -	- - - - - -	- - - - - -	- - - - - -	*Percent*	- - - - - -	- - - - - -	- - - - - -	- - - - - -
Agency										
Forest Service (*N* = 328)	177	54	8	16	24	28	33	61	30	9
Park Service (*N* = 40)	14	35	38	3	5	4	5	23	47	30
Bureau of Land Management (*N* = 15)	8	53	13	3	3	1	2	85	7	8
Fish and Wildlife Service (*N* = 28)	2	7	54	<1	4	7	7	38	62	0
Region										
Northeast (*N* = 16)	0	0	63	0	0	—	—	—	—	—
Southeast (*N* = 68)	6	9	25	<1	4	2	8	91	9	0
Midwest (*N* = 51)	19	37	14	3	14	4	17	95	4	1
Rocky Mountains (*N* = 141)	101	72	6	27	30	36	38	52	37	11
Pacific (*N* = 103)	71	69	11	13	15	15	16	68	22	10
Alaska and Hawaii (*N* = 32)	4	13	16	<1	3	2	5	35	57	8
All units (*N* = 411)	201	49	14	11	20	21	24	59	31	10

1980; three of those areas already prohibited packstock use in 1980. The remaining 23 areas allowed stock use in 1980 but prohibited it in 1990; less than 2 percent of the total wilderness visitation in these areas had been by packstock users. Twelve of the areas that began prohibiting packstock between 1980 and 1990 were National Park Service areas, six were Fish and Wildlife Service areas, four were Forest Service areas, and one was a Bureau of Land Management area. National Park Service policy generally prohibits packstock use, allowing it only in specially designated areas (36 Code of Federal Regulations 2.16, Office of Federal Register 1990). Interestingly, packstock were permitted in 1990 in three areas where they were prohibited in 1980.

Wilderness managers used different units of measure when reporting wilderness visitation for our survey; their responses included total visitor days, total visits, and total overnight stays. These measures were converted to visitor days using equations presented by Washburne and Cole (1983). A constant of three nights for the length of overnight stay was used in this calculation; the survey responses did report actual average length of stay for each of the wildernesses. Over 90 percent of the responses were for use levels in 1989. We asked managers how they estimated visitor use: whether they used systematic counts, field observations, or "best guesses." Overall, systematic counts were used in 16 percent of the areas, field observations were used in 21 percent, and "best guesses" were used for 63 percent. Nearly half of the National Park Service areas used systematic counts; another 24 percent used field observations. Other agencies were more likely to rely on "best guesses."

Eleven percent of total wilderness visitation was by parties with packstock (table 1). This has not changed since 1980 (Washburne and Cole 1983). The proportion of packstock use was as high as 95 percent of all use in one area; packstock use exceeded 50 percent of all use in 28 areas. Packstock use did not exceed 3 percent of all use except in the wilderness areas managed by the Forest Service and in the Rocky Mountain and Pacific regions (table 1).

When only overnight use is considered, 21 percent of all use was by parties with packstock (table 1). Parties with packstock are more likely to be staying overnight, since their proportion of total overnight use (21 percent) is higher than their proportion of total wilderness visitation (11 percent). When only areas with packstock use are considered, 20 percent of the total visitation was with packstock, and 24 percent of overnight use was with packstock. In 50 wilderness areas more than 50 percent of the overnight use was with pa&stock.

Private users accounted for nearly 60 percent of overnight packstock use; commercial use accounted for nearly one-third (table 1). The proportion of private use was greatest in Bureau of Land Management areas; commercial use was greatest in the Fish and Wildlife Service areas; administrative use was greatest in the National Park Service areas. The Alaska-Hawaii and Rocky Mountain regions had the greatest proportion of commercial use.

Llamas and Goats as Packstock

Llamas and goats have entered the packstock scene in the past 10 to 15 years as alternatives to horses, mules, and burros. Although these alternative packstock animals generally represent less than 5 percent of all packstock use, they account for more than 20 percent of packstock use in four areas. Between 1985 and 90, 57 percent of all wilderness areas with packstock use had some llama use, 27 percent had more than 10 visits by parties with llamas, and 7 percent had more than 50 visits (table 2). Only 5 percent of the areas were 'used by parties with goats. Llamas and goats were rarely used in Bureau of Land Management and Fish and Wildlife Service areas. Llama use occurred on a greater proportion of Forest Service areas than National Park Service areas, but llamas were used more frequently in the National Park Service areas than in the Forest Service areas. Coat use was most common in National Park areas.

Horses, mules, and burros remain the most corn-mon pack animals, but llamas were conspicuous visitors to many wilderness areas in the 1980's. Claims that llamas are easier to handle and cause less damage by trampling and grazing have bolstered their use as private and commercial packstock (Markham 1990). The establishment of regional and national llama breeding and trade associations (Markham 1990) indicates that llamas may become more common as recreational pa&stock. One constraint on this growth may be the cost of buying llamas: a breeding animal's price can exceed $10,000.

Coats have not become as popular as llamas. However, some claim they too are easier to handle and cause less impact than traditional stock. Coats could become more popular as packstock because they are inexpensive to buy, feed, and handle. In addition, they can provide fresh milk in the backcountry. At least one commercial operator uses goats for packstock (Strom 1988).

Some wilderness managers have expressed concern that llamas and goats might transmit diseases to wildlife. In addition, some managers are concerned that the animals could escape, establishing feral populations. These concerns have led some managers to prohibit llamas and goats from some wilderness areas.

Table 2- Overnight visits by groups with llamas and goats, 1985-89[1]

Agency and region	Groups with llamas 0	1-10	11-50	>50	Groups with goats 0	1-10
	percent					
Agency						
Forest Service (N = 172)	40	32	21	7	95	5
Park Service (N= 11)	55	9	27	9	82	18
Bureau of Land Management (N=8)	88	12	0	0	100	0
Fish and Wildlife Service (N=2)	50	50	0	0	100	0
Region						
Southeast (N=6)	83	0	17	0	100	0
Midwest (N= 16)	94	6	0	0	100	0
Rocky Mountains (N=l0l)	44	27	21	8	98	2
Pacific (N = 66)	21	44	26	9	89	11
Alaska and Hawaii (N=4)	75	25	0	0	100	0
All units (N= 193)	43	30	20	7	95	5

[1]Visits are the sum for the years 1985 to 1989. Wildernesses with no packstock use are excluded.

PACKSTOCK IMPACTS

Packstock impact wilderness vegetation, soils, water, wildlife, and esthetics by defoliating vegetation, trampling, depositing wastes, and interacting with wildlife and with visitors. These impacts occur mainly when animals graze vegetation and when they are confined around camps. This section reviews how these impacts affect wilderness resources, evaluates the severity and extent of these impacts, and describes factors that influence the severity of these impacts. Pa&stock impacts on trails and camp sites are not described because they do not differ fimdamentally from impacts caused by backpackers; in addition, they are covered elsewhere (Cole 1990a).

The nature of some impacts must be inferred from knowledge describing cattle and sheep, because there is a paucity of information on packstock impacts (Cole 1989a). Cattle are better than sheep in serving as a surrogate for the impacts of horses and mules because cattle are similar to horses and mules in body and hoof size, prefer to graze in meadows (Gillen and others 1985; Platts and Nelson 1985), and prefer to eat graminoids (grasses, rushes, and sedges) (Vallentine 1990). However, horses tend to spend more time grazing than cattle, and they graze more at night (Arnold 1984). Horses also can crop forage closer to the ground than cattle because they have teeth on both their upper and lower jaws while cattle just have teeth on their lower jaw (Vallentine 1990). In addition, because horses' hooves are not cloven like those of cattle and sheep, and because horses are typically shod, horses may cause greater impacts by trampling soil, shearing it, or dislodging it when they skid.

Trampling

Trampling occurs primarily when packstock hooves contact the ground or vegetation when the animals walk or stand, and when they roll while taking a dust bath. These actions directly influence the soil and plants, and may indirectly influence water quality and vegetation composition.

Trampling causes soil compaction and shearing, and dislodges soil particles. This reduces the space between soil particles and decreases water infiltration and oxygen diffusion (Thurow 1991). Soil shearing occurs when hooves cut through the soil surface; shearing can also sever plant roots (Vallentine 1990). Soil particles become dislodged when horses slide or scuff their hooves across the soil surface and when horses roll on their backs to take dust baths. Erosion can increase after trampling because soil compaction decreases infiltration, and because shearing, scuffing, and skidding dislodge soil particles.

Trampling can also reduce plant growth directly by killing plant material and indirectly by lowering oxygen diffusion and water infiltration into the soil. Compaction can also make it more difficult for roots to elongate and seeds to germinate. Water quality can be harmed if trampling results in increased erosion and sediment is deposited in streams and lakes. Vegetation composition can change if some plant species are more tolerant of trampling, compacted soil, and severed roots.

Trampling by packstock is most severe where stock are restrained in small areas for long periods and where they take dust baths. Cole (1983) found greater soil compaction and tree mortality in packstock camps than backpacker camps. Fortunately, these areas are small. Trampling impact is usually less severe when animals are grazing because they are less confined, but they graze over larger areas. The impact can be greater when animals are picketed, because picketing concentrates grazing in small areas.

The severity of soil compaction from trampling is a function of an animal's weight, its hoof size, and the amount of trampling (Thurow 1991). Weaver and Dale (1978) found that horses compacted meadow soils more than hikers or motorcycles because horses' hooves exerted a greater downward force (a function of hoof size and animal weight). Although soil compaction increases with the amount of trampling, the relationship is asymptotic (Cole 1987); as trampling increases, the incremental increase caused by additional trampling decreases. This type of relationship also suggests that the initial passes are the most critical and should be prevented if possible. Soil compaction will not increase much after a large number of passes, so the additional passes will not be as influential as the initial ones.

Soil shearing and severing of roots is more likely when soils are wet (Vallentine 1990). Jardine and Anderson (1919) suggested production livestock should not begin grazing in mountain meadows until the soils are dry enough to support the animals' hooves without shearing. Sequoia and Kings Canyon National Parks set grazing commencement dates based on the soil's ability to support the weight of packstock (McClaran 1989).

Soil erosion is a critical problem because soil forms the basis for plant growth, and because soil develops very slowly. Erosion in mountain meadows and other riparian settings is particularly detrimental because it can lead to stream incision and the lowering of the water table (Ellison 1949). Vegetation composition and productivity are strongly related to the depths of water tables in meadows (Allen-D& 1991; Manning and others 1989; Ratliff and others 1987). Therefore, camp sites should be located on level ground with thin or no soil and away from streams and lakes. In areas where packstock graze, managers should pay special attention to avoid soil compaction, to prevent erosion, and to avoid shearing of streambanks. Avoiding these problems helps prevent streambank sloughing and streambed widening.

Two aspects of grazing animal behavior influence the selection of commencement dates in mountain meadow and other riparian situations. Production livestock (Platts and Nelson 1985) and pa&stock avoid wetter areas in meadows if possible, and production livestock and big game congregate along streambanks as a function of the length of stream available rather than the land area available (Bohn and Buckhouse 1986). Therefore, commencement dates should be selected considering the amount of dry area available and the length of stream available.

Defoliation

Packstock defoliate plants by removing their leaves and stems. Defoliation directly influences the plant and indirectly influences vegetation composition and soil erosion.

The removal of leaf tissue reduces the amount of photosynthetic area available to the plant. This can reduce biomass production, plant size, and seed output (Briske 1991). These responses to defoliation can be magnified when grazed plants grow in association with ungrazed plants. Certain individual plants and species will be defoliated more frequently and intensively than others because livestock prefer them. This can give plants that are not defoliated a competitive advantage for soil water and nutrients, as well as for light (Briske 1991). Soil erosion is indirectly influenced by defoliation because plant cover and plant litter (dead plant biomass on the ground surface) increase the rate of water infiltration into soil (Wood 1988). Foliar plant cover (measured by the ground area with plants above it) weakens the impact of falling raindrops and reduces the dislodging of soil; plant litter also weakens the impact of raindrops and slows the rate of water flowing over the soil surface. Basal plant cover (measured by the ground area covered by the bases of plants) increases the rate of water infiltration into the soil.

Defoliation is most severe when animals are confined to small areas for extended periods such as in corrals, small pastures, and around picket pins. In general, these areas are not large and are typically associated with camps. Defoliation is more dispersed when animals are not confined; it tends to be greatest near camps and between barriers to movement, such as drift fences.

The severity of defoliation depends on the amount of leaf area remaining, the frequency of defoliation, and the timing of defoliation. Leaf area is important because leaves produce carbohydrates for regrowth after defoliation (Briske 1991; Davidson and Milthorpe 1966). The frequency of defoliation determines how much time the plant has to regrow before being grazed again during a growing season. The timing of defoliation is important because plants are generally more susceptible to defoliation during actively growing periods, particularly during flowering (Heady 1975).

The severity of defoliation also depends on the amount of use. Defoliation increases as stocking rate (animals/area/time) increases. At low stocking rates, the rate of increasing defoliation can vary from linear, (where each additional animal increases defoliation a constant amount) to curvilinear (where each additional animal increases defoliation by an amount that varies depending on how many animals are already present). At very high stocking rates, the rate of defoliation per animal decreases (a curvilinear increase) because the small amounts of available forage reduces consumption by each animal (Heitschmidt 1988).

The relationship between stocking rate and defoliation applies over a broad area, and not for any particular plant or localized site (Heitschmidt 1988). For example, animals will often return to preferred locations or plants in an area that has already been grazed rather than graze uniformly. This selection of preferred areas is called patch grazing (Vallentine 1990). Patch grazing is most common when forage availability greatly exceeds forage demand (Ring and others 1985) or during seasons when forage quality is poor (Ruyle and others 1988). Therefore, patch grazing could lead to intense defoliation in localized areas even when stocking rates are low. The size of areas with high levels of defoliation will increase as stocking rates increase.

Patch grazing was described for horses on bermudagrass pasture in Texas (Hansen and others 1987). Packstock will be more likely to patch graze in areas that are lightly visited, where regrowth has occurred after previous defoliations, where nutritious feed is concentrated, or that are some distance from bothersome insects. In addition, horses avoid grazing around areas where they defecate.

The relationship between defoliation levels and indirect changes in vegetation composition is not clear, because most studies have compared only grazed and ungrazed areas. For example, meadows grazed by production livestock in eastern Oregon had a higher diversity of plant species. Grazing created opportunities for plants typically found on drier sites, while these species declined after grazing ceased (Kauffman and Krueger 1984). Similarly, grazed patches generally have more species representative of drier sites than the surrounding ungrazed vegetation (Wilms and others 1988).

Animal Wastes

Animal wastes influence soil nutrient status, water quality, plant vigor, and defoliation patterns. Since urine contains the majority of the nitrogen in animal wastes, urine patches are associated with elevated levels of nitrogen in the soil (Archer and Smeins 1991). Defoliation intensity can increase in urine patches. This increase may be related to the concentration of nitrogen in the foliage (Jarmarillo and Detling 1992).

Packstock wastes can be a serious problem in camp settings and near bodies of water. Odor and flies increase when packstock are confined to small areas for prolonged periods. Water can be contaminated with bacteria if packstock are confined for prolonged periods near lakes and streams.

Feces deposited away from streams and later carried there by runoff are the primary source of bacterial contamination of surface waters from production livestock grazing (Doran and Linn 1979). Gary and others (1983) estimated that only about 5 percent of feces are deposited directly in streams. Bacterial contamination generally increases with increasing animal density (Gary and others 19831, but the distribution of animals is also important. Tiedemann and others (1987) suggested that fecal bacterial contamination was more strongly influenced by the congregation of animals in meadows near streams than by absolute animal density.

Interaction With Wildlife

Livestock can influence the presence and abundance of wildlife directly by interfering with animal movements, and indirectly by altering habitat characteristics or reducing the available forage (Barnes and others 1991; Kie and Thomas 1988). Because no studies document the influence of packstock on wildlife, it is necessary to infer these influences from research on production livestock and feral horses. It is not known how well this information represents packstock influences on wildlife.

Wildlife movements are disrupted when more dominant animals displace them from preferred habitats and watering sites. Cattle are known to alter elk movements more than deer, primarily because cattle and elk prefer meadow habitats more than deer (Wallace and Krausman 1987). However, Loft and others (1991) suggested that cattle also alter the movements of female deer in Sierra Nevada meadows. Feral horses displace pronghom antelope and prevent them from approaching water developments Miller 1983).

Grazing can indirectly influence the habitats of terrestrial and aquatic wildlife by altering the amount and kind of vegetation and increasing soil erosion and sediment deposition in streams and lakes. Increased sediment concentrations in the water column and streambed gravels can reduce the reproductive success of cold-water fish (Platts 1981; Platts and Nelson 1989). Grazing can decrease habitat quality for cold-water fish by contributing to the collapse of overhanging streambanks and reducing streambank vegetation that shades the water; the outcome is increased water temperature (Platts 1981). Grazing that reduces streamside vegetation also reduces the abundance of insects that depend on the vegetation; fish may have less to eat. Leaves and other plant materials (detritus) add nutrients to the stream; grazing that reduces streamside vegetation also reduces this source of nutrients (Platts 1981). Grazing may also affect birds. Since shorebirds are attracted to grazed areas where the grass is shorter, bird biomass, species richness, and diversity increase in meadows grazed by production livestock (Medin and Clary 1990). Small mammal populations increased on the g-razed area, but species richness and diversity were higher on the ungrazed area (Medin and Clary 1990).

Because cattle and horse diets are dominated by graminoids (Vallentine 19901, g-razing will most affect forage availability for wildlife species with similar diets. For example, the diets of feral horses and cattle are significantly different from the diet of pronghom (McInnis and Vavra 19871; the potential impacts of grazing on forage availability for elk will be much greater because the diets of elk are similar to those of feral horses and cattle.

Packstock are more likely to inhibit wildlife movements when they are grazing than when they are kept in camps because packstock are less confined when grazing. However, habitat alteration will be most severe in areas where packstock are confined, such as camps, corrals, and small pastures. The intensity of defoliation and soil disturbance in confined areas will generally be greater than in larger areas where packstock are allowed to graze freely. Available forage will be reduced the most where grazing is most concentrated.

The amount of time that packstock are present may have more to do with disruption of wildlife movements than the absolute numbers of pa&stock. Small numbers of packstock that are continually present are more likely to disrupt wildlife movements than large numbers of packstock that are present for only a short time. Even for habitat alteration, absolute numbers may not adequately describe packstock impacts. The location of concentrated grazing will be more important than the level of overall use because these concentrated use areas (grazed patches) will be the most different from ungrazed areas. Habitat alterations may be more serious if they reduce the availability of critical habitats (breeding sites, nests, and shelter) during the seasons when they are most needed by wildlif'e. Similarly, the relationship between packstock and the reduction of forage should also be greatest in the most heavily defoliated areas, but the seasonality of use will also be important, particularly if critical early-season or late-season forage is reduced.

Interaction With Visitors

Packstock can influence a visitor's wilderness experience by introducing smells, sounds, and sights that conflict or accord with their wilderness values. In addition, packstock can leave their wastes at camps and in water supplies and increase the number of insects along trails and in camps.

To some wilderness visitors, the sights and smells of packstock may enhance the pioneering experience of a wilderness visit, while others may find the smell of domestic animals and the sounds of their bells and neighing to be the antithesis of an experience predicated on escaping the sights and sounds of man (Moore and McClaran 1991). The sight of grazed vegetation, trampled soil, feces, hitchracks, and drift fences also influence the visitor's experience.

The impact of packstock on other visitors is greatest in camp and trail settings where visitors and animals are in close proximity. The sight and smell of animals and feces, the number of insects, and the sights of hit&racks and drift fences are greatest in these settings. Visitors may have to hike away from such camps to find clean drinking water. Grazed vegetation will not be as apparent where packstock are allowed to graze freely, but the effect will be spread over a larger area. Grazed vegetation can conflict with visitor perceptions of wilderness; some visitors may be disappointed if they cannot find ungrazed specimens to identify.

In general, hikers' satisfaction is reduced when they encounter packstock during wilderness visits (Lucas 1980). Moreover, one study suggests that negative experiences caused by packstock encounters were greater in a wilderness with little stock use than in a wilderness with heavier stock use (Stankey 1979). If this is a general pattern, packstock use would have a greater negative influence on visitors if it were dispersed away from traditional travel areas than if it were concentrated in traditional travel areas.

The relationship between packstock use levels and the indirect impacts of trampling and feces in camp settings are likely to be asymptotic. The direct impacts of trampling are asymptotic (Cole 1987). Although visitors' tolerance of feces in camp settings may decrease as fecal matter increases, their reaction to the initial fecal dropping will be greater than their reaction to the addition of one more dropping when many are already present. Although the negative influence of grazed vegetation and fences on the visitor's experience increases with increased use by production livestock and the number of fences (Sanderson and others 1986)) it is unclear if this relationship is asymptotic,

Summary

The most obvious packstock impacts in wilderness are likely to be (1) trampling along streambanks and in camps, and trampling before soils are dry enough to support animals without shearing and skidding; (2) severe defoliation in heavily grazed areas; and (3) animal wastes in and around camps, streams, and lakes. This suggests that monitoring and management should focus on soil erosion, shearing, skidding, streambank deterioration, defoliation levels (particularly near streambanks and popular camping areas), and bacteria in streams. Because the impacts of trampling and packstock encounters typically are asymptotically related to packstock use levels, effective management should concentrate packstock use in areas that are most resistant to these impacts and that already receive significant use. Visitors should be informed of what to expect in specific areas, and where they might travel to avoid unsatisfactory experiences, such as packstock encounters. Because the most intense defoliation appears to be concentrated in patches around camps and small pastures, managers should establish camps and pastures in areas that are least susceptible to defoliation impacts, such as areas away from streams where forage is abundant and plant species can withstand repeated grazing. Finally, research on packstock impacts to wildlife is needed.

MONITORING PACKSTOCK IMPACTS

Monitoring packstock impacts is essential to understanding (1) the current magnitude of impacts, (2) changes in these impacts over time, (3) the relationship between current conditions and management objectives (as in the LAC process), and (4) the strengths and weaknesses of a management program (Cole 1990b; Hendee and others 1990; Stankey and others 1985).

This discussion will focus on monitoring the impacts of trampling and defoliation in packstock grazing areas because techniques for monitoring those impacts have not been described before. Techniques for monitoring wilderness campsites and trails have been described elsewhere (Cole 1983, 1989b). This discussion will briefly review those techniques and provide examples of their use. More thorough treatments of monitoring are available (Bonham 1989; Cook and Stubbendieck 1986; Ruyle 1991). In addition, procedures for monitoring defoliation, vegetation composition, and soil erosion have been distilled into cookbook procedures in the Range Analysis Handbook for each Region of the Forest Service, and similar documents in the State Offices of the Bureau of Land Management. Because range management professionals are familiar with these methods, they can assist in selecting and implementing procedures that can best be applied in wilderness situations.

Current Status of Monitoring

Packstock impacts to camps and trails were monitored in over half of the wilderness areas experiencing packstock use, but impacts to grazing areas and to other wilderness visitors were monitored in only about 30 percent of the areas (table 3). The Bureau of Land Management was the agency most likely to monitor grazing areas; the Forest Service was the agency most likely to monitor camps, trails, and visitors. The National Park Service and Fish and Wildlife Service rarely monitored impacts to other visitors. The Pacific region was the most likely to monitor grazing areas; the Southeast and Midwest regions were least likely to monitor grazing areas.

The low frequency of monitoring runs counter to suggestions that monitoring is essential to evaluate and direct effective wilderness management (Cole 1987, 1990b; Hammitt and Cole 1987; Hendee and others 1990; Stankey and others 1985). This result was consistent with the General Accounting Office's finding that monitoring in Forest Service wilderness areas was insufficient for managers to judge resource conditions (United States General Accounting Office 1989). Information on monitoring campsites and trails is readily available (Cole 1989b); however, no information on monitoring packstock grazing areas in wilderness is available (Cole 1989a). This may explain why campsites and trails were more likely to be monitored than grazing areas.

Fundamentals of a Monitoring Program

Monitoring methods should be objective and simple, repeated frequently enough to detect trends, and designed to reveal the role of packstock grazing in the

Table 3- Proportion of wilderness areas that monitor packstock impacts to grazing areas, campsites, trails, and visitors

Agency and region	Grazing areas	Campsites	Trails	Visitors
	------------------------ *percent*	---------------------		
Agency				
Forest Service (N = 178)	28	71	57	29
Park Service (N= 14)	29	57	50	7
Bureau of Land Management (N=8)	38	38	25	25
Fish and Wildlife Service (N-2)	0	0	50	0
Region				
Southeast (N=6)	0	67	67	33
Midwest (N= 19)	5	58	74	26
Rocky Mountains, (N = 102)	27	66	56	29
Pacific (N=71)	38	77	56	25
Alaska and Hawaii (N=4)	25	0	50	0
All units (N = 202)	28	68	55	27

measured change. Methods should yield consistent results when data are collected by different people. This is important because personnel frequently change positions.

The design of a monitoring system should identify (1) what, (2) where, (3) when, (4) how many, and (5) how often monitoring measurements will be made. In addition, the system should be designed to fit within time and budgetary constraints.

What Should Be Monitored?- The monitored parameters should be direct measures of the impacts from packstock, or indirect measures closely associated with direct measures of impacts. For example, a manager might be concerned about packstock-related soil erosion. Packstock trampling can increase soil erosion by decreasing water infiltration and plant cover. One option is to take direct measures of soil erosion, such as soil loss or the amount of sediment in streams. Another option is to take indirect measures such as soil compaction, plant cover, or plant litter. In many cases, indirect measures are easier to quantify; they may be preferable if they have predictive value.

The three basic approaches to measuring defoliation levels are: utilization, residual biomass, and the proportion of plants that have been grazed. As the proportion of grazed plants increases, defoliation levels are assumed to increase. However, livestock's propensity to regraze in patches can cause defoliation levels to be underestimated with this method. Both the utilization and residual biomass technique measure the amount of biomass present; the utilization approach attempts to estimate how much was eaten, while the residual biomass approach attempts to estimate how much was not eaten. Utilization is the percentage of the current year's biomass production that has been removed by grazing animals (Bonham 1989). One shortcoming of the utilization method is that after biomass has been removed by grazing, it is no longer available to be measured. The most accurate estimates of utilization require exclosures where ungrazed plants can be measured for comparison. Even with exclosures, estimates of utilization can be inaccurate because grazed plants may regrow before being measured.

Residual biomass is easier to measure because it is simply the amount of biomass present. Proponents of this approach suggest that measures of how much vegetation is left are better predictors of **plant** and soil response to defoliation than measures of how much vegetation has been removed Plant regrowth and soil erosion are influenced more by how much plant material is present than by how much has been removed (Bement 1969; Hyder 1954).

Plant biomass is typically expressed as plant weight per unit area, such as pounds per acre or kilograms per hectare. The most accurate method of measuring biomass involves clipping and weighing plant biomass in plots no larger than a square meter. For herbaceous vegetation, the biomass is clipped at ground level, dried, and weighed. Woody biomass is more difficult to measure because it is difficult to distinguish the current year's growth from the growth of previous years. Cook and Stubbendieck (1986) discuss various methods of woody biomass measurement. Less accurate methods of measuring herbaceous biomass involve visual estimates calibrated with a ranking procedure, double sampling, or height-weight relationships (Cook and Stubbendieck 1986). Comparative yield uses three to five classes (ranks) of standing biomass as standards to judge the amount of biomass on the monitored site. The ranks are established in areas adjacent to the monitored site. After biomass on the monitored site has been ranked, 15 or more plots adjacent to the monitored site are ranked and clipped to establish the relationship between the ranks and the amount of biomass (Haydock and Shaw 1975). Double sampling involves clipping and weighing samples taken at ap proximately 10 percent of the sample plots to calibrate the visual estimates made for the remaining plots. Unlike the comparative yield method, double sampling requires clipping in the monitored area. Height-weight equations can be developed to estimate the amount of biomass present when individual plants or vegetation is a certain height. Photo guides that depict the relationship between plant height and biomass have also been developed. Because this height-weight approach focuses on individual plants, it is most applicable in bunchgrass vegetation where individual plants are easily distinguished. It is less applicable in the sod-forming vegetation found in many mountain meadows.

Although ranking, double-sampling, and height-weight relationships are less accurate measures than clipping and weighing vegetation on every plot, these techniques can be performed more quickly.

Species composition (or vegetation composition) describes the proportion of vegetation contributed by each species. That proportion may represent density, cover, biomass, or frequency (Bonham 1989). Density is the number of individuals of a species per surface area. Cover can be expressed as basal or foliar cover. Basal cover is the amount of ground surface area covered by the base of plants. Foliar cover is the amount of ground surface with foliage above it. Biomass is typically the amount of aboveground live biomass. Frequency is the proportion of sample plots that contain at least one individual of a species.

Density is the most time consuming and difficult parameter to measure because every individual in the sample plot must be counted. In addition, individuals can be difficult to distinguish from clumps of individuals when rhizomatous or stoloniferous plants are present. Density is rarely used to monitor species composition because of these problems.

Cover measurements can be used to describe species composition or to estimate the ground cover of plants and plant litter as measures of soil erosion potential. The more common techniques to measure cover are line intercept, point intercept, and visual estimates of cover in plots (Bonham 1989). The line intercept technique involves determining the proportion of a length of tape (usually at least 100 feet) that has foliar or basal cover intercepting it. The point intercept technique uses either point frames, where metal pins are pushed through a frame and into the vegetation, or single pins that are pushed through the vegetation. The proportion of pins that strike foliar or basal cover is the basis for the cover estimate. Visual estimates are strictly subjective estimates of the amount of the plot covered by any or all species. Visual estimates are the least accurate and the least repeatable, but the most rapid. Point intercept using a point frame is the most time consuming and precise method, it is most accurate in dense herbaceous vegetation, but not necessarily in other types of vegetation. Isolated points are not as repeatable as point frames, but they are quicker and can be more easily used in conjunction with plots. Line intercept is the most accurate technique for measuring composition and ground cover in sparse vegetation. However, line intercept is less precise than point intercepts using a point frame.

In situations where cover is used to compare species composition in grazed and ungrazed sites, basal cover should be measured; foliar cover only reflects short-term changes in biomass following defoliation. Basal cover reflects long-lasting changes in plant size and the area of ground covered by plants.

Techniques to measure biomass are described in the previous discussion on measures of defoliation. The biomass of each species must be measured to describe species composition. Because it takes so much time to assign biomass values for each species, biomass is not commonly used to monitor species composition.

Frequency is a rapid and repeatable method of describing species composition changes by assigning an occurrence value for a species. Frequency is measured by listing all the species present in each plot. The frequency of a species is the proportion of all plots where it was present. The frequency value should be repeatable because field personnel only have to identify plants; they do not have to estimate the amount of each species in the plot. However, because the abundance of each species is not measured, frequency is not an absolute measure of species abundance. Because it does not measure the absolute abundance of species, frequency has little utility as a diagnostic parameter in research situations. Therefore, frequency should not be used to compare the abundance of species between sites, but can be used to compare changes in the frequency of a species between sampling dates within a site.

In summary, basal cover and frequency are the most common and appropriate parameters used to monitor species composition because they are relatively rapid and repeatable. Frequency is a popular monitoring parameter for composition because it is very rapid and repeatable; however, it has very little utility beyond monitoring changes for individual species over time. Basal cover is rapidly measured with line intercept, and it can be used as a measure of total plant ground cover or litter cover when monitoring soil erosion. However, in areas of dense vegetation, point intercept using a point frame or isolated points would be more applicable. Isolated points have the advantage of rapidity and can be combined more easily with plots that are used to measure biomass for defoliation monitoring.

Photographs can be used to monitor soil erosion, plant biomass remaining after defoliation, and some aspects of species composition, such as the changes in the abundance of woody or large herbaceous species when documenting gullying and other dramatic types of soil erosion (McClaran 19891. Photographs taken from the same location at different times (repeat photography) do not describe conditions quantitatively, but they can provide dramatic visual descriptions (Rogers and others 19841.

Where Should Monitoring Occur?- Ideally, monitoring should take place in areas representing a spectrum of different levels of impact severity and packstock use. This spectrum would include areas that are not used by packstock, as well as lightly, moderately, and heavily used areas. Unfortunately, there are rarely enough time and personnel to monitor the number of areas needed to represent a spectrum of impact levels. Therefore, monitoring is typically done in areas where impacts are greater than average, or where changes in packstock management have occurred recently.

Traditionally, production livestock impacts are monitored on “key areas” that represent the impact levels for an entire area (Holechek 1988). These “key areas” are located away from sites of livestock concentration such as corrals and livestock drinking water developments, but not so distant that they -underrepresent the general impact level for the area. Packstock impacts to soil erosion, defoliation, and species composition also tend to be concentrated at corrals, small pastures, streambanks, and near camps. However, it may not be appropriate to exclude these areas in the monitoring scheme. For example, a goal of packstock management may be to prevent serious impacts from spreading beyond the areas where they already exist. If so, the monitoring plots might be located along a transect crossing the area of concentrated impacts, with its beginning and end in adjacent, less-impacted areas. This scheme would provide monitoring information documenting changes in the extent of impact, as well as changes in the severity of impacts.

When Should Monitoring Occur? -Consistency and seasonal changes are important considerations in determining when to monitor. Consistency is the most important consideration. Monitoring should occur at the same time(s) each year so comparisons between years are not confounded by seasonal differences. For example, basal cover will change during the growing season; therefore, differences in basal cover would be expected between years if the measurements were taken at different seasons.

Some parameters are difficult to measure during certain seasons. For example, species composition should be monitored when plants are mature enough to be identified. Grasses and sedges are particularly difficult to identify without flowering parts. The timing of species composition monitoring can be flexible if the management concerns are focused at a more general level, such as gross categories of grasses, sedges, forbs, and woody species. If soil compaction or the basal cover of plants are being monitored to evaluate the potential for soil erosion, the best time for monitoring would be when overland flow of water was most likely. In mountain meadows overland flow is most likely during spring snowmelt. However, soil compaction and basal cover of plants can be monitored later in the season after grazing has begun.

How Much Monitoring Is Needed?- The intensity of monitoring needed for a single location depends on the level of precision desired. Precision reflects variability around the average that was measured (Bonham 1989). It is usually expressed as the standard error or standard deviation. Increasing the precision of measurements increases the confidence in conclusions that differences between measurements taken at different times on the same site represent real change or just sampling error. Precision is a function of the number of measurements, or sample size, the variability of the parameter being measured, and the measurement techniques employed.

Precision increases asymptotically as sample size increases. For example, the standard error for a given average value will decrease rapidly as the sample size increases by 10 plots when the sample size is between one and 30 plots, but the precision increases much less when the sample size increases by 10 plots when the sample size is between 200 and 300 plots. If the measured parameter is randomly distributed throughout the monitoring site, then the variability between plots is low and the potential for increasing precision with increased samples is great. But if the distribution of the measured parameter is patchy, then the variability between plots is high and the potential for increasing precision with increased samples is low. In most cases, sample sizes between 100 and 200 per site should be the goal for monitoring. For example, between 100 and 200 plots per site should be used to measure plant cover, uneaten plant biomass, soil compaction, or species composition.

How Frequently Should Monitoring Occurl- The frequency of monitoring should reflect the dynamics of the parameter being measured and the frequency of management decisions. If the parameter can exhibit dramatic and important responses to packstock management within a month, the ideal frequency of monitoring would be monthly. But if the parameter is slow to respond to changes in packstock management, there is little reason for frequent monitoring. For example, the amount of uneaten plant biomass will change witbin a season and between years. It should be monitored at least every year. Although species composition will change within a season, lasting changes require several years. Therefore, species composition monitoring should occur every 3 to 5 years.

The frequency of management decisions will also determine the frequency of monitoring. For example, if the decision to allow grazing in an area is determined by the amount of plant biomass present at the start of every month, monthly monitoring is necessary.

What Type of Monitoring Will the Budget Allow? -Budget constraints can prevent the best-designed monitoring system from meeting its objective. Therefore, monitoring must be addressed in the context of budget constraints. Time constraints demand the consideration of tradeoffs: monitoring speed or accuracy, few sites or extensive information; appropriate seasons or seasons when measurements can be made easily; frequent or opportunistic measurements; and precision or error. In addition, not all employees are equally skilled at monitoring. It will cost more to use personnel trained in more sophisticated monitoring procedures than personnel with less training, such as backcountry rangers and trail crews, who may be performing other duties in the monitored areas.

Example of a Monitoring System

The following monitoring system is designed for wilderness areas that have little opportunity to expand their budget to pay for monitoring. The description is not overly detailed because it will need to be tailored for specific situations. But this basic skeleton should provide some guidance to packstock managers. This system will monitor packstock impacts that could lead to soil erosion, plant biomass remaining after defoliation, and species composition. The potential for soil erosion will be monitored indirectly by measuring total basal cover of vegetation and plant litter. Basal cover will be measured with isolated points. Plant biomass remaining after defoliation will be monitored directly by measuring residual biomass with the comparative yield technique. Species composition will be monitored directly by measuring the basal cover of species using isolated points. The isolated points and plots will be combined to save time by using plot frames that have a pin-point on one side. In addition, repeat photography (pictures taken from the ends of the transect) will be used to document conditions in the sampling area and to document isolated impacts, such as eroding streambanks and dust-bathing areas.

Areas that are most heavily impacted by packstock, such as small pastures and areas near camps, will be monitored. Sampling will be done along permanently marked transects that pass through the most heavily impacted areas, but begin and end well beyond the heavily impacted areas. Information for individual plots must be recorded separately to document changes in the extent of impact as well as changes in the severity of impact.

Monitoring will occur about 1 month before the end of the growing season or as close to then as personnel are available. At this time of year, significant impacts to basal cover and remaining plant biomass will have occurred, but they will not be as great as at the end of the growing season. Monitoring before the end of the growing season provides the opportunity to change packstock management while plant regrowth is still possible. Some plants may be difficult to identify at this time because some plant parts may not have completely developed or may have been eaten. As a result, species may need to be lumped into generic or familial groups, such as grasses, sedges, and composites.

Annual monitoring will measure plant and litter basal area and the amount of residual plant biomass; monitoring every 3 to 5 years will measure species basal cover. This approach will address the yearly dynamics of basal area and plant biomass, as well as the longer term dynamics of species composition.

Monitoring intensity will be from 100 to 200 points per site for plant, litter, and species basal area, and from 100 to 200 plots per site for residual plant biomass. The number of points and plots for plant and litter cover and plant biomass should take two people no more than half a day to complete. The number of points for species cover should take two people no more than 1 day to complete.

Existing backcountry personnel should be able to implement the majority of this monitoring with minimal training or with the assistance of a specially trained person. The existing backcountry personnel would need annual preseason training in plant and litter basal area measurement and the comparative yield technique for plant biomass. Personnel trained in plant identification will be needed for species basal area measurement. Species basal area is monitored every 3 to 5 years, but personnel trained in plant identification could work for short periods each year if the sampling efforts were staggered among sites.

To foster communication among user groups and the managing agency, all monitoring efforts should include user-group members. This shared monitoring experience can build positive relations among groups that otherwise might have little in common and can strengthen their respect for the agency. In addition, when agency officials work with user groups on monitoring programs, they can discuss needed management changes.

Judging the Results of Monitoring

Monitoring results can be used to evaluate whether packstock impacts are within acceptable limits. The criteria used to judge acceptability should identify the type and amount of change that is acceptable. The type of change refers to specific impacts, such as soil erosion or species composition. The amount of change refers to the amount that will require changes in management to limit further change. These criteria will be difficult to define because there is little agreement about the baseline against which change should be measured or the amount of impact that would be unacceptable. Unacceptable impacts are not perceived equally among wilderness managers (Moore and McClaran 19911, between wilderness managers and users (Martin and others 1989; Peterson 1974)) or among wilderness users (Stankey and McCool 1984). Therefore, the criteria in this discussion should only be used as starting points when interdisciplinary planning team members and the public develop limits of acceptable change (Stankey and others 1985).

Criteria used to evaluate production livestock impacts are presented as examples because packstock criteria have not been widely developed. Both wilderness and production livestock managers are concerned about resource degradation. However, production livestock managers are more concerned about declines in production (Holechek and others 1989), while wilderness managers are more concerned about declines in naturalness (Cole 1989a). The perception of degradation will differ between typical production livestock management and wilderness management, even though livestock production is an accepted nonconforming use in wilderness (McClaran 1990). Therefore, criteria used for judging production livestock impacts should not be ap plied blindly to packstock impacts in wilderness.

One possible management goal would be to prevent deterioration of existing conditions. In this case, a monitoring system should be designed to detect changes in the severity and extent of impacts over time. Any substantial increase in impact would signal the need for more intensive management.

Another possible goal is to prevent deviation from natural conditions; this raises the difficult issue of defining natural conditions. One possible definition of natural could be: conditions existing in areas that are not impacted by packstock. The amount of change would be assessed as the deviation from ungrazed conditions. Monitored sites would have to be established in grazed areas and in ungrazed areas nearby that have similar soils, slopes, and other physical features. Both grazed and ungrazed areas would be monitored because grazing by wildlife and unusual weather patterns can influence species composition, residual biomass, and plant cover in ungrazed areas: These background dynamics should be considered when evaluating the naturalness of grazed areas (McClaran 1989).

The amount of change needed to identify degradation or loss of naturalness is subjective. A monitoring program with large sample sixes will easily detect changes in conditions, but the degree of degradation or loss of naturalness is not always clear.

Criteria have been developed for production livestock based on residual biomass that should result in long-term maintenance of plant production. These estimates are based on a plant's ability to regrow, biomass decomposition rates, and soil erosion. In Sierra Nevada meadows, estimates of the minimum amount of residual plant biomass were based on decomposition rates (Ratliff and others 1987). Because decomposition rates and total plant production varied with elevation and meadow type, minimum residual plant biomass was described for wet, mesic, and dry meadows at 2,000-foot intervals of elevation. For riparian areas in the Intermountain West, Clary and Webster (1989) presented minimum residual plant height values that would maintain streambank stability for three types of riparian areas. In the riparian type with the greatest streambank instability, they recommended a minimum plant height of 4 to 6 inches. Most production livestock criteria for amount of defoliation are expressed as percent utilization rather than residual biomass. These values vary from 20 to 30 percent use of key forage species in Alpine Tundra to 50 to 60 percent use in the Southern Pine Forest and Eastern Deciduous Forest (Holechek 1988). In general, the percent of allowable use increases with average annual precipitation, except for Alpine Tundra which has a very short growing season.

The criteria for acceptable levels of change in species composition resulting from livestock grazing have been developed based on deviation from climax vegetation composition or desired vegetation composition. This approach is often referred to as evaluating range condition. Traditionally, range condition is expressed in four categories representing increasing departure from climax composition: excellent, good, fair, and poor (Dyksterhuis 1949). Critics of this approach have proposed using departure from a desired composition as a criterion because the climax composition is not always the desired composition (Range Inventory and Standardization Committee 1983). They also note that vegetation composition does not always respond to changes in livestock management (We&by and others 1989). The climax vegetation may not always be known or obtainable because of poor records and introduced plant species (Smith 1989). Currently, the Forest Service and Bureau of Land Management use departure from potential natural vegetation composition to evaluate range condition (Moir 1989; Wagoner 1989). Although this approach recognizes the introduction of new species to an area, it assumes that changes in composition due to high livestock grazing pressure can be reversed if livestock pressure is decreased.

In light of the ongoing debate concerning range condition, packstock managers should be cautious about using departure from climax or potential natural vegetation composition to assess packstock impacts. In addition, these debates should warn the packstock manager not to use existing vegetation composition as a barometer of current packstock impacts. Existing composition may be the result of past livestock and packstock grazing pressure, rather than a result of grazing at current levels of use. In addition, reducing or eliminating packstock may not change vegetation composition. Therefore, in the best cases, packstock management may be able to prevent an undesired change in composition, but may not be able to bring about a desired change in composition.

Finally, a monitoring program has value, even in the absence of criteria for evaluating impact levels. As monitoring records the status and dynamics of packstock impacts, the criteria that eventually are established will be less subjective. However, the goals of wilderness management must be considered during the design of the monitoring program. For example, if departure from naturalness is the criterion of acceptability, ungrazed areas should be included among the sites being monitored.

Summary

Wilderness management goals, significant indicators of impact, and time and budgetary constraints all dictate the type of monitoring system that will be used. If preventing a change in naturalness is a goal, then both grazed and ungrazed areas need to be monitored. Because subjectivity is unavoidable in establishing acceptability criteria, interdisciplinary teams and the public should work together to establish them. Criteria do not have to be established before instituting a monitoring program.

PACKSTOCK MANAGEMENT TECHNIQUES

A wide variety of strategies are available for keeping the impacts of recreational packstock impacts within acceptable limits (Cole and others 1987). We have organized management techniques based on whether they control: (1) how much, (2) when, (3) what type, or (4) where packstock use occurs (table 4). The prevalence of each of these techniques was assessed in the mailback questionnaire. In addition, we

Table 4 -Sources of packstock impact and management techniques to control packstock impact

Source	Management technique
Amount of use	Number of animals Length of stay Number of parties
Timing of use	Season of use (opening dates)
Behavioral aspects of use	Party size Pack in feed Stay on trails No loose-herding No tying to trees Use hitchlines Hobble stock Do not picket stock
Location of use	Use designated campsites Camp away from water Provide facilities

comment on advantages and disadvantages of each technique and provide tips for implementation.

Once a particular strategy has been selected, it can be implemented in a variety of ways, from strict enforcement of regulations to attempts to obtain voluntary compliance through education. Some have suggested that regulations should be used as a last resort (Lucas 1982, 1983) and applied at the minimum levels (Hendee and others 1990) necessary to achieve wilderness management objectives because regulations infringe on the visitor's wilderness experience. Therefore, visitor education programs are often recommended as the initial management response to prevent or control unacceptable impacts. Others suggest that it is more equitable to institute regulations before problems become severe (Dustin and McAvoy 1984).

Agencies vary in their propensity to apply regulations (Bury and Fish 1980; Fish and Bury 1981; Washburne and Cole 1983). In particular, managers of National Park Service wilderness areas have been more inclined to apply regulations than managers of Forest Service wilderness areas. Forest Service managers generally prefer to promote educational programs initially. The result is that National Park Service managers often apply regulations to prevent serious wilderness impacts, while Forest Service managers often resort to regulations only after impacts exceed acceptable levels. The managers we surveyed were asked whether strategies were implemented through regulations or through less restrictive guidelines.

Table 5- Wilderness areas that regulate overnight packstock use and those that require permits for entry

Agency and region	Have regulations	Require permits
	-------- *Percent* -------	
Agency		
Forest Service (N = 174)	57	9
Park Service (N= 11)	91	73
Bureau of Land Management (N-8)	13	14
Fish and Wildlife Service (N=2)	50	0
Region		
Southeast (N=6)	67	17
Midwest (N= 16)	31	0
Rocky Mountains (N= 101)	55	7
Pacific (N = 68)	65	22
Alaska and Hawaii (N=4)	50	25
All units (N= 195)	57	13

Presence of Packstock Use Regulations

Packstock use was regulated in 57 percent of the wilderness areas with packstock use (table 5). Virtually all National Park Service areas had some regulations; about half of the Forest Service and Fish and Wildlife Service areas had regulations; and only one of eight Bureau of Land Management areas had regulations. Between 50 and 67 percent of the areas in all regions had regulations, except for the Midwest, where only about one-third of the areas had regulations.

The finding that regulations *were* most common in National Park Service areas corroborates findings from earlier surveys (Fish and Bury 1981; Washburne and Cole 1983). Overall, the proportion of wilderness areas with packstock use that had regulations was less than the 69 percent reported in 1980 (Washburne and Cole 1983).

Only 13 percent of all wilderness areas with packstock use required permits for entry (table 5). Permit requirements are not necessarily part of a use-rationing program. Many wilderness areas required permits for other reasons, such as to count or locate visitors, or to distribute educational materials. The National Park Service was the agency most likely to require permits. The Fish and Wildlife Service did not require permits anywhere. Permits were seldom required in the Rocky Mountain region and never in the Midwest.

Techniques for Controlling the Level of Packstock Use

The three primary means of controlling the amount of packstock use are limiting the number of packstock that can visit during the year, limiting the number of groups with packstock, or limiting the length of time any packstock group can stay in the wilderness. Regulations limiting the length of stay were most common (table 6). Over half of all areas had regulations or guidelines limiting the length of stay. Where managers attempted to limit the length of stay, the limit was more likely to be a regulation than a guideline. Limits on the number of packstock or packstock parties were only common in National Park Service areas. This strategy was most common in the Southeast region, where one in six areas

Table 6- Use of regulations (Regs) or guidelines (Guides) to manage the amount and season of packstock use

Agency and region	Number of animals (Regs)	Number of parties (Regs)	Length of stay		Season of use	
			Regs	Guides	Regs	Guides
	percent					
Agency						
Forest Service (N = 172)	4	2	35	16	3	12
Park Service (N= 11)	27	30	82	0	27	0
Bureau of Land Management (N=7)	0	0	0	25	0	0
Fish and Wildlife Service (N=2)	0	0	50	0	50	0
Region						
Southeast (N=6)	17	0	50	0	0	0
Midwest (N = 16)	0	0	13	13	0	0
Rocky Mountains (N = 99)	5	2	41	15	1	10
Pacific (N = 67)	6	6	34	18	12	16
Alaska and Hawaii (N=4)	0	0	0	0	25	0
All units (N = 192)	5	3	37	15	5	11

limited the number of animals and half of the areas limited the length of stay. Areas in the Midwest region, and in the Alaska and Hawaii regions were the least likely to employ these strategies.

Length-of-stay limits are often implemented to prevent people from "homesteading" a campsite, rather than to limit the amount of use. Most wilderness visits are for only a few days, and most regulations limit stays to no more than a couple of weeks. So stay limits often have little influence on the amount of use in most areas. Since few areas set any other limits on use, the strategy of limiting the amount of use is rarely used, except in National Park Service areas.

The rarity of limits on the amount of packstock use may reflect the advice to use regulations as a last resort (Hendee and others 1990; Lucas 1982, 1983). More likely, however, either use limits are unnecessary, managers do not have the expertise to develop the limits, or the political resistance to limits is high. Cole (1990a) has suggested that wlderness-wide limits on number4 of packstock are likely to be unnecessary or ineffective. In most wilderness areas, unacceptable grazing impacts occur in a relatively small number of places. Limits are needed only in those places. Moreover, even with a wilderness-wide limit on number of packstock, these popular places can still be overgrazed. As will be discussed later, regulations limiting numbers of packstock are usually applied only in specific locations within the wilderness.

Techniques for Controlling When Packstock Use Occurs

In general, managers rarely limited the season of use to control packstock impacts (table 6). In the few cases where Forest Service managers addressed season of use, they tended to employ guidelines rather than regulations. The National Park Service and Fish and Wildlife Service areas were more likely to prohibit use during certain seasons; when they did so, they relied exclusively on regulations. None of the Bureau of Land Management areas regulated Season of use. Such regulations were most common in the Pacific region and in the Alaska and Hawaii regions. A few Rocky Mountain areas had regulations, but most used guidelines. The likelihood that wilderness areas with packstock use regulate season of use has not changed significantly since 1980 (Washburne and Cole 1983).

Limiting the season of packstock use addresses the concern that early spring and summer grazing can cause excessive soil compaction and erosion, and reduced plant vigor (Cole 1990a; Heady 1975). Restricting early season use can be extremely beneficial in mountain meadows. Soils are saturated during snowmelt there and plants are growing rapidly. Mangers have limited the season of use of production livestock since the early part of this century (Jardine and Anderson 1919). This survey shows that managers generally have not limited the season of use for packstock in wilderness. This is unfortunate, given the high potential season-of-use restrictions offer for reducing impact. Controlling season of use in arid areas is less of a concern because arid soils are less prone to become water logged. Therefore, it is logical that the Bureau of Land Management has no restrictions on season of use in the generally arid wilderness areas that it administers.

Techniques for Controlling the Type of Packstock Use

Visitor behavior influences the type and amount of impact caused by packstock groups. For example, if visitors regularly tie packstock to trees in campsites, more roots will be exposed and many trees will become diseased and die. Fewer trees would be damaged if visitors tied horses to hit&lines fastened between trees instead of to the trees themselves. Managers were asked about the following regulations or guidelines that either encourage low-impact behavior or discourage high-impact behavior: limiting party size, requiring feed to be packed in for stock, encouraging riders to stay on trails, restricting loose-herding of stock on trails (encouraging packstock users to tie animals together when they are on the trail), restricting the practice of tying stock to trees, encouraging the use of hitchlines (as an alternative to tying horses to trees), restricting the practice of picketing stock (picketing involves tethering animals to portable stakes), and encouraging the hobbling of stock (binding two of their legs together as an alternative to picketing).

All of these behaviors, except "do not picket stock, were either required or recommended in a majority of wilderness areas with stock use. The most common desired behaviors were 'no tying to trees," "use hitchlines," and "pack in feed" (table 7). All of these behaviors were recommended much more often than they were required. However, party-size regulations were required more frequently than they were recommended.

Forest Service and National Park Service managers tended to be equally likely to implement each of these techniques, except "hobble stock" and "do not picket stock." Forest Service managers were more likely to recommend that stock be hobbled than Park Service managers; Park Service managers were more likely to prohibit stock from being picketed than Forest Service managers.

The Park Service was much more likely to rely on regulations when implementing these policies. None of these behaviors was regulated in a majority of Forest Service wilderness areas. Only party-size limits were regulated more frequently than they were recommended. In contrast, all of these behaviors except "hobble stock" and "do not picket stock" were regulated in a majority of Park Service wilderness areas. Even in the case of picketing, Park Service areas were more likely to rely on regulations than recommendations.

Since 1980, the frequency of regulations limiting party size and governing the use of various methods of restraining packstock have changed little (Washburne and Cole 1983); however, the proportion of areas that require parties to carry feed for their packstock has declined from 29 percent in 1980 to 17 percent in 1990.

All of these behaviors have been suggested as potential means of reducing packstock impacts (Cole 1989c). If visitors would comply with these regulations or guidelines, impacts associated with packstock use could be reduced substantially without reducing the amount of use. Of these behaviors, limits on party size may have the least effect on physical impacts. Party-size limits are likely to be most effective where physical impacts are likely to occur quickly (Cole and others 1987). Because most impacts occur with the initial use in such areas, subsequent use isn't as important. Party-size limits may be more important to avoid conflict with backpacking groups. Such groups particularly dislike encountering large parties with stock (Stankey 1979).

Carrying feed (typically grains, occasionally hay) will maintain animal weight and vigor, reducing the demand for wild forage (Elser and Brown 1980). Stock will still trample areas, but feed can reduce the impacts associated with grazing. A point of diminishing returns can be reached on extended trips when additional animals are required to carry more feed. In addition, concerns about feed being contaminated by seed of weedy and invasive plants has led to suggestions that only certified weed-free feed be allowed in wilderness (Cole 1983,1989c).

Restricting packstock to existing trails and prohibiting loose-herding is important in preventing the destruction of existing trails, the development of ulations (Regs) or guidelines (Guides) to manage behavioral aspects of packstock use

	Party size		Pack in feed		Stay on trails		No loose-herding		No tying to trees		Use hitchlines		Hobble stock		Do not picket stock	
	Regs	Guides	Regs	Guides	Regs	Guides	Regs	Guides	Regs	Guides	Regs	Guides	Regs	Guides	Regs	Guides
	Percent															
	44	35	15	67	8	53	17	53	27	69	16	71	8	70	8	37
	73	0	55	36	91	0	82	0	73	9	64	9	9	27	36	27
	0	43	0	86	14	0	0	29	14	71	0	29	0	71	0	43
	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0
	17	17	17	67	67	17	33	50	50	33	33	50	17	50	17	50
	31	50	0	69	13	44	13	50	31	69	31	63	6	56	0	50
	46	30	20	64	6	48	19	49	25	70	11	70	6	67	7	29
	46	36	16	69	16	54	22	49	33	63	24	64	9	75	13	43
	0	0	0	25	25	0	25	0	25	0	0	0	0	25	25	0
	43	33	17	65	13	48	20	48	29	65	18	65	7	67	9	36

new trails, and in preventing visitor conflicts caused by runaway animals (Cole 1989c). Appropriate methods for restraining packstock can prevent damage to trees and soils, and minimize grazing impacts. Particularly in camp settings, tree damage can be prevented by tying animals to a hitchline rather than directly to trees. Soil disturbance can be minimized by placing the hitchline on level sites with thin soil or no soil (Cole 1989c). Picketing and hobbling limit the movement of animals while they are grazing. The use of these techniques is often a matter of preference and may depend on whether animals are experienced with one method or the other (Elser and Brown 1980). Picketing eliminates problems of wandering animals, but the stakes must be moved regularly to prevent localized impacts. Hobbling disperses grazing impacts, but can cause problems for parties with inexperienced animals that can become injured and with experienced animals that head home despite the hobbles.

Techniques for Controlling Where Packstock Use Occurs

Our survey explored three techniques for controlling where pa&stock use occurs. These include attempts to prohibit camping within a certain distance of water, to confine stock to specially designated packstock campsites, and to provide facilities to confine stock and their impacts (table 8). Of these actions, restrictions against camping close to water were most common; 40 percent of areas with packstock had regulations prohibiting camping close to water and another 53 percent discouraged camping close to water. The most commonly recommended setback distance was 100 feet, although 200 feet was nearly as common. This regulation was found only in National Forest and National Park Service wildernesses. It was most common in National Park Service wildernesses.

Table 8 -Management techniques for controlling where packstock use occurs

Agency and region	Camp away from water	Designated packstock sites only	Provide hitchracks	Provide pastures/corrals	Provide drift fences	Provide stock water developments
	------------------------------			Percent	------------------------------	
Agency						
Forest Service (N = 170)	40	8	18	19	12	12
Park Service (N= 11)	71	45	64	27	27	18
Bureau of Land Management (N=8)	0	0	0	13	0	13
Fish and Wildlife Service (N=2)	0	0	0	0	0	0
Region						
Southeast (N=6)	33	0	0	0	0	0
Midwest (N = 16)	26	0	19	0	0	6
Rocky Mountains (N = 98)	36	7	19	22	10	17
Pacific (N = 67)	51	12	21	18	19	6
Alaska and Hawaii (N=4)	0	25	50	25	0	25
All units (N = 191)	40	9	20	18	12	12

Restricting packstock parties to designated sites was much less common. This regulation was found in 45 percent of National Park Service wildernesses, but in relatively few National Forest areas (8 percent) and in no areas managed by other agencies (table 8). Facilities are another means of attracting visitors to a relatively small number of sites that can be located at places resistant to the impacts of packstock. About 20 percent of wilderness areas with packstock use provided some type of facility for containing or watering packstock (table 8). The Park Service provided facilities much more frequently than other agencies. Hitchracks were the most common facility in Park Service wildernesses; they were provided in 64 percent of Park Service areas with packstock use. Hitchracks and pastures or corrals were equally common in National Forest and Park Service areas; drift fences and water developments were less common in National Forest areas. The popularity of stock containment facilities varied between regions; hitchracks were the primary facility in the Midwest region, and in the Alaska and Hawaii regions; drift fences were most common in the Pacific region.

Concentrating use on durable sites is one of the most time honored approaches to impact management. In wilderness, however, both provision of facilities and attempts to "confine" use are generally considered inconsistent with management goals. This appears to have made the provision of facilities to reduce packstock impacts unpopular, except in National Parks.

The impacts of packstock on visitors are usually concentrated at popular places in wilderness, often near campsites and along trails in particularly scenic or accessible areas. For example, in the Eagle Cap Wilderness in Oregon, Cole (1981) estimated that grazing impacts were confined to less than 2 percent of the entire wilderness area-and the impacts were severe only on a fraction of that 2 percent. Therefore, wilderness-wide application of regulations may not be required, and may unnecessarily infringe on the visitor's wilderness experience (Cole and others 1987). The site-specific application of regulations is indicative of management targeting specific problem situations.

However, most regulations were applied across an entire wilderness, rather than in the specific places where problems were severe or likely to become so (table 9). Of the 14 types of regulations studied, only four generally applied to specific areas rather than the entire wilderness: limits on numbers of packstock, limits on numbers of packstock parties, limits on season of use, and requirements to camp in designated stock sites. These include the two most direct means of limiting the amount of use, the only means of controlling season of use, and one of the means of influencing where use occurs.

The Forest Service was more likely than the Park Service to apply tactics for limiting the amount and

Table 9- The proportion of regulations that only apply in part of the wilderness

Agency and region	Number Of animals	Length of stay	Number of parties	Season of use	Party Size	Pack in feed	Stay on trails
	Percent						
Agency							
Forest Service	71	8	33	83	8	19	38
Park Service	100	50	100	100	25	50	30
Region							
Rocky Mountains	80	7	100	100	11	20	50
Pacific	75	23	50	87	10	38	38
All units	80	13	87	90	10	25	33

Agency and region	No loose-herding	No tying to trees	Use hitchlines	Hobble stock	Do not picket	Camp away from water	Designated packstock sites only
	Percent						
Agency							
Forest Service	3	9	7	38	50	11	75
Park Service	0	0	0	0	25	0	40
Region							
Rocky Mountains	0	12	18	**50**	43	14	100
Pacific	7	5	0		50	6	44
All units	3	7	8	38	44	10	65

season of use to the entire wilderness; the Forest Service was less likely than the Park Service to apply regulations of user behaviors and limits on where use occurs to the entire wilderness. Regional differences exhibited no obvious pattern.

It seems logical that regulations most limiting visitor freedom and access should be applied only where necessary (in a site-specific manner). Limits on numbers of animals and parties and on season of use are the packstock management actions most likely to interfere with freedom. These actions were the ones most frequently applied in a site-specific manner. This suggests that wilderness managers have adjusted their application of management techniques to minimize unnecessary visitor restrictions. For all three types of actions, the Park Service was more likely than the Forest Service to apply regulations only to a portion of the wilderness.

Summary

Wilderness managers used a wide variety of strategies and tactics for managing packstock. However, nearly half the wilderness areas with packstock had no regulations on their use. Even in those areas that regulated packstock, the only common regulations were limits on party size and length of stay; very few parties were affected by these regulations because the limits are often many times greater than the typical party size or trip length.

Managers of production livestock on public lands typically limit both the number of animals and season of use to avoid overgrazing and to avoid use when soils are particularly fragile. Despite the proven value of these approaches, they have seldom been used when managing pa&stock. Only in National Park Service areas have even a substantial minority of managers addressed this goal;

MANAGEMENT PROGRAM FORMULATION

When considering the adequacy of current packstock management programs, it is worthwhile considering the sources of information used to formulate these programs and managers' satisfaction with them. This suggests how programs are likely to change in the future and how new information might lead to improvement.

Methods Used To Formulate Regulations

We asked managers which of the following sources they used to formulate regulations: research, tradition, production livestock (cattle and sheep) standards, professional judgment, and public participation. The products and utility of research, professional judgment, and public participation are more obvious and familiar than tradition and production livestock standards. Tradition refers to the use of historical or ongoing packstock practices in developing new regulations. Production livestock standards refer to the use of existing information on appropriate stocking rate, season of use, and forage utilization to manage production livestock grazing.

Professional judgment was consistently the most common basis for regulations; research was the least common (table 10). The most frequent use of research was to set party-size limits; public participation was most commonly used to limit the number of packstock parties per season. The most frequent uses of tradition were for limiting the length of stay and party size. Production livestock standards were used most frequently to limit the season of use. The National Park Service tended to use all sources of information, except production livestock standards, more frequently than the Forest Service. Rocky Mountain areas tended to use all sources of information except production livestock standards more frequently than Pacific areas.

The general lack of information about packstock impacts and management (Cole 1990a) is indicated by managers' use of professional judgment and tradition rather than other sources of information when formulating regulations. The United States General Accounting Office (1989) suggested that a lack of information was hindering Forest Service management of wilderness. The infrequent use of public participation is unfortunate because public involvement is required for most public land-use decisions (Culhane 1981) and is fundamental to sound wilderness management (Hendee and others 19901. The infrequent use of research can be explained by the general absence of applicable research on the impacts of recreational packstock (Cole 1987). Tradition may have been used for establishing party size and length-of-stay regulations because of longstanding packstock practices of using a large number of animals per party and establishing base camps (Elser and Brown 1980). The infrequent use of production livestock standards is unfortunate because those standards could help managers develop packstock impact standards.

Satisfaction With Existing Regulations

To what extent were managers satisfied that existing packstock regulations were controlling ecological impacts? Responses to this question will vary with the severity of packstock impacts, the success of current management programs, and the managers' philosophy. Management philosophies can range from

Table 10 -Methods used to formulate packstock regulations

Regulation	Research	Tradition	Production livestock standards	Professional judgment	Public participation
	Percent				
			All wilderness units		
Party size (N = 83)	30	41	31	71	41
Season of use (N=9)	11	33	33	33.	11
Length of stay (N =71)	17	42	25	55	31
Total use (N= 10)	20	10	10	50	30
Number of parties (N= 6)	0	17	17	67	50
Five combined (N=l79)	22	39	27	61	35
			Forest Service		
Party size (N = 75)	31	40	31	68	40
Season of use (N= 6)	0	17	33	0	17
Length of stay (N= 61)	16	38	29	51	31
Total use (N=7)	0	0	0	43	14
Number of parties (N= 3)	0	0	0	67	33
Five combined (N = 152)	22	36	28	57	34
			Park Service		
Party size (N=8)	25	50	38	100	50
Season of use (N=3)	33	67	33	67	0
Length of stay (N=9)	22	78	11	89	33
Total use (N=3)	67	33	33	67	67
Number of parties (N=3)	67	0	33	33	67
Five combined (N = 26)	35	54	27	81	42

beliefs that regulations should only be used as a last resort to minimize infringing on wilderness experiences (Hendee and others 1990; Lucas 1982,1983) to beliefs that regulations should be instituted early, preventing inequitable use and access to wilderness (Dustin and McAvoy 1984; McAvoy and Dustin 1983).

and in about three-fourths of the Bureau of Land Management areas felt that current levels of regulation were appropriate. A majority of managers in National Park Service areas felt there were too few regulations; one manager felt there were too many. Only in the Pacific region did a majority of wilderness managers feel there were too few regulations;

Table 11- Proportion of wilderness units where managers feel the current level of regulations is appropriate, not enough, or too much to manage the current level of ecological impacts from packstock

Agency and region	Current level of regulation		
	Appropriate	Not enough	Too much
	----------	Percent	----------
Agency			
Forest Service (N= 173)	55	45	0
Park Service (N= 11)	36	55	9
Bureau of Land Management (N=8)	75	25	0
Fish and Wildlife Service (N=2)	50	50	0
Region			
Southeast (N=6)	67	33	0
'Midwest (N= 16)	61	19	0
Rocky Mountains (N=100)	57	43.	0
Pacific (N= 68)	46	53	1
Alaska and Hawaii (N=4)	50	50	0
All units (N= 194)	55	44	1

they found that National Park Service managers often used regulations to prevent impacts. In this study, nearly two-thirds of National Park Service managers were dissatisfied with the current level of regulations, but so were about half of all wilderness managers. These results suggest that impacts commonly exceed managers' standards of acceptability.

Summary

Current levels of packstock regulations are likely to change. Nearly half of all wilderness managers are dissatisfied with existing regulations; the information they are using to formulate regulations is meager at best. Professional judgment was the source of information used most often to formulate regulations. Research results, production livestock standards, and public participation were either underutilized or unavailable. Public participation should be used more often, both to meet legal requirements and to conform to wilderness management principles. Research results will be used more often only if more research is conducted to meet managers' needs. Production livestock standards can be used more often if range management knowledge and expertise are adapted for packstock management (Heady and Vaux 1969). Range management professionals can be found in nearly all Forest Service Ranger District and Bureau of Land Management Area offices; they should be included as members of interdisciplinary wilderness planning and management teams. University cooperative extension specialists in range management are also available in all Western States to assist wilderness managers. The use of production livestock standards will also increase if inservice range management training is developed for wilderness managers, and if academic training combining range and wilderness management through cooperative education programs is promoted.

Professional judgment will always be important in formulating regulations, but managers should use other information more often than they do now. Furthermore, the use of additional information from public participation, production livestock standards, and research will enhance the quality of professional judgment.

EXAMPLES OF EXISTING PACKSTOCK MANAGEMENT PLANS

Existing packstock management plans provide ideas for managers who are attempting to develop or revise such plans. We critiqued two plans to identify potential problems as well as areas for improvement. The examples are the Bob Marshall-Great Bear-Scapegoat Wildernesses Recreation Management Plan (USDA Forest Service 1987) and the Sequoia and Kings Canyon National Parks Stock Use and Meadow Management Plan (USDI National Park Service 1986). These plans are among the more comprehensive attempts to manage packstock impacts in wilderness settings.

Bob Marshall, Great Bear, and Scapegoat Wildernesses

The Bob Marshall, Great Bear, and Scapegoat Wildernesses form the 1.5-million-acre Bob Marshall Wilderness Complex in northwestern Montana. As in many Northern Rocky Mountain wildernesses, packstock use in the Bob Marshall complex accounts for a significant amount of the total visitation. Lucas (1985) estimated that nearly 40 percent of the total use in the complex was from packstock parties, and 17 percent of the packstock use was from commercial parties.

The complex used the LAC (Limits of Acceptable Change) planning process (Stankey and others 1985) to set impact standards; designate the spatial distribution of acceptable impacts; and describe the ap propriate management tools, implementation schemes, and monitoring procedures. All uses were addressed in this plan, including backpacking, packstock use, and aircraft use of a wilderness landing strip. The primary packstock management objective was to limit forage utilization to levels that would protect wilderness values and provide sufficient winter forage for wildlife. The plan was a joint effort of an interdisciplinary team of managers, researchers, and interested citizens.

The plan identified four opportunity classes that varied in their social, environmental, and management characteristics. The plan set limits for the number of encounters on trails per day, the number of camps within sight and sound per day, and the degree of risk and challenge available. It set guidelines for the number of contacts with administrative personnel, amount of rules and regulations, intensity of trail construction and maintenance, and the number of signs, administrative structures, and management facilities. It also set limits for campsite size, condition, and density; forage utilization, range condition and trend, and visual appearance of grazed areas; and forest vegetation changes. The four opportunity classes were organized along a gradient of impact severity based on their deviation from primitive conditions.

Production livestock impact standards were applied to the least primitive opportunity class; more stringent standards were applied to the more primitive opportunity classes. Forage utilization standards varied from 40 percent in the least primitive class to 20 percent in the most primitive class; range condition standards varied from generally good to excellent; range trend standards varied from improving to static orimproving; and visual appearance standards varied from moderately grazed to lightly grazed.

The plan will be implemented through the development of allotment management plans for all areas with packstock use. These plans will describe the packstock management practices permitted, based on the impact standards established for the applicable opportunity class. Educational information with suggested guidelines will be the implementation method of first choice in all opportunity classes, leaving regulations to be applied when needed. However, a 35-animal maximum party size regulation was set for the entire wilderness. Management strategies will vary by opportunity class. Limits on party size and closures of areas so they can recover from impacts (often rotating yearly or seasonally) should be more common in the more primitive opportunity classes; management facilities will be more common in the least primitive settings.

Monitoring procedures for packstock grazing impacts were taken directly from the Range Analysis Handbook for the Forest Service's Northern Region. Forage utilization estimates were based on the grazed plant method measuring the percent of all plants that were grazed. Range condition and trend estimates were based on deviations from the potential natural vegetation composition and biomass production, and the monitored changes in these parameters. Range condition was to be estimated every 5 years on each allotment. Forage utilization was to be estimated annually.

The designation of impact standards for each opportunity class and the establishment of grazing allotments provide definite direction and methods for managing packstock use in the Bob Marshall Wilderness Complex. The different management tools and implementation schemes used in the various opportunity classes will help address packstock management on a site-specific basis. However, the use of traditional range condition and utilization standards is not ideal since the relationship between packstock management and range condition improvement is unclear, as is the relationship between utilization and the potential for plant regrowth. Residual biomass standards may prove to be more representative of use levels and impacts, and produce more consistent values when different persons do the monitoring. Description of the desired vegetation composition rather than the potential natural vegetation would be more helpful in judging impacts and understanding how packstock management can affect vegetation composition. Finally, the lack of attention to soil characteristics (beyond range condition ratings) and the failure to restrict early season use are potential shortcomings. These omissions are significant because meadows are especially susceptible to erosion and trampling damage early in the growing season.

Sequoia and Kings Canyon National Parks

Sequoia and Kings Canyon National Parks cover over 850,000 acres in the southern Sierra Nevada in California. About 85 percent of the parks are federally designated wilderness. In 1989 packstock use accounted for only about 5 percent of overnight visitation. Commercial use represented 55 percent of the packstock use, administrative use represented 32 percent, and private use represented 13 percent.

The 1986 packstock management plan was an elaboration of a less specific treatment of packstock in the 1986 Backcountry Management Plan (USDI National Park Service 1986). In addition, the packstock management plan was used to organize a growing number of site-specific regulations and management practices into a single planning document (McClaran 19891. The plan was written by Park staff. Public input was sought throughout the process. One of the team members had training and professional experience in range management.

The primary packstock management objective was to protect the Parks' natural resources, ecological processes, and visitors' experiences by preventing or reversing erosion and adverse changes in vegetation composition. The plan emphasized maintaining the existing levels of packstock use and management except where impacts were unacceptable. Therefore, the plan did not use a formal zoning process similar to Opportunity Classes under LAC.

Wilderness-wide impact standards were established for changes in vegetation composition and bare ground. For the dominant herbaceous species and bare ground, the impact standard was that changes be comparable in grazed and ungrazed meadows. If the frequency of the dominant species decreased more than 15 percent or basal plant cover decreased more than 15 percent in the grazed meadow, and a similar change did not occur in the ungrazed meadow, packstock management would change. The impact standard for woody plants was an increase of more than 15 percent on any meadow.

Although the impact standards applied across the wildernesses, application of management tools was site specific. Specific opening dates for packstock grazing were established for all areas. These dates were based on more than 5 years of investigation of the date when stock hoofprints did not penetrate more than 1 inch of soil,% and the influence of yearly variations in snow levels on these dates. Each meadow had an opening date for normal, heavy, and light levels of winter snowfall. In many popular or sensitive areas, length-of-stay and party-size limits were more stringent than those applied elsewhere. Off-trail travel was limited to specific areas. Most existing drift fences and pasture fences were to be maintained, but new fences would only be approved after review. The only management tools with wilderness-wide application were campsite behaviors: tying to trees and camping less than 100 feet from water were prohibited; hitchlines were required.

Regulations were used to implement all management tools and practices. Permits were required for access, and information packets describing the regulations were included with the permit. Tentative opening dates were set after snow surveys in April. Final dates were set in May of each year. Most backcountry rangers were authorized to cite violators of any regulation. In addition, an educational program describing minimum-impact packstock practices was planned.

Packstock use was monitored with reporting cards users completed identifying the date, location, length of stay, and party size for every camp their party used. All packstock parties, whether private, commercial, or administrative, were required to complete reporting cards. Herbaceous species composition and bare ground were to be monitored every 3 years in sites receiving heavy use. The plan also provided for additional monitoring sites to be established if stock density exceeded 15 nights of use per acre over the summer grazing season. Permanent photograph stations were established in most meadows to monitor changes in woody species abundance and obvious changes in the amount of herbaceous vegetation or bare ground.

Vegetation composition and bare ground were compared in nearby grazed and ungrazed meadows to separate the impacts of grazing from the effects of other environmental changes in the area. A number of meadows were closed to packstock grazing to facilitate the comparisons and to provide ungrazed meadows for visitors. In most cases, closed meadows were not on maintained trails and had received little or no packstock use in previous decades.

The establishment of site-specific opening dates, and length-of-stay and party-size limits at Sequoia and Kings Canyon National Parks are good illustrations of matching management tools with management problems and goals. However, impact standards for vegetation composition and bare ground were the same in all areas, suggesting managers paid little attention to the spectrum of experiences that visitors may be seeking. However, the establishment of ungrazed meadows can provide some variety of experience. In addition, the impact standards do vary slightly from meadow to meadow because the composition of ungrazed meadows used for comparison varies. The absence of defoliation standards and the uniform overnight pa&stock-use capacity of 15 nights per acre are shortcomings. Defoliation is a major impact to individual plants and can lead to changes in vegetation composition. Also, most meadows would have been visited annually if defoliation had been monitored. A uniform capacity ignores the variety of biomass production and susceptibility to trampling damage among meadows: some meadows may require attention at low use and others only at high use. Finally, the reliance on regulations rather than education or guidelines can present enforcement and public relations problems. However, the public involvement established in the planning process and continued in the educational program has the potential to overcome these problems, especially if the public becomes involved in monitoring.

Summary

The goals of wilderness management are understanding conditions, setting acceptable impact limits, selecting appropriate management tools and implementation schemes, and monitoring the changes in conditions that represent management sucess (Cole 1990b; Hammitt and Cole 1987). Because packstock studies are so rare, managers must rely on production livestock information to begin to understand the nature of grazing impacts, impact standards, implementation schemes, and monitoring programs. Range management principles should be incorporated into the wilderness management process through interdisciplinary teams and inservice and cooperative education training. Existing production livestock standards for defoliation, changes in vegetation composition, and opening dates to restrict early season use provide models that could be adapted to packstock management. Monitoring procedures can be transferred from production livestock to packstock situations. Specific procedures should be developed to monitor the relationship between existing conditions and objectives established in the planning process. Finally, implementation schemes for packstock management should not follow the exclusively regulatory approach traditionally used for production livestock. Instead, the decision to rely on guidelines or regulations for implementation should be made on a site-specific basis.

RESEARCH TO IMPROVE PACKSTOCK MANAGEMENT

The management of packstock is limited by a depauperate research base (Cole 1987, 1989a). This may help explain why managers surveyed in this study used research results less often than other sources of information when formulating regulations. For management to benefit, future research must address the basic mechanisms of impact as well the ways in which packstock management techniques and implementation programs can be evaluated (Cole 1987). Research is needed on three fronts: (1) relationships between use and impacts, (2) relationships between packstock handling techniques and impacts, and (3) relationships between management programs and impacts.

Relationships Between Use and Impacts

Characteristics of packstock use that influence the amount of impact include the intensity and season of use, and the kind of pack animal. The important research questions are: How do impacts vary among use levels, seasons of use, and kinds of animals used? In addition, how do all these relationships vary among sites with different characteristics?

The relationship between use levels and impacts to vegetation and soils in campsite and trail settings has been described in some detail (Cole 1987). Similar information is absent for packstock grazing and is only roughly described for production livestock (Heitschmidt 1988). Do packstock impacts increase linearly or curvilinearly as use levels increase? Studies of patch grazing suggest that impacts will be significant, but localized, even at very low use levels (Ring and others 1985; Ruyle and others 1988; Wilms and others 1988). Research is needed to predict the impacts associated with various intensities of packstock use in different environments.

The relationship between season of use and impacts to soils and vegetation has not been described in much detail for campsites, trails, or grazing areas (Cole 1987). Opening dates for production livestock grazing are generally set on the basis of plant phenology and response to defoliation. Opening dates could also be set on the basis of soil vulnerability to compaction and shearing. A clearer understanding of the seasonal variability of the soil impacts would greatly enhance packstock management.

To date, there has been no objective comparison of vegetation and soil impacts among horses, mules, llamas, and goats. How much biomass is consumed by these animals, what are their diet preferences, and how do they impact soils? How does previous experience in a grazing location influence packstock behavior and resulting impacts? In unfamiliar environments, production livestock consume less forage and spend more time walking than in familiar environments (Provenza and Balph 1988). What influence does mixing packstock from different visitor parties have on impacts to vegetation and soils? Although Vallentine (1990) suggested that there will be no effect from mixing animals, no empirical evidence has described the influence of herd mixing on patch grazing patterns or soil impacts. Similarly, what influence do sequential changes in the packstock animals grazing in a meadow have on the patterns of forage consumption and trail development?

What makes one site more susceptible to packstock impacts than another? Clary and Webster (1989) and Ratliff and others (1987) recognized susceptibility depended on soil characteristics, elevation, species composition, and other parameters. Clearly, in mountain meadow and riparian settings, erodibility should be of paramount concern (Ellison 1949). Research that differentiates and classifies erodibility potential and the potential for species composition to change in the face of packstock use should be pursued.

Finally; studies of packstock impacts to wildlife, water quality, and other visitors are severely lacking. Studies similar to those for impacts to vegetation and soils should be pursued for impacts to wildlife, water quality, and other visitors.

Relationships Between Management Techniques and Impacts

To date, the lack of empirical information on the effect of packstock handling techniques on packstock impacts has meant that regulations and guidelines are primarily based on professional judgment (Cole 1989c; Cole and others 1987). More rigorous evaluation of various alternatives is needed. For example, what is the relationship between the length of stay and impacts? Does forage consumption or soil compaction decrease linearly or curvilinearly as the length of stay is reduced? Does patch grazing increase or decrease as party size is decreased, and what is the shape of the response curve? What is the relationship between the number of hit&racks and the extent of soil compaction? Similar questions regarding techniques of packstock restraints in camp or for grazing, season of use limitations, or other management techniques further illustrate the need for quantitative evaluations of management techniques.

Relationships Between Management Programs and Impacts

Implementation programs include the selection of acceptable impact levels, application of management techniques, and institution of a monitoring program.

Because acceptable impact levels define the major management objectives for all subsequent management actions, their selection must include public participation. This study revealed that public participation in the selection of packstock regulations was surprisingly low; however, wilderness planning efforts (USDA Forest Service 1991) will require more public input. The varying acceptance of packstock impacts among visitors, between visitors and managers, and among managers suggests that packstock management will benefit from research and development of educational systems and public participation processes that improve the understanding of issues and working relations among seemingly disparate viewpoints.

Debate over implementation programs for wilderness management has focused on regulations versus voluntary conformity (Bury and Fish 1980; Dustin and McAvoy 1984; Hendee and others 1990; Lucas 1982, 1983; McAvoy and Dustin 1983). Analysis of the effectiveness and cost of these divergent approaches is needed. It would be more beneficial, however, to enlarge the debate to include approaches between the poles of regulation and voluntary conformity. For example, how much would voluntary compliance improve if packstock organizations sponsored an educational program? This program might include a packstock enthusiast that travels the backcountry informing packstock users of minimum impact practices, suggested practices, and the reasons for these suggested behaviors.

In this study, less than a third of the wilderness areas with packstock use had developed and implemented packstock grazing impact monitoring programs. Because monitoring is a prerequisite of effective management, this situation must change. Initially, a compilation of monitoring procedures should be developed similar to those available for campsites (Cole 198913). Simultaneously, procedures used to monitor production livestock impacts should be analyzed to reveal their strengths and the modifications needed to monitor packstock impacts.

Research Approaches and Opportunities

Cole (1987) described and evaluated four types of approaches to research describing impacts to vegetation and soils in wilderness: (1) descriptive studies that quantity existing conditions, (2) comparison of used and unused sites, (3) before-and-after natural experiments, and (4) before-and-after controlled experiments. He called for long-term studies in a variety of settings to improve the understanding of the longevity of impacts and the variation in the susceptibility among sites.

Controlled experiments provide the greatest opportunity to understand the ways impacts occur, but they also are generally more costly and have limited application. Descriptive studies and comparisons of used and unused sites are less costly because they can often be part of monitoring programs for ongoing management. However, they typically do not reveal the causes of impacts or the relationships between impacts and the amount and kind of use. Natural experiments provide a compromise between these approaches. Furthermore, opportunities for securing long-term studies carried out in a variety of settings should become more readily available if vigorous monitoring programs are implemented. If monitoring programs are designed to compare changes in soil, vegetation, and other parameters among sites with various types and amounts of use, and various physical settings, then a great deal of long-term information from a variety of settings will become available.

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