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ABSTRACT: Rangelands occupy a large portion of the western United States and the world. Grazing by ruminant animals provides the only means of obtaining usable products from these lands. Sheep and goats are more efficient producers, better adapted to many ranges, and are useful in controlling or manipulating shrubs and other undesirable vegetation which results in improved range conditions and increased water yields. There has been a general decline in sheep and goat numbers and a shift toward cattle. Predation has been a major factor in the abandonment of many sheep and goat operations and the shift to other livestock. A viable range sheep and goat industry can survive only with an adequate predator management program that includes all methods of protecting livestock as well as all available lethal methods.

The range livestock industry is an important segment of American agriculture that supplies livestock products required and desired by society. Grazing by sheep, goats, and cattle provides the only means by which millions of acres of range land can be harvested for the production of food and fiber. These rangelands are not suitable for intensive land use because of rough topography, severe temperatures, rocky, shallow, or salty soils, and lack of moisture. The contribution of rangelands to national and world food supplies is direct in terms of livestock products, and indirect because management of vegetation affects water yield, biological stability, and environmental enhancement (Bowns 1981).

Range livestock production requires considerably less cultural energy (labor, machinery, transportation, tillage, fertilizers, herbicides, etc.) for the production of meat and fiber than that required in confined fattening procedures (Cook 1976). Food production by ruminants is also complementary to humans rather than competitive (Hodgson 1976). As the population grows and as world demand for grain and energy increases, there will be a shift to greater reliance on forages and less reliance on grain to produce the foods that ruminants are capable of supplying.

It is known that sheep are more efficient than cattle in converting forage to animal products. This is a result of multiple births, faster growth rates, and the ability of lambs to fatten on range forages without grain. Alonso et al. (1978) have shown that ewes are capable of producing their own weight, or more, in lamb on rangelands within six months. Sheep are also better suited to many western rangelands because they are better adapted to use areas that are too steep, too rough, too high or too arid to be used by other livestock. Sheep also produce both lamb and wool. Economic returns from sheep also come more quickly following management decisions, and wool can easily be stored and shipped. Another significant advantage of sheep is that they readily use browse and other plants not acceptable to cattle.

Goats are valuable for milk, meat, fiber and leather, and millions of people depend upon them for their livelihood (Martin and Huss 1981). In the southwestern United States and Mexico where goat meat is not excluded by prejudice, kid goat is a favorite food for festive occasions (Merrill and Taylor 1976). Goats prefer browse, an attribute that can be beneficially exploited, even when exposed to palatable grasses. Preference for browse may be due to the goats nutritional requirements or to the character of the goat's mouth. Its mobile upper lips and prehensile tongue permit it to eat tiny leaves of browse, even spiny species, which other animals cannot normally consume (Martin and Huss 1981).

Sheep and goats are often maligned as being inherently detrimental to ranges or causing range damage. In the United States, it was commonly thought that sheep were the most detrimental to ranges, and early-day corrective measures involved their removal (Stoddart, Smith and Box 1975). John Muir campaigned for the elimination of sheep from the newly established forest reserves (Talbot and Cronemiller 1961). At the same time, Coville (1898) concluded that "sheep grazing without proper restrictions and regulation was detrimental to the reproduction of forest growth and to soil conditions and water flow." He did recognize, however, that with effective control sheep could be grazed on selected areas without damage.

In the West the sheep industry started to develop in the late 1800s. Large numbers of sheep grazed the deserts, foothills, and mountain ranges during the next several decades. These sheep operations were largely seminomadic, moving from one area to another as the seasons dictated and as the forage was consumed. This resulted in a philosophy of "get there first" before the forage was consumed by another herd. Many areas were grazed too early and this necessity to "get there first" was probably as much a factor in range abuse as anything else including excessive numbers (Talbot and Cronemiller 1961). It should also be acknowledged, however, that hordes of cattle and horses shared the range forage year after year with the sheep (Anderson 1964). Early studies indicated that prolonged grazing abuse had killed out valuable forage species and several inches of topsoil had been washed or blown away. Mountain ranges had been damaged so severely in two or three decades that an era of summertime floods, resulting in much property damage, began (Keck 1972). This observed damage by sheep resulted from excessive numbers and improper season of use, rather than any feature inherent in sheep grazing.

The goat, from a world view, is both hated and treasured because it remains productive in areas that are seriously overgrazed and eroded. Goats, even though they are accused, are not generally the initial cause of rangeland deterioration, but they may be the primary culprit during the latter stages

of destruction (Huston 1978). In some areas of the world, goats are considered highly destructive of vegetation and principal contributors to severe soil erosion (Maher 1945).

The problem is not the goat per se, but uncontrolled and continued overgrazing by the total herbivore population. Huss (1972) feels that most of the world's deteriorated rangelands were caused by overgrazing by sheep and cattle and, eventually, overgrazing left pasturage that only the goat could utilize.

It is clearly apparent that sheep and goats do a great deal of damage to soils and vegetation if not controlled. Controlled grazing, however, has positive impacts on rangelands and most ranges are more productive when grazed with more than one species of herbivore. Some positive impacts of proper grazing are: 1) loosening of the soil surface, 2) removal of excess vegetation, 3) incorporating mulch into the soil, 4) improved recycling of nutrients, 5) maintenance of optimum leaf areas, 6) trampling of seed into the ground, 7) application of growth substances from saliva, and 8) reduction of fire, insect, and rodent problems resulting from the accumulation of vegetation (Holechek 1980).

Sheep numbers reached their maximum in the early 1940s, but have declined since then (Goodsell and Belfield 1973). There has been a shift from sheep and goats to cattle in the United States which is regrettable because many rangelands are poorly suited to cattle and some cannot be grazed by cattle at all. The consequence of this trend will be lower livestock production and, possibly, deterioration of the range resource (Stoddart, Smith and Box 1975). Federal land management agencies recognize that the great bulk of National Resource Lands is more suitable for grazing by domestic sheep, and the conversion from sheep to cattle has caused problems based on vegetative, environmental, and other conditions (Turcott 1974). This conversion to cattle has necessitated changes in season of use, more fences and additional livestock water.

Sheep operations in the United States have been categorized as farm flocks having an average of 30 sheep, stock, or sheep farms with an average of 500 sheep, and sheep ranches with 1,500 to 10,000 sheep (Goodsell and Belfield 1973). Approximately 80 percent of the sheep in the United Stated are raised in the 17 western states, and one-half in the 11 western states where the ranges are better suited to sheep than cattle (Gee and Magleby 1976). More than two-thirds of the commercial sheep operations are joint enterprises with cattle or goats. This diversification reduces risk, permits better use of ranges and provides flexibility to shift to other livestock or crops in response to changing prices, costs, labor availability and predation (Gee and Magleby 1976).

Goats are classified as dairy, Angora and Spanish, or meat goats. Ninety-five percent of the Angora goats are located in Texas, with New Mexico having the second largest population. California has the largest number of dairy goats and Texas the largest number of Spanish or meat-type goats. Dairy goats are found in small herds under intensive management, but Angora and Spanish goats are generally produced under extensive range conditions (CAST 1982).

An important advantage of sheep and goats is their effectiveness in the control and/or manipulation of vegetation. In California, where 10 percent of the state is covered with brush, goats are a valuable addition or replacement for other brush control methods, often reducing costs or producing monetary returns (Spurlock, et al. 1978). These brush lands are needed for animal production, wildlife use, recreation, and constitute an extreme fire danger. Goats are used to maintain fuel breaks that are constructed to break up the vegetation for better fire management and to facilitate protection of urban areas and watersheds (Green, et al. 1979). Goat grazing is an alternative to herbicide and mechanical methods to maintain these fire breaks. Rangelands dominated by densely rooted shrubs and trees that remain in leaf most of the year consume huge quantities of ground water resulting in reductions in stream flows, springs and soil moisture (Burgy and Papazafiriou 1971). Converting these brush lands to shallow-rooted grasses and forbs reduces both evapotranspiration and interception losses with resultant increases in water yields. Clearing mesquite and brush in Texas resulted in a once-dried-up creek and springs flowing again. This increased the water supply to ranchers and municipalities (San Angelo Standard Times 1981).

Goats have been used in South Africa to control brush infestation once thorn trees were removed, and in Mexico to eliminate the regrowth of some woody species and retard regrowth of others (du Toit 1979, Martin and Juss 1981). In both instances desirable grasses were either unharmed or production was increased, thereby enhancing beef production.

Goats were effective in controlling gambel oak in Colorado as a follow-up treatment to mechanical control (Davis et al. 1975). Provenza (1981) used goats in Utah to manipulate blackbrush and convert it to a form more palatable, digestable and nutritious for cattle use.

Goats are used extensively in Texas to control low-growing brush or as followup maintenance control of brush sprouts that have otherwise been treated for initial control (USDA 1964).

The Spanish goat is generally preferred over the mohair or Angora goat for brush control. These animals are more rangy, can browse to heights of 7 feet or more, are readily available, more prolific and less vulnerable to predation and extreme weather conditions. Angoras are less efficient browsers, more susceptible to predation, have very high nutritional requirements for production of both mohair and milk and are thus highly susceptible to adverse environmental conditions. Vulnerability to adverse weather is further complicated by the fact that biological brush control is conducted under conditions that place stress on the animals (Merrill and Taylor 1976).

Sheep are also efficient in reducing or controlling woody plant species. They have been used to reduce sagebrush density and rehabilitate grass seedings, and maximize utilization of herbs so as to leave browse plants for deer winter forage (Frischnecht and Harris 1973, Jensen, et al. 1972). Sheep and cattle have been used to suppress rapid growth of shrub sprouts following fire, thereby prolonging availability of deer browse (Biswell, et al. 1952, Hedrick, et al. 1968). Controlled sheep grazing that reduced understory forage species, with resultant increases in soil moisture, resulted in increased growth rates in Douglas fir seedlings (Hedrick and Keniston 1966). Sheep are also effective in reducing plant species that are toxic to cattle, and in altering the amount and type of fuel present for safe and effective burning (Winward 1981, James 1981, CAST 1974).

The effectiveness of sheep and goats to produce food and fiber and control brush and other undesirable plants is reduced by the decline apparent in these industries. This steady decline in western sheep numbers is caused by heavy predation, reduced grazing permits on public lands, labor problems, and increased production costs (Goodsell and Belfield 1973, Gee and Magleby 1976).

Predation on livestock in the western United States is one of the most serious problems facing the range livestock industry. Predation causes very serious economic losses to many producers, forcing the abandonment of many livestock operations. These losses also reach levels that prevent proper use of range land, and the proper utilization of forage resources.

Producers in Montana, Utah, New Mexico, Arizona, Colorado, and Wyoming have abandoned or avoid sheep and goat operations because of excessive predation. Many also feel that predators and fear of losses to them are a major factor preventing young people from establishing sheep and goat operations (Wade 1982).

An encroachment of coyotes to the Edwards Plateau in Texas has caused many ranchers to abandon sheep and goat production. Many others would prefer to utilize sheep and goats for better range management and brush control, but are unwilling to risk major capital investments in areas of high predator populations. Some banks and loan agencies will no longer risk capital on sheep and goats in areas of high predator populations without additional collateral as security (Wade 1982). Kensing (1980) noted alterations in the economy, decreased importance of agriculture to the economic base, a decline in industries which both depend on and support the agricultural sector, and forced changes in living conditions of rural families. Those forced to sell or to abandon livestock operations had to seek other ways of life. For many this meant a shift to urban living and a major decline in their personal quality of life.

The addition of sheep and goats to existing cattle operations also adds diversity to a livestock operation. This diversification adds stability to farm family income, the community, state, and national economies. Therefore, the inability to utilize mixed kinds of livestock adversely impacts rural families and communities and, ultimately, larger sectors of the United States (Wade 1982).

Economic losses to predation take several forms; the most obvious and dramatic loss is the direct killing of livestock, but losses occur in several other ways. These include: 1) reduced animal production caused by molestation, 2) reduced production and death losses because of efforts to evade losses. Examples of these would be parasite infestations or smothered animals resulting from close confinement, 3) cost of supplemental feed for animals under confinement, 4) gathering sheep scattered by predator attack, and treating injured animals, 5) direct costs of control efforts, 6) reduced attention to other phases of farm or ranch operations and, as discussed earlier, and perhaps the most serious, 7) the inability or unwillingness of ranchers to produce sheep and goats in areas where they are well suited or use pastures suitable for sheep and goats because of the excess predator losses certain to occur (Wade and Connolly 1980, Shelton and Klindt 1974, Nesse 1974, and Howard 1980).

The range sheep and goat industry can survive only with an adequate predator control program that includes all possible lethal methods of removing predators as well as all practical, effective, and economical nonlethal and noncaptive methods of reducing predation.

In recent years there has been a trend toward, and an emphasis on, the use of nonlethal, noncapture methods to reduce predation losses or reduce the occasion for conflict between predators and livestock (Andrus 1979). These proposed nonlethal, noncapture methods and husbandry techniques need to be discussed in relation to their effectiveness and practicality under range or large pasture conditions. Some of the methods proposed are confinement production of livestock; penning at night; pasture selection to avoid high predation areas; herding; alterations in lambing, kidding, and calving seasons; shed-lambing, kidding, and calving; carrion disposal; exclusive fencing; repellents; aversive conditioning; reproductive inhibitors; and guard dogs.

Confinement production generally results in greater parasite and disease problems and is best suited for small farm flocks. This method is totally inappropriate for large pasture or range operations that rely on native forage plants.

Penning at night usually helps reduce predation but predators adapt to this practice and kill during daylight hours. This technique has been termed "futile and ridiculous" under large pasture situations and would be neither practical nor possible under these conditions (Howard 1980).

Pasture selection avoids pastures where predation is severe. This results in poor use of pastures and range resources and is rarely of any significant benefit to producers (Wade 1982).

Herding is a method that may help reduce predation by more intensive surveillance and human activity. Gee and Magleby (1976) reported that sheep grazed on federal ranges, approximately one-half of all commercial sheep, and another 10 percent on private lands are open grazed under the care of herders. The cost of extra herders to reduce predation may not be economical due to operation size and profit margin. Thus, the lack of good herders either results in curtailment of sheep placed on open ranges or higher sheep-to-herder ratios and increased losses. The use of close herding to reduce predation losses is an extremely poor management practice in terms of reduced animal performance and deterioration of the range resource and subsequent soil erosion.

Alterations of lambing, kidding, and calving seasons can be effective by keeping livestock off pastures and ranges during periods when predation is most severe. In some regions this is a viable option, but livestock operations have evolved with the availability of range forages. Major alterations are totally impractical in northern range areas where highly productive and nutritious range forage is available only during the spring and summer seasons.

Shed-lambing, kidding, and calving may reduce overall losses and predation losses of very young animals, but these flocks may still suffer serious predation losses when transferred to pastures or open ranges. For many large sheep operations, particularly migratory ones, shed-lambing is simply not practical. For others the cost and labor requirements are such that many would leave the business rather than make the investment (Gee and Magleby 1976). Close confinement also leads frequently to increased nutritional, disease, and parasite problems.

Carrion disposal has been used to reduce predation by removing food sources that might attract coyotes to livestock. This method may be practical and effective for small farm flocks, but it is not practical or possible for large pasture or range operations.

Exclusive fencing of predators is the only consistently effective nonlethal method of reducing predation (Wade 1982). The main disadvantages are the high cost of construction and maintenance, and the detrimental effects on wildlife movements. These objections make this method completely impractical and prohibitively expensive on public lands.

Repellents using various sonic and visual devices have shown relatively limited, short-term effects, but may be useful in combination and with frequent alterations (Wade 1982). Chemical repellents have shown little or no value in repelling predators so there is insufficient proof of efficacy to encourage extensive testing that could lead to EPA registration of chemicals.

Aversive conditioning involves the treating of dead animals or meat with an emetic, causing illness after ingestion. Although theoretically attractive, research and field trials have been inconclusive or negative and have not provided proof of efficacy. Therefore, no chemicals are currently registered for this purpose (Wade 1982).

Reproductive inhibitors as a means of limiting predator populations is very attractive and appealing, but much more research is needed. Delivery systems must be developed and appropriate chemicals found before their potential can be fully explored, and currently none are operational (Wade 1982).

Guard dogs, used to protect livestock from predators, are presently receiving a great deal of attention. There are undoubtedly some situations and some individual dogs that make this method effective in reducing predation. It is my opinion, however, that the use of guard dogs is somewhat limited, not worthy of the euphoria associated with them, and considerably more research and field testing is needed before this method is considered operational for range sheep operations.

In summary, many nonlethal, noncapture methods and husbandry practices are applicable and effective on farm flock operations, but may be neither practical nor effective for large pasture or range operations. The final decision to use any method or practice will be made by individual producers based on its suitability to his operation and its economic advantage.

Lethal methods of predator control, which are required in order to keep predation at a reasonable level, can be used to stop depredations after losses have occurred (corrective control) or in areas with perennial chronic problems as population depressants (preventive or prophylactic control).

Lethal control methods currently available and utilized are: 1) traps, 2) snares, 3) ground hunting, 4) aerial hunting, 5) denning, and 6) the M-44. These methods are used in various combinations and degrees of intensity depending on local situations. Whenver possible, control is directed toward those offending individuals or local popualtions by choosing the appropriate time, location, methods and specific application of the control technique. Criteria used for the selection of these methods are efficacy, selectivity, humaneness and cost.

Each method has advantages and disadvantages and each is effective in some situations, but not in others. Some specific limitations of these control methods are: 1) high cost, 2) high manpower requirements, 3) excessively time consuming, 4) require a high degree of skill, 5) inoperative because of adverse weather or soil conditions, 6) ineffective during certain seasons, or due to dense vegetation and rough terrain, 7) ineffective or inappropriate due to the presence of livestock, 8) coyotes become accustomed to or "wise" to the method, and 9) restrictions imposed by federal, state and local laws, policies, guidelines and regulations (Bowns 1980). For a complete discussion of these lethal methods see Wade (1982).

No individual control technique can supplant, but can only supplement another. The loss of cyanide, strychnine, and 1080 in 1972 left a void that has not been efficiently or effectively filled. With the techniques presently available, there are areas in the western states where coyote depredation cannot be reduced to levels consistent with economic livestock production. Until new or more effective methods are developed, there is a demonstrated need for toxic chemicals, including 1080, to reduce coyote populations.

In conclusion, good range and livestock management is beneficial to the land, livestock, and wildlife. A variety of products that are useful to society can only be obtained from rangelands through the grazing animal. These products can also be obtained with a considerable saving of energy compared to intensive agricultural operations. Livestock and wildlife can be efficiently produced on our western rangelands only with proper management and husbandry practices which include an effective predator management program. This program should include all methods to protect livestock including herders where feasible, fencing, penning at night, shed lambing, etc. These methods, with their limited effectiveness on range operations, will not be adequate to resolve the predator problem. An effective program must include all currently available lethal techniques in combinations that can adequately deal with the problem.

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