Karl Wood *was named director of the NM Water Resources Research Institute in June 2000. He joined the New Mexico State University faculty in 1979. Prior to his tenure at the WRRI, Karl was assistant department head and range coordinator for NMSU's Department of Animal and Range Sciences. Much of his research over the years has been related to water resources and for 20 years, he has been a member of the Range Improvement Task Force, which provides scientific expertise to help resolve disputes over management of water and other natural resources. Karl completed a B.S. in 1974 in forestry and range management and an M.S. in 1976 in range science with field emphasis on soils and range improvements both from the University of Nevada/Reno. In 1978, Karl received a Ph.D. in range science with field emphasis on watershed management from Texas A&M. Karl has nearly 150 journal articles, research bulletins, special reports and conference proceedings publications to his credit, mainly in the areas of range hydrology, range vegetation and soil assessment, and rangeland management, including reclamation of disturbed lands, range improvement techniques, grazing systems and management of rare and endangered species.*

GRAZING MANAGEMENT FOR HEALTHY WATERSHEDS

M. Karl Wood, Director
Water Resources Research Institute
NMSU - MSC 3167
Box 30001
Las Cruces, New Mexico 88003-8001

ABSTRACT

Most watersheds of the western United States have been grazed and trampled by ungulates (wild or domestic animals with hooves) for many millennia. Their impacts can be positive, negative, or changeless depending on watershed goals and management practices. Grazing reduces interception of precipitation and evapotranspiration, but grazing may increase runoff and erosion. Watersheds will usually remain sustainable if about 50% of the current year's forage is grazed. Grazing usually enhances nutrient cycling by changing above ground plant parts to a more available form. Animal wastes may enhance stream productivity or pollute streams, but usually have little effect. Management strategies may include fencing, adjustments of stocking rates, grazing systems, and rangeland improvements to enhance or maintain watershed goals.

INTRODUCTION

Lands grazed by livestock comprise 43.5% of the land area of the contiguous 48 states (USDA, Forest-Range Task Force 1972), and wild ungulates graze a higher percentage. Most of the western United States and New Mexico is suitable for ungulate production. Free-roaming domestic livestock on New Mexico watersheds include cattle, horses, burros, mules, sheep, goats, bison, and swine. All of these are ungulates (hooved animals) and herbivores. The most prevalent is cattle followed by sheep. Non-domesticated ungulates include elk; mule, whitetail, and Cous deer; javelina; pronghorn; Rocky Mountain and desert bighorn sheep; ibex; barbary sheep; and oryx. Livestock are easy to see because they are large, easy to identify, diurnal in habit, and often not secretive. Hence, it is easy to blame watershed problems on livestock when other animals may be as prevalent but not as conspicuous, and mismanagement from other uses is not obvious or easily controlled. When a land manager is pressured to lower the total maximum daily load (TMDL) of contaminants in a stream, it is easy to show that the problem is being addressed by removing livestock, even though the problems may originate from a totally different source. Any grazing management plan should include all grazing animals. Ungulates, both domestic and non-domestic, can have negative and/or positive impacts on watersheds.

In determining if the impacts are positive or negative, a land goal is needed with a determination of trends toward or away from that goal. The land goal may range from exploitation to total protection, but usually a sustainable use is desirable. An example of justifiable exploitation may occur when a municipality desires to capture all precipitation in surface runoff into a reservoir. Control of vegetation on shallow soils of a contributing watershed may result in little or no relative evapotranspiration loss. Sediments in the reservoir from the bare watershed can periodically be removed and are a lesser problem than a shortage of water. An example of justifiable total protection may occur when the supply from a watershed exceeds demand and a municipality desires the runoff be of high quality. Total protection may help prevent flooding and recharge groundwaters. Resource exploitation and complete protection represent the extremes and are rarely observed. Most watersheds in New Mexico and the western United States have multiple sustainable uses as goals.

A vogue expression of watershed condition is "watershed health?" The question arises as to what this means. Does a "healthy watershed" mean it resembles the desired characteristics of the watershed? And does "sustainability" relate to "healthy watersheds?" Should "health" even be related to watersheds when definitions in dictionaries refer to the well-being of living fauna and flora? Should the desired condition mean that it provides the desired products of the watershed?

HISTORICAL PERSPECTIVE

Wild ungulates have roamed New Mexico and the West since at least the Pleistocene. But their distri-bution was limited by scarcity of drinking water rather than forage as even the Chihuahuan Desert was predominantly grassland. Their impacts were dynamic and consisted of herds that moved from one green spot to another when drinking water was available. Overgrazing was certainly probable.

Spanish conquistadors introduced domestic livestock from Europe nearly 500 years ago when Coronado in 1540 traveled from western Mexico northward through Arizona, New Mexico, and Colorado into Kansas with about 1,000 horses, 500 cows, and 5,000 sheep (Stewart 1936). But their distribution in New Mexico and much of the West was quite limited until the mid-19th century. Small herds and bands were herded from one green spot to another in a method that closely simulated wild herds. In the second half of the 19th century, an increased human population with more stabilized government and increased demands for animal products resulted in large numbers of domestic livestock and reduced numbers of wild ungulates in New Mexico and most of the West. This caused overgrazing on many watersheds, especially those subjected to communal grazing or what has been called worldwide "the tragedy of the commons." Domestic sheep numbers in New Mexico have steadily declined for the last 100 years from a high of about 4.5 million to about 400,000 today (Schickedanz 1980), while cattle numbers have remained about the same from a high of about 1.75 million in the 1920s to about 1.2 million since then. During this same period, wild ungulate numbers have increased. Raising of livestock is strictly controlled or influenced on both public and private lands by federal and state laws, economics, and agricultural ethics. Yet livestock and sometimes wild ungulates continue to be blamed for many of society's ills including flooding, droughts, water pollution, and soil erosion.

UNGULATE IMPACTS

Generally, ungulates in this region graze and recycle the plants, and trample the soils with some minor burrowing and digging (Wood 1988). Direct impacts from ungulates include changes in plant cover, plant volume, soil surface roughness, soil surface configuration, soil moisture evaporative loss, soil organic matter content, soil particle sizes, soil bulk density and porosity, soil structure, and nutrient cycling (Figure 1).

Grazing Effects on Plants

Grazing reduces plant cover and volume. Some plants have little resistance to grazing while others have great resistance. Most plants fall on a continuum between great resistance and little resistance. Some plants such as antelope bitterbrush and both crested and bluebunch wheatgrass are stimulated by ungulate grazing up to a point (Nowak and Caldwell 1984). Some plants like blue grama may be large and robust bunch grasses when moderately grazed but change to a low sod-former with increased cover but less volume when grazed heavily. This condition can lead to higher runoff and erosion rates (Gamougoun et al. 1984). Consequently, most runoff and erosion models use only plant cover, and not cover and volume, and are thrown way off by this species, which happens to be the most abundant grass species in New Mexico. Plants with little resistance are usually those in desert areas where grazing was rare before drinking waters were developed. Their resistance has probably increased greatly since they were first grazed. Plants with great resistance are associated with the Great Plains of North America and include the Shortgrass Prairie of eastern New Mexico.

Reduction of plant cover and volume may decrease losses to transpiration and precipitation interception (Thurow et al. 1987). However, it also decreases soil protection from the erosive energy of precipitation, and it decreases the volume of organic matter that is added to the soil surface, which aids in protecting the soil and increasing soil aggregation. Research has found that there is a threshold at which removing the plant cover and volume have little effect on infiltration rates and soil protection. This threshold is generally about 50% of the current year's growth, which corresponds with the old adage of "take half and leave half" for sustainability. However some watersheds cannot tolerate this much plant utilization, and other sites like sandy areas, may tolerate more.

Anecdotal evidence suggests that livestock can retard or stop the invasion of salt cedar. This has been observed in several places in southern New Mexico. The creek from Capitan to Lincoln runs through Fort Stanton. When this area was actively grazed by cattle, salt cedar was found in dense stands of large trees in protected areas along the stream above the grazed pastures and in protected areas below the grazed pastures. Only small salt cedars less than 4 feet high were occasionally found in the grazed pastures. The research station manager could only attribute the difference to livestock impacts. An area on the West Fork of the Gila River near the visitors' center of the Gila Cliff Dwellings has not been grazed by livestock for several decades. Large salt cedars are found there, but they are not found in grazed areas above or below this excluded area. On the Gila River below the area where the forks converge, an allotment has been excluded for several years. This is the only allotment between the convergence point of the forks and Turkey Creek (about 35 miles) where salt cedar is found.

Trampling or Hoof Action

Trampling or hoof action has several effects on plants and soils, some may be desirable and some may not. It reduces plant cover and volume. Too much reduction may kill the plants, but some may stimulate plant growth by compensatory photosynthesis (Nowak and Caldwell 1984). Trampling increases soil roughness when the soil is wet and decreases soil roughness when the soils are dry. Runoff and erosion usually decrease as roughness increases. Southwestern soils are typically dry. Trampling may change the soil's surface configuration. This is often observed with animal trails. Trails may go up and down hillsides, which promote runoff and erosion, or trails may parallel hillsides, which decrease slope lengths

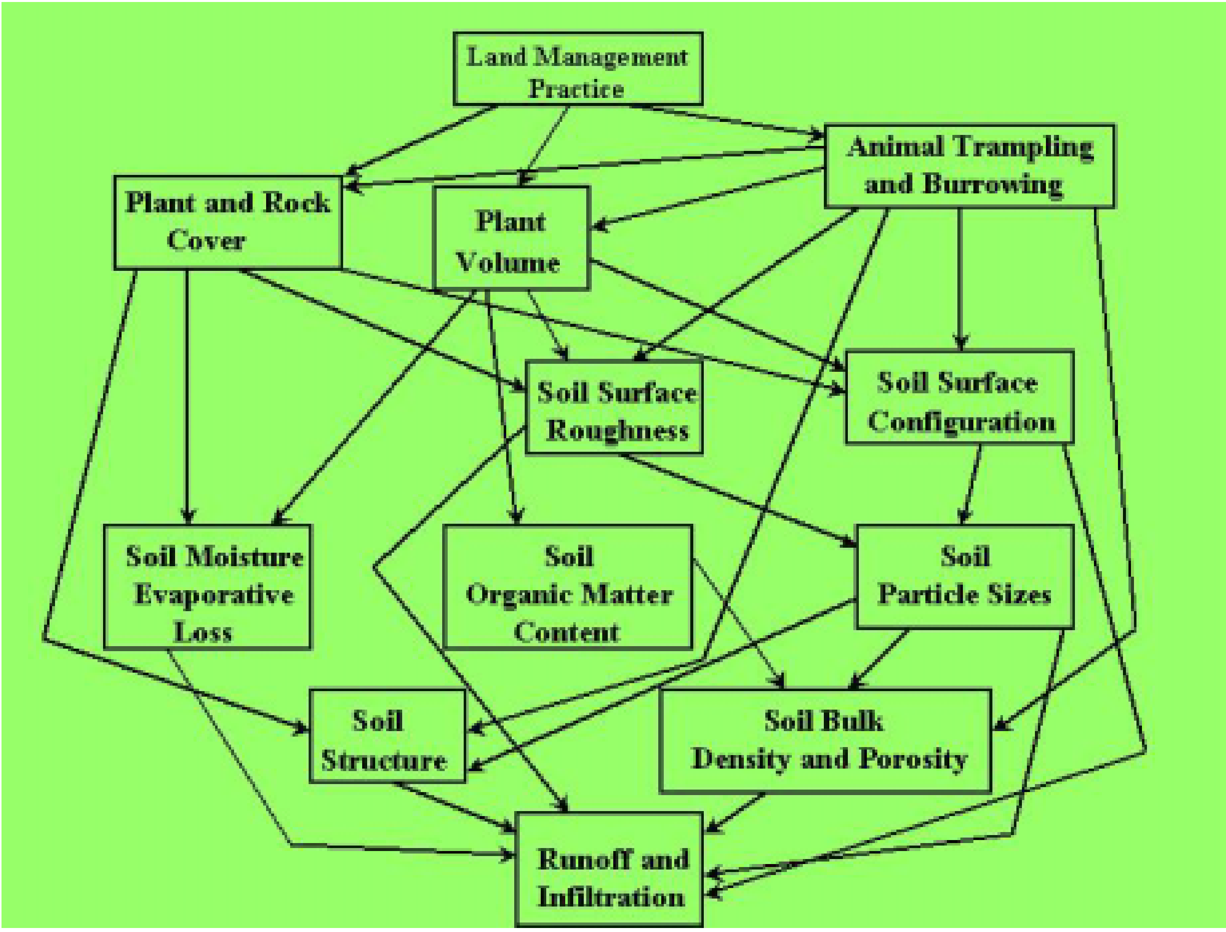

Figure 1. Influences of Rangeland Management on Surface Runoff and Water Infiltration (Wood and Eldridge 1993).

for reduced runoff and erosion. This was observed in the Guadalupe Mountains of southeastern New Mexico where sheep trailing back and forth across the steep escarpment reduced the effective slope length from 1,000 to 6 or 7 feet (Wilcox and Wood 1989). This reduced the erosion prediction from 80 to 3 tons per acre per year.

Trampling may increase bulk density, which corresponds to decreases in porosity. Increased bulk density may impede water infiltration in loamy and clayey soils, resulting in increased runoff and erosion. But increased bulk density may increase water-holding capacity in sandy soils, which would benefit plant growth (Montes-Helu 1997). Perhaps the greatest impact of trampling is changing soil structure from aggregates to massive, which results in increased runoff and erosion. Changes in soil bulk density and structure are often mitigated by shrinking and swelling during winter and early spring freezing-thawing cycles (Weltz et al.1989).

Livestock trampling can be an effective biological control of gophers. Gophers can be controlled by trampling under wet soil conditions, even in a short period of time, if a large number of livestock, especially cattle or horses, are used. The burrow systems of pocket gophers are often remarkably extensive. The burrow system of each pocket gopher may consist of more than 500 feet of tunnels, from 4 to 18 inches below the surface (Hansen et al. 1960). Each system is occupied by only a single animal except during the breeding season. The amount of soil removed may be as much as 160 cubic feet or about 7 tons of soil per acre for some burrow systems. These surface soil mounds are susceptible to erosion and transport by runoff into the adjacent stream (Ellison 1946). The tunnels close to the stream banks are prime candidates to cause piping, which is often blamed on livestock trampling. A pocket gopher's diet consists entirely of plants with the majority (75 to 95%) being forbs. In Colorado study, it was estimated that pocket gophers eat about 365 pounds per acre each year. Pocket gophers damage grasses, shrubs, and trees on watersheds in the following ways:

1. Winter soil casts partially seal the soil against water infiltration; the tunnels aerate the soil and aggravate drought.
2. The undermined plants are destroyed or weakened, and seedlings are used for food and nesting material.
3. The mounds and winter casts cover, smother, and kill some seeded plants and weaken others.
4. Beneath the snow, pocket gophers eat and destroy the root crowns and stem bases of grass clumps.

Pocket gopher activities encourage the growth of forbs, which contribute heavily to their diet. Control of pocket gophers on watersheds has included considerations of poisons and traps. Traps are only effective in very small areas such as gardens and lawns. Poisons called rodenticides are expensive and create environmental concerns. Pocket gophers may be controlled in early spring when soils are wet by concentrating livestock to get maximum trampling. Pocket gophers give birth from mid-March until mid-June so that it would be advantageous to control their numbers before birthing.

ANIMAL WASTES AND NUTRIENT CYCLING

Ungulates influence nutrient inputs, outputs, and transformations. Standing forage can fall directly to surface litter or pass through animals and fall to the surface as dung and urine. Both mechanisms result in a small nutrient loss (Briske and Heitschmidt 1991). Nutrient cycling via grazing animals can be important in enhancing or maintaining soil fertility (Floate 1981). Cycling of nutrients though grazers may help keep a pool of readily mineralizable organic nutrients near the soil surface where they are more accessible to plants and microbes (Botkin and Wu 1981). Consumption of vegetation and subsequent defecation could also increase the turnover and availability of various elements that would otherwise remain in recalcitrant organic forms. Shoots of plants on grazed areas may have higher nutrient concentration than plants from comparable ungrazed areas (Copprock et al. 1983; McNaughton 1984). Under conditions where erosion and runoff increase because of grazing, nutrient losses from a site may be greatly accelerated (Archer and Smeins 1991).

ANIMAL WASTES AND WATER POLLUTION

A concern for many land managers, downstream users, and government regulatory agencies is the loading of animal wastes into streams. Like for land, a goal for each stream and river is needed with a determination of trends toward or away from that goal. If the goal is high instream productivity, then adding dung and urine may be beneficial as domestic livestock have long been considered important contributors to stream enrichment (Holt et al. 1970, Robbins et al. 1971, and Omernik 1976). But if the goal is stream water for municipal use for example, then dung and urine would not be desirable. Dung deposited along stream banks is more susceptible to downstream mobilization than dung deposited above flood level. Much of the ungulate dung that reaches streams is mobilized during high water or during floods (Cole et al.1986). Additionally, according to Cole and others (1986), just as the amount of soil eroded from a watershed is controlled partly by the amount of ground cover (Dunne and Leopold 1978, Dissmeyer and Foster 1980) in the form of vegetation or litter, nearly all dung deposited on dense ground cover is also expected to remain in the watershed, where its nutrients are recycled to the vegetation. Only that dung deposited on bare ground connected to a runoff system is expected to be eroded from the watershed. Therefore, if proper grazing is practiced, loading of dung and urine into streams should be minimal.

Of the dung originally deposited, what is not eroded away by wind and water eventually disintegrates from trampling, other physical disruption, and decay. Cole and others (1986) also claimed that fisheries in watersheds of low fertility may benefit from accelerated erosion in watersheds because it leads to increased instream plant production and fish production as long as oxygen concentrations remain high enough to maintain the fishery. Fisheries in highly fertile watersheds are more likely to be harmed by accelerated erosion because over-enrichment causes environmental changes that increase chances for fish kills, decreased fish growth and vigor, or decreased yield for the fishing effort.

LIVESTOCK AND WILD UNGULATE MANAGEMENT STRATEGIES

Many watersheds have a road, corral, salt lick, and/or supplemental feeder next to the central drainage. Coupled with shade trees, these areas are prime for livestock and wild ungulate congregations. To solve problems with managing ungulates in watersheds, several guidelines can be given.

Fences

Probably the worst case scenario for state and national legislation and regulations requiring “projects” and “action plans” is that well-meaning people interpret these words to mean “building exclosures” in watersheds. Fencing livestock out of watersheds is not the only solution to grazing problems. Land managers need to determine watershed problems, identify the sources, and document it through monitoring before all grazing is ceased or before exclosures are built. Exclosures can be a menace to land managers be-cause they often result in unused forage, problems with animal movement, annual maintenance hassles in the floodway, excessive expenses, and undesirable aesthetic considerations.

Stocking Rates

The actual number of animals on a specific area at a specific time is referred to as the stocking rate. The stocking rate determines the amount of use or the proportion of the current year’s forage production that is consumed or destroyed by grazing animals. Utilization levels are often referred to as none, light, moderate, heavy, and extreme and relate to around 0, 25, 50, 75 and 100% utilization of the current year’s entire growth, respectively. Stocking rates and utilization levels as they relate to hydrologic characteristics of watersheds have been studied for many decades. Dyksterhuis (1949) noted that heavy stocking tends to result in intense defoliation of palatable species resulting in their decline. Heavy grazing intensity, regardless of grazing strategy, does not appear suited for long-term maintenance of hydrologically desirable bunchgrass species (Thurow at al.1988). Moderate or light grazing, regardless of grazing strategy, generally have little effect on bunchgrass cover (Ellison 1960; Rich and Reynolds 1963) and thus has little effect on runoff, infiltration rates, and erosion (Blackburn 1984). Gamougoun and others (1984) found that under moderate stocking, blue grama maintained a bunchgrass form. Under heavy stocking, blue grama was found as a sodgrass with increased cover but reduced volume. This resulted in lower hydrologic sustainability.

Grazing Systems

Grazing systems are designed to balance the conflicting relationships between energy capture and plant production, harvest of those plants, and energy conversion efficiencies (Heitschmidt and Taylor 1991). They are designed to enhance ungulate production over time by improving and/or stabilizing the quantity and/or quality of forage produced and/or consumed. Production improves if the benefits of rest or deferment of the land and its plants exceeds the detrimental impacts of grazing. Stabilization results if the benefits of rest equal the detrimental impacts of grazing, while degradation results when the benefits of rest are less than the detrimental impacts of grazing. A grazing system defines recurring periods of grazing and deferment for two or more pastures or management units within a watershed. These grazing systems are often referred to as deferred rotation, rest rotation, short duration, or time control, among others. The effectiveness of each system varies depending on the type of country in which it is being used. Most systems probably work somewhere. None of them work everywhere.

The effect of a particular grazing system on the plant and soil resources needs to be closely monitored. It can be expected that hydrological responses to a particular grazing system will closely correspond to the plant and soil resources responses. Generally, grazing systems that rest a small portion of the entire grazed area with ungulates distributed across the remaining large area respond hydrologically better than grazing systems that rest a large portion of the entire grazed area with the ungulates congregated within the re-maining small area (McGinty et al. 1978; Gamougoun et al. 1984; Wood and Blackburn 1981; Wood and Blackburn 1984; Pluhar et al. 1987; Warren et al. 1986; Weltz and Wood 1986a; Weltz and Wood 1986b; Thurow et al. 1988; Weltz et al. 1989). Examples are given in Tables 1, 2, and 3.

Table 1. Mean infiltration rates (cm hr^{-1}) and sediment production (kg ha^{-1}) from four grazing schemes and grazing exclusion in the Texas Rolling Plains (Wood and Blackburn 1981).

System	Stocking Rate	Infiltration Rate cm hr^{-1}	Sediment Production kg ha^{-1}
Exclosure	None	15.2 a[1]	11 b
Deferred – Rotation	Moderate	13.9 ab	14 b
Continuous	Moderate	11.4 bc	28 ab
Short Duration	Moderate	8.2 c	40 ab
Continuous	Heavy	8.1 c	114 a

[1] Means followed by the same letter within a column are not significantly different at the 95% level of probability.

Table 2. Mean infiltration rates (cm hr^{-1}) and sediment production (kg ha^{-1}) from three grazing schemes and grazing exclusion at Fort Stanton in southcentral New Mexico (Weltz and Wood 1986a, Weltz and Wood 1986b).

System	Stocking Rate	Infiltration Rate cm hr^{-1}	Sediment Production kg ha^{-1}
Exclosure	None	7.4 a[1]	65 b
Continuous	Moderate	4.9 b	307 a
Short Duration after resting	Heavy	3.9 c	221 a
Short Duration after grazing	Heavy	2.3 d	565 a
Continuous	Heavy	2.6 d	334 a

[1] Means followed by the same letter within a column are not significantly different at the 95% level of probability.

Table 3. Mean infiltration rates (cm hr^{-1}) and sediment production (kg ha^{-1}) from two grazing schemes and grazing exclusion near Fort Sumner in central New Mexico (Weltz and Wood 1986a, Weltz and Wood 1986b).

System	Stocking Rate	Infiltration Rate cm hr^{-1}	Sediment Production kg ha^{-1}
Exclosure	None	6.3 ab[1]	20 c
Continuous	Moderate	5.5 b	80 b
Short Duration after resting	Heavy	7.0 a	25 c
Short Duration after grazing	Heavy	3.8 c	268 a

[1] Means followed by the same letter within a column are not significantly different at the 95% level of probability.

Rangeland Improvements

Range improvements can alter livestock and wild ungulate distribution away from sensitive areas (Vallentine 1989). Burned areas have long been known to attract grazing as has spot fertilized rangeland and seedings at certain times of the year. Placement of salt and other nutrition supplements away from sensitive areas is helpful. However, the most important rangeland improvement in a watershed often involves converting shrublands and woodlands to historical grasslands and converting forests to historical savannahs. This was explained by Aldo Leopold, a forester who became known as the father of wildlife management:

> "If the prime objective is wood products, we may continue to overgraze, letting in the woodland and sacrificing watershed values. If on the other hand the prime objective is watersheds, we should restore the grass, which all the evidence indicates is a better watershed cover than either brush or woodland."

Monitoring

Monitoring means observing what happens and keeping records of actual use, growing conditions, and events that change the resources such as, for example, floods or beavers building dams. Monitoring involves exploring the watershed with one or more key members of a planning team and looking for problems, such as damage to the resources, under-use, or non-use of forage. Monitoring includes actual measurements, making notes, and taking pictures at the same time every year, especially in areas where improvement is targeted.

CONCLUSIONS

Four note-worthy points can be made regarding the question "Can we graze watersheds?"

1. We can graze these areas.
2. We ought to be able to increase the amount of forage harvested in watersheds without damaging other uses.
3. We do not yet know how to do this in all areas because watersheds and their management situations are so diverse.
4. If we do not get our management act together, the public will not let us graze watersheds because of the high resource value and the potential for damage from improper grazing.

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