Sheep: A Method For Controlling Rangeland Weeds[1]

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Summary

Noxious rangeland weeds are difficult to control. Where the use of many control treatments are limited by environmental and economic constraints, sheep grazing is a potential weed control method. Sheep possess many traits that enable them to be used to control noxious weeds and reduce poisonous plant infestations. Currently, sheep are used to control leafy spurge, spotted knapweed, tall larkspur, tansy ragwort and other weeds. In some cases, landowners assess renters a lower fee when their sheep graze weed-infested rangelands. Federal land management agencies often do not charge any fee when sheep grazing is used to control noxious weeds. The value of sheep as a weed control method, and subsequently their use on rangelands, is expected to increase in the future.

Introduction

Many plant species growing on rangelands and pasture lands conflict, restrict or otherwise interfere with land management objectives and are defined as "weeds." Through legislation, more than 500 weeds in the U.S. and Canada have been designated noxious by weed or seed laws (Lorenz and Dewey, 1988).

Noxious weeds are not native to areas where they become a problem. Most were introduced unintentionally as contaminants in seed grain and as packing material-ballast in early shipping from Europe. They are often difficult to control because they compete for moisture and nutrients and because their natural enemies, pathogens and herbivores, from their native countries were not introduced along with the plant. Environmental and economic considerations often limit the feasibility of mechanical, biological, herbicidal and cultural treatments; thus, the potential of using livestock to control weeds is intuitively appealing.

Most weeds have nutritional value if the range is grazed when the weed is palatable and therefore selected by certain animals. When animals readily use weeds the term "weed," as defined above, is difficult to apply. An alternative would be to regard "weedy" plants as potential forage that could support different ungulate(s) than the one(s) that currently graze an area.

Grazing habits and dietary requirements of sheep enhance their potential to alter plant communities. Therefore, in this review we summarize what is known about using sheep as a method to control noxious range weeds.

Sheep Characteristics in Relation to Weed Control

Sheep are well-adapted to harvesting forage (Lynch et al., 1992) and, given an opportunity, will graze selectively (Vallentine, 1990). Like other animals, sheep prefer young over mature plants and leaf over stem material. Sheep have a muscular pad in their upper jaw (rather than teeth), a cleft upper lip and a relatively narrow muzzle which allows them to take small bites and select specific parts of a plant (Arnold and Dudzinski, 1978). Thus, unlike most larger ungulates, sheep can harvest prostrate plants, strip leaves from branches, break and chew twigs and pick off individual leaves.

Despite their relatively small size, sheep have a relatively large rumen and a very long intestine (Hofmann, 1989). Because of these and other

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characteristics, Hofmann (1989) categorized sheep as bulk and roughage eaters, which have slow passage rates, low fermentation rates and rely on cellulolytic bacteria to degrade fibrous material. Thus, sheep can do well on a variety of forages, including fibrous weeds.

Sheep generally consume larger quantities of forbs and actively select for a greater number of forb species compared with cattle and horses (Hanley, 1982). During the growing season, forbs generally provide a high-quality diet. Most noxious weeds are forbs.

Feed intake for sheep is influenced by three variables: grazing time, bite size and biting rate. Sheep normally initiate and cease grazing when there is some light in the sky (Lynch et al., 1992). They graze eight to nine hours a day, which includes biting, chewing and preparing the bolus to be swallowed, and time spent walking to, searching for and selecting forage. Grazing times for sheep that graze weed-infested rangelands have not been documented. However, grazing times should not be appreciably different unless grazed weeds contain secondary compounds that deter microbial growth or reduce subsequent digestibility of the forage and thereby decrease intake. Bite size and rate of herbage intake increase as forage height increases, but biting rate decreases when tillers are longer than five centimeters or when there is more than 1,000 kilograms per hectare of forage in a pasture (Allden and Whittaker, 1970). This study refers to grazing behavior on grass-dominated pasture. Similar measures on pastures dominated by weeds (forbs) have not been documented.

Diet selection is influenced by differences in plant availability, level of hunger and prior experience. For example, sheep moved from dry, native pastures to improved pastures in Australia preferred different species for 6 to 12 months compared with sheep that were raised exclusively on improved pastures (Lynch et al., 1992). Sheep that have been raised on grasses compared with those raised on shrubs are more efficient at grazing than browsing.

Changing from one forage type to another often requires an adaptation period. For example, an adaptation period is often required before naive (inexperienced) sheep will utilize leafy spurge (Landgraf et al., 1984). It is not known whether this period simply requires the learning process or possibly requires some physiological adaptation such as developing the ability to detoxify secondary compounds or adjusting the composition of rumen microflora.

Young sheep accept non-weed, new feeds more readily than adults, but it is unclear if the same is true with weedy feeds (Lynch et al., 1992). Previous grazing experience significantly affects subsequent preference for some forages (Ramos and Tennessen, 1992; Walker et al., 1992). Part of this previous grazing experience includes the social environment. Animals learn to eat or avoid new feeds quicker when their peers are present. The importance of a social model in influencing diet selection by lambs is well established (Provenza and Balph, 1988).

The role of experience and memory in selecting diets interacts with an animal's sense of smell, sight and touch. When learning to eat a new feed, one sense usually does not dominate the learning process (Lynch et al., 1992). Often, selectivity is associated with taste, but sheep will avidly forage on weeds that are bitter or acrid tasting. Similarly, what sheep eat in one situation may be ignored in another because of differences in moisture content, tearing resistance and availability of associated vegetation. When available forage is reduced or limited by drought or other environmental factors, the ability to select is reduced. Therefore, previously rejected plants or plant parts may be eaten.

Sheep are well adapted to grazing steep topography. Their small size, sure-footedness and climbing instinct enable them to graze forage found on steep rocky slopes (Stoddart and Smith, 1955). Many weeds first become established on these sites. Birds and small and large mammals frequent these sites, and thus are potential agents of spread. These areas are often inaccessible to normal weed control methods but could be grazed by sheep. In addition, sheep prefer to rest overnight in higher areas, presumably an instinct passed down from their ancestors to reduce predation. They generally move to lower elevations in the morning. During the day sheep normally rest at the site where they cease grazing.

Sheep normally do not graze a pasture uniformly. Lange (1985) reported that the stocking intensity (a measure of how uniformly animals are distributed) in a one-hectare pasture of high-quality forage varied from 0.125 to 8 times the average stocking rate. In a 2,200-hectare saltbush pasture which had a stock density of 6.5 hectare per sheep, the stocking intensity varied from 0 to 800% of the average. Variations in stocking intensity within pastures are related to locations of water and preferred plants and day and night resting areas. With non-uniform grazing across the landscape, a manager either needs to use an ungulate that selects the weed as a preferred plant or use methods to concentrate the animals in weed infested areas.

How Sheep Control Weeds

Herbivory and competition are two factors that greatly affect plant abundance and distribution (Harper, 1977; Crawley, 1983; Fowler, 1986; Louda et al., 1990). Herbivory may decrease growth, stimulate regrowth or cause mortality. After domestic livestock were introduced into North America and wildlife numbers were reduced, the diversity of plant species was reduced in many areas. With selective grazing, too many animals of one kind in a relatively small area will eliminate or severely reduce the preferred forage and thus decrease the preferred species' ability to compete in the plant community (Crawley, 1983; Louda et al., 1990). This opens the community to new plant species, many of which are weedy species.

Cattle and horses graze grasses and grass-like plants during most of the growing season. Their grazing will shift species composition to favor

forbs, including weeds. Sheep may be used to reduce some of these forbs, which many other ungulates avoid, and thus restore a balance to the plant community. However, we believe that the sheep could not be removed after a year or two and then expect the forb component to remain low with continuous grazing by other ungulates that avoid these forbs. Plant communities are dynamic, reflecting abiotic and biotic (grazing) forces that continually favor one species over another. Depending on the changing mix of abiotic and biotic forces, no one species will always be the dominant species.

Examples of Sheep Controlling Weeds

Leafy spurge *(Euphorbia esula)* is a perennial rhizomatous plant that effectively competes with grasses (Selleck et al., 1962). It has invaded approximately 600,000 hectares of rangeland in North Dakota and Montana. Leafy spurge is extremely difficult to control with mechanical, cultural or herbicidal means (Fay, 1992). Successful control with biological agents on a large scale has not been documented.

Cattle do not usually graze leafy spurge. Furthermore, they avoid leafy spurge-infested sites (Lym and Kirby, 1987; Hein and Miller, 1992). In contrast, sheep readily graze leafy spurge and the plant can make up 50% of their diet (Landgraf et al., 1984). In Landgraf's study, ewes were not affected by consuming leafy spurge. In a related study, average daily gains of lambs grazing leafy spurge-infested pastures were greater than gains of lambs grazing grass pastures (Bartz et al., 1985). Because leafy spurge is a high-quality forage, some sheep producers consider the plant a valuable resource on rangelands.

Several Montana ranchers are using sheep to control leafy spurge on rangelands (Lacey et al., 1984). Grazing with sheep may reduce the rate of spread of leafy spurge. Continuous grazing of sheep through four growing seasons reduced a leafy spurge population over 90% (Helgeson, 1942; Johnston and Peake, 1960). Although stem densities and basal areas are often reduced, no studies have documented that livestock grazing will actually kill leafy spurge. As with any weed control method, grazing with sheep requires a long-term commitment.

Spotted knapweed *(Centaurea maculosa)* is an aggressive invader of rangelands and pasture in the Northern Intermountain Region (Harris and Cranston, 1979; Myers and Berube, 1983). In Montana, about two million hectares of rangeland and pasture are infested with spotted knapweed (Lacey and Olson, 1991; Bedunah, 1992). Spotted knapweed invasion is probably facilitated by disturbance (Silvertown and Smith, 1989) and increases soil erosion (Lacey et al., 1989). Tyser and Key (1988) found that spotted knapweed is invading and even displacing native plant species on relatively pristine sites in Glacier National Park. Many of the plants grow on pocket gopher mounds, in sites where elk concentrate and other areas of localized natural disturbance. Although excluding livestock from certain areas may minimize disturbance, it clearly will not prevent weed invasion; this is exemplified by the infestation in Glacier National Park.

A Montana rancher (Cox, 1989) reported that sheep readily graze spotted knapweed and the potential of sheep controlling the weed is being evaluated (Olson et al., 1993). Repeated (mid-June, mid-July, early September) short duration grazing is reducing flower stem production of spotted knapweed on a knapweed-infested Idaho fescue *(Festuca idahoensis)* range site in southwestern Montana (Olson et al., 1993). In some years, sheep actually grazed spotted knapweed more than they grazed Idaho fescue. By repeatedly grazing spotted knapweed while the associated grasses are dormant, Olson et al. (1993) hope to suppress knapweed growth and reproduction, while favoring growth of the associated grasses.

Fringed sagewort *(Artemisia frigida)* is widely distributed on western rangelands (Spang, 1954). Although the plant has some forage value in the southern U.S., the species is avoided by cattle foraging on the northern Great Plains and in the mountain foothills. However, utilization of fringed sagewort averaged 60% on a winter sheep range in Montana (Spang, 1954). Presumably, this fringed sagewort population would have been reduced if this level of use had been continued for several years.

Kudzu *(Pueraria lobata)*, an introduced perennial vine, is invading many native plant communities in the humid southeastern U.S. (Glimp, 1985). Kudzu growth was reportedly controlled with sheep grazing, and ewe gains and breeding results indicated that the sheep suffered no ill-effects from grazing the weed. Glimp (1985) suggested that sheep grazing would be a cost-effective alternative to chemical control at $360.00 per hectare.

Oxeye daisy *(Chrysanthemum leucanthemum)* is a perennial herb with shallow, branched rhizomes and adventitious roots. It is native throughout Europe to northern Scandinavia and Lapland, and was probably carried in contaminated seed or introduced as an ornamental to North America. Oxeye daisy is more common in grazed than ungrazed communities. Although cattle refuse to eat oxeye daisy, the plant is grazed readily by sheep (Howarth and Williams, 1968). Thus, oxeye daisy tends to increase under close cattle grazing but decreases under continuous sheep grazing (Norman, 1957). This exemplifies how a certain kind of animal can be used to shift species composition of plant communities.

Small clubmoss *(Selaginella densa)* is an important component on 6.4 million hectares of foothills and glaciated plains in Montana. Although it may occupy from 10 to 80% of the soil surface, it does not produce much forage (Van Dyne and Vogel, 1967). Mechanical treatments are often recommended to reduce clubmoss cover, but grazing may be a better alternative than mechanical treatments that seriously disturb the soil surface. Van Dyne and Vogel (1967) reported a greater decrease in clubmoss cover

on grazed areas compared with protected areas. Clubmoss was reduced by grazing and trampling and by the additional nutrients supplied by fecal material. Presumably, these added nutrients increased the competitive ability of associated plants, allowing them to shade out the clubmoss.

Sheep have been used to reduce poisonous plant problems on rangelands in the Southwest. Sheep readily graze senecio *(Senecio* spp.) plants that are, on a body weight basis, 20 times more poisonous to cattle than to sheep (Dollahite, 1972). However, James Pfister (personal communication) cautions that sheep are susceptible to acute poisoning when grazing the plant.

Tall larkspur *(Delphinium* spp.), a native herbaceous forb, is the leading cause of cattle deaths on mountain rangeland (Ralphs et al., 1991). Some ranchers (Etchepare, 1985) believe that cattle losses are most likely in early spring because tall larkspur is one of the first plants to produce significant growth. On the other hand, Pfister et al. (1988) found that the plant was unpalatable to cattle from the bud stage until flowering racemes elongate. Cattle generally consumed more in the pod stage. Even though the plant is less toxic at this stage, cattle losses are more likely to occur. Losses can be reduced by grazing sheep before cattle. Sheep are four to six times more resistant to larkspur alkaloids than are cattle (Olsen, 1978). Sheep effectively reduce the availability and/or acceptability of larkspur to grazing by cattle (Ralphs et al., 1991). Sheep consumption varies from 40 to 90% in some years to 0% in other years (Ralphs et al., 1991). Similar to cattle, immature larkspur is relatively unpalatable to sheep. Because of this factor and the year-to-year variability in palatability, a herding program forcing sheep to eat, trample or bed down on larkspur patches is recommended. Although sheep will not eliminate larkspur, they are a cost-effective method for controlling the spread of the plant and for allowing more cattle grazing on larkspur-infested range.

Sheep are rarely poisoned by the alkaloids in tansy ragwort *(Senecio jacobaea),* a plant that is poisonous to cattle and horses (James Pfister, personal communication). Intensive early-season grazing by sheep will suppress tansy ragwort, reduce the ability of plants to flower and produce seed and kill some mature plants (Bedell et al., 1981; Sharrow and Mosher, 1982). Sheep grazing is most effective if it coincides with the rosette stage when the sheep seem to prefer the plant (James Pfister, personal communication). Although photosensitization is possible, particularly in young animals consuming large amounts of leaf material, sheep may be able to suppress tansy ragwort.

Sheep are also less susceptible than cattle to poisoning from St. Johnswort *(Hypericum perforatum;* Southwell and Campbell, 1991). Sheep need to ingest 4% of their body weight of St. Johnswort before they are affected, whereas cattle are affected by this species when they ingest only 1% of their body weight. However, the use of sheep to control the plant is not generally recommended. The plant affects the liver of sheep (causing photosensitization), depresses the central nervous system and increases their sensitivity to temperature change and handling.

Federal land management agencies are using sheep to control noxious or poisonous weeds on some federally-managed ranges. The Bureau of Land Management is grazing sheep on 1,260 hectares, specifically to control weeds (Table 1). The Forest Service (Charles Richmond, personal communication) reports that sheep are being used to reduce the threat of tall larkspur poisoning to cattle on forests in Montana and Idaho. Because of the magnitude of the noxious weed problem on federally-administered lands, using sheep to control weeds is expected to increase (Hank McNeal, personal communication).

A realistic expectation of sheep grazing for weed control is needed. Sheep grazing will not be able to control all weeds. For example, with bull thistle *(Cirsium vulgare),* a serious biennial weed, sheep grazing reduced the competitiveness of associated plants and thereby increased the growth, seed production and seedling survival of bull thistle (Forcella and Wood, 1986).

Dyers woad *(Isatis tinctoria)* is an introduced cruciferous forb that is displacing desirable forage plants on Intermountain rangelands (West and Farah, 1989). In their grazing study, sheep grazed about 16% of their marked plants. On these grazed plants, use ranged from 18 to 29%, and thus did not significantly increase mortality or decrease percent flowering, mean fruit production or fruit weights of the dyers woad (West and Farah, 1989). West and Farah concluded that the high stocking rates that would be needed to limit dyers woad would likely cause further range deterioration.

Cost of Sheep Grazing (Prescription)

Economic factors also influence the feasibility of using sheep to control weeds. Each sheep flock operates within a different set of farm objectives, balance of enterprises and variable and fixed costs (Pollott, 1986). Profitability depends on the physical performance of a flock and

Table 1. Current status of sheep grazing for weed control on Bureau of Land Management lands.[a]

Target weed	Number of projects	Location	Number of hectares	Relative success
Leafy spurge	6	UT, WY	1,260	good-excellent
Perennial pepperweed	1	UT	2	(began in 1993)

[a] Information compiled by Hank McNeal, Weed Coordinator, Bureau of Land Management, State Office, Billings, MT 59107-6800.

the influence of the national economy.

Sheep production is limited on some leafy spurge-infested ranges because landowners are limited by human, physical or capital resources. These situations may be a win-win situation for the landowner and a sheep producer who is seeking additional pasture. However, most sheep operations are managed as a long-term enterprise, where numbers are balanced with long-term feed resources. There may be no economic advantage to leasing a weed-infested pasture, especially if predators are a problem in the area. Predator problems often reduce or even eliminate the profit from producing sheep.

Landowners in some parts of Montana partially reimburse sheep producers for leafy spurge control (Mark Kossler, personal communication). Sheep producers often seek long-term leases (five or more years) and have negotiated private lease rates of $4.00 to $6.00 per animal unit month. Although reports of private landowners actually renting sheep or goats to control leafy spurge are rare, federal land agencies in Montana have developed several strategies encouraging the use of grazing animals to control weeds. For example, the Bureau of Land Management, the Forest Service and the Bureau of Reclamation have allowed sheep to graze leafy spurge infestations on cattle allotments and on areas traditionally managed for recreation (Huhtala, 1993). In these situations, no fee is charged for grazing the sheep.

The above strategy uses sheep as a method of biological weed control. Prescriptive grazing treatments include controlled periods of grazing and rest. Reportedly, agencies have paid goat producers to graze weeds in woody riparian areas, but we have not heard of agencies actually paying a rental fee to sheep producers. As noxious weeds continue to increase on rangelands, land administration agencies and landowners may eventually be willing to rent sheep.

Management Tips

Sheep probably need to be herded on rangelands and in large pastures to enhance their effectiveness as a weed control method. Open herding of sheep, compared with "close" herding, is more beneficial in some situations (Stoddart and Smith, 1955). With open herding, the flock is "herded" from the front by guiding the movement of lead animals and by avoiding excessive use of dogs. Sheep are allowed to feed quietly and are moved only enough to secure feed. Sheep are allowed to water once each day and are not allowed to use shade for more than one hour. They are never driven hastily (Stoddart and Smith, 1955). In contrast, close herding keeps the animals bunched and much forage, including weeds, is trampled into the ground. Thus, it is wasted for subsequent use by livestock and wildlife.

Knowing how sheep behave will enhance the potential of using them to control weeds. Stoddart and Smith (1955) recommended the use of a one-night bedding system. This avoids excess travel which occurs if sheep are brought into a central camp each night. It also prevents the rangeland around a camp from becoming excessively disturbed, opening the site to weed invasion. Alternatively, increased grazing of noxious weeds could be encouraged by using heavy weed infestations as bed grounds.

Because they are a social animal, sheep are easier to control if they can see other sheep. They balk at changes in light or shadows and at changes in textures of surfaces underfoot (Lynch et al., 1992). Flocking, or the tendency of sheep to bunch up, is more pronounced when sheep are resting or during times of disturbance. Flocks in adjacent pastures usually select respective resting sites directly across the dividing fence. Flocking also creates uneven distribution of nutrients from excreta and may increase the likelihood of "patchy" grazing.

Patchy grazing and uneven forage utilization may require a better herder or additional fencing. Greater concentrations of sheep in smaller areas are needed to overcome patchy grazing. Intensive management is possible with power (electric) fencing.

Seeds of many plant species are ingested as animals graze during or after seed formation (Heady, 1954; Lehrer and Tisdale, 1956; Piggen, 1978; Simao Neto et al., 1987). Ingested seeds can be transported great distances while in the digestive tract of animals. Consequently, seeds that retain their viability after passage through the digestive tract will contribute to the spread of plant species. Some leafy spurge and spotted knapweed seeds remain viable after passing through the digestive tract of sheep (Lacey et al., 1992; Wallander et al., 1993). Although this has serious consequences when weedy species are ingested, seed passage through ruminants is being considered as a means to seed desirable species in areas inaccessible for conventional seeding methods (Archer and Pyke, 1991).

Seed disseminated in feces of sheep may have influenced the spread of weeds, just as seeds disseminated from feces of other herbivores may partially explain the rapid spread of weedy species on western rangelands (Fisher, 1947; Heady, 1954; Lehrer and Tisdale, 1956). Thus, sheep should not be moved from weedy pastures onto weed-free areas until all weed seeds have passed through the digestive tract. For leafy spurge, a five-day waiting period is recommended (Lacey et al., 1992).

Landowners with a weed infestation should try to buy or lease grazing rights to flocks that have had experience with the particular weed. Selective grazing can be minimized by altering the timing of grazing to prevent desirable species from being overgrazed when they are most susceptible and by regulating the number and kind of livestock. Controlled grazing systems that concentrate animals into smaller pastures and shorten the length of the grazing period are usually recommended. An increased stocking density (number of animals on a unit of land at a specific time) will: 1) improve animal distribution which

promotes more even utilization of forage throughout the pasture; and 2) reduce selective grazing which in turn will increase the number of species grazed, including weeds.

Grazing programs should be designed to minimize damage to desirable plants and maximize damage to undesirable plants. Since grasses are most susceptible to grazing when their growing points (apical meristems) are being elevated, grazing should occur either before internode elongation or after the grasses have flowered. For controlling weeds, the probability of success increases if "weedy" species are palatable, susceptible to grazing when defoliated or, preferably, both.

Single grazing events may not be enough. While spotted knapweed and other weeds are not seriously impacted by a single defoliation, they are susceptible to repeated defoliations (Kennett et al., 1992). Therefore, an intensive grazing system that includes two or more grazing periods (followed by a rest period to enhance regrowth) per growing season is recommended over continuous season-long grazing. Grazing periods should be ended when foliage on desirable plants reaches the minimum levels required for photosynthesis and rapid growth.

Conclusions

Sheep have many characteristics that enable them to be used to control weeds on rangelands. However, it is misleading to describe sheep as self-propelled integrated weed management units with built-in weed detectors. For effective weed control, sheep grazing must be integrated with proper rangeland and pasture management. Grazing programs should be planned to minimize damage to desirable plants while maximizing damage to weeds. This usually requires that animals be grazed in smaller pastures for shorter periods of time.

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