Sheep Grazing and Leafy Spurge Control

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The Biology of the Leafy Spurge Plant

Leafy spurge is a highly adaptable plant that can thrive in a many different conditions and situations. It is a long-lived, deep-rooted perennial that reproduces by seed and from spreading roots (Morrow, 1974). Once established, the weed spreads quickly displacing native vegetation. Prolific seed production and extensive root systems gives it a large competitive advantage and once established make consistent long-term control difficult. Flowering of terminal clusters consists of a small green and inconspicuous flower surrounded by a pair of yellow leaves (bracts) that are more noticeable and usually mistaken for flowers (Messersmith et.al., 1985). In Montana these yellow bracts appear in late May with maximum presence in mid-June. The first fully developed seeds occur in early July with seed dispersal in mid-July. After seeds mature, the seedpods burst and throw seeds up to 15 feet (Bakke, 1936; Wicks and Dersheid, 1964). Once released from the capsule, birds, rodents and insects may further disperse the seeds. In addition they float and are frequently dispersed by streams and irrigation ditches. An average of 140 seeds is produced per stem and seeds often remain viable in the soil for as long as 8 years (Bowes and Thomas, 1978). It has been estimated that plants within a mature dense patch of leafy spurge produce about 2,500 seeds per square meter annually (Best et.al. 1980).

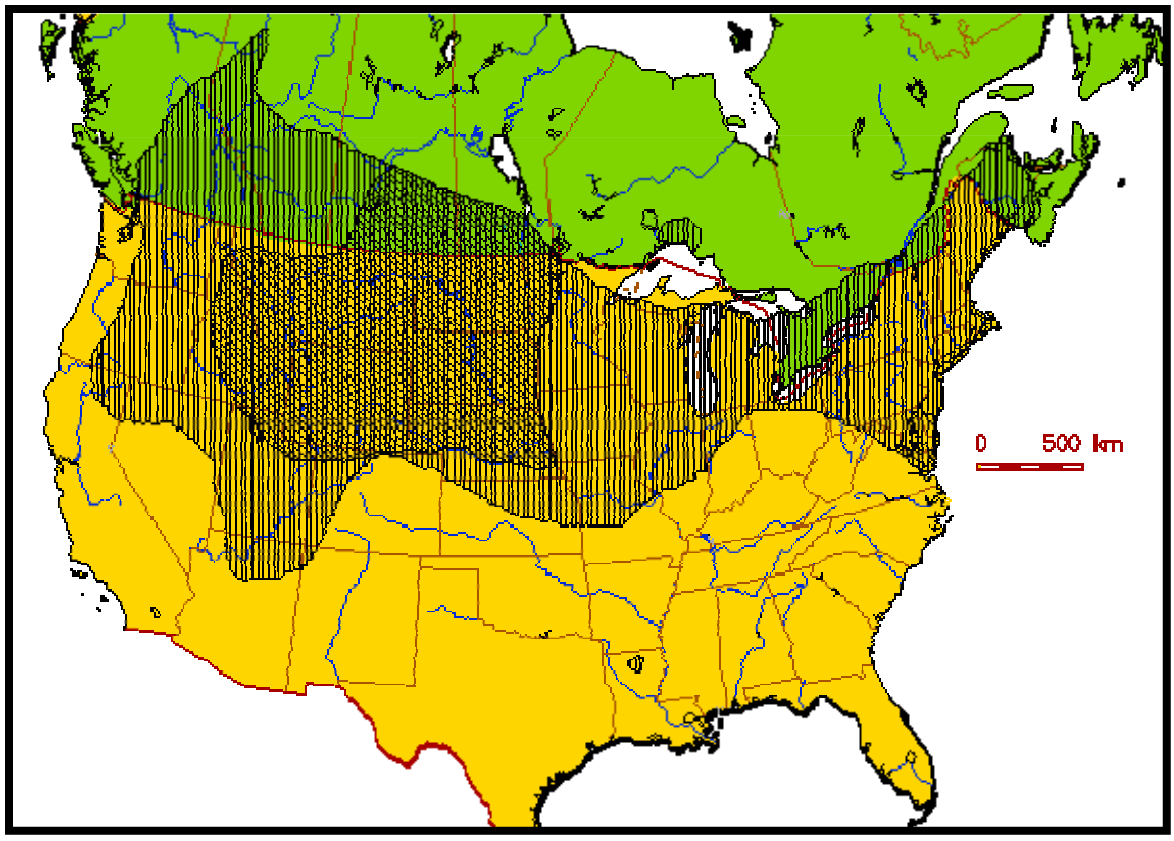
Leafy spurge has an extensive root system that occupies a large volume of soil. They are most abundant in the upper foot of soil but some roots can extend to a depth of 30 feet (Coupland and Alex, 1954). Root fragments as small as ½ inch long can give rise to a new plant (Raju et.al., 1964). They have the ability to regenerate a new plant from almost any depth. Leafy spurge plants tend to grow in parches representing clones derived from individual spreading root systems that produce numerous root buds. An established, mature patch of leafy spurge will usually spread at a rate of 1 to 3 feet per year (Stroh et.al., 1990). New plants emerge in late April from rootstock and in May from seed.

Distribution of Leafy Spurge

Leafy spurge is an invasive perennial weed that overruns and destroys grazing lands for livestock, degrades wildlife habitat and wildlife-associated recreation, decreases rangeland plant diversity, threatens native plants and reduces land values (Belcher and Wilson, 1989; Leistritz et.al., 1992). The single greatest direct impact of leafy spurge is the reduction of populations of native grasses and forbs and associated ecosystem changes caused by the superior competitive abilities of this nonnative plant (Steenhagen and Zimdahl, 1979). In North America, leafy spurge infestations range from about 36^{o}N

in northern Arizona to about 58°N in the Peace River district of Canada (Selleck et.al., 1962). It infests more than 2.7 million acres, mainly in the northern Great Plains and Intermountain West of the United States and the prairie provinces of Canada (Best et.al., 1979; Dunn, 1979: Figure 1.). By the mid 1980's it had infested over 640 thousand acres of rangeland in Montana and has increased substantially since than (Lacey et.al. 1985). Economic losses due to leafy spurge infestation in the upper Great Plains (Montana, North Dakota, South Dakota and Wyoming) is estimated at $129.5 million and represents a potential loss of 1433 jobs (Montana Weed Control Assn.).

Figure 1. Map of Leafy Spurge infestation in North America. The crosshatched area represents the region of greatest infestation. (from magi.com)



Leafy Spurge and Cattle and Wildlife Grazing

Leafy spurge reduces cattle carrying capacity in two ways. It suppresses forage production by displacing many of the desirable grasses and forbs that are normally consumed by cattle, deer, elk or most other grazing animals. In most instances areas heavily infested leafy spurge plants contain less than 50% desirable grass and forbs. Secondly, cattle avoid range sites heavily infested with leafy spurge. If cattle and wildlife stocking density is not reduced, leafy spurge infestations causes them to concentrate or increase use of non-infested sites, resulting in over use of these areas which in turn decreases preferred herbage species, decreases species diversity and improves conditions for additional invasion of undesirable plant species (Lym and Kerby, 1987). In a North Dakota study, a range site producing 5500 pounds of grass per acre had no cattle utilization because of leafy spurge infestation (Hein et.al., 1992). It was estimated that in 1994, the grazing area lost to leafy spurge infestation in the upper great plains (eastern Wyoming, South Dakota and North Dakota) would support 90,000 cows (Leitch et.al., 1994).

In order to achieve optimum forage utilization with cattle (50% utilization of available forage) on a particular range site, canopy cover of leafy spurge cannot exceed 10% (Hein et.al. 1992). As leafy spurge canopy cover increases above 10%, forage utilization declines rapidly to practically no utilization when canopy cover exceeds about 40% (figure 2).

Although leafy spurge density varies with range site, the percent composition of leafy spurge in mature, established leafy spurge patches usually exceeds 40%. As a rule of thumb, ranchers should expect to receive little to no cattle grazing from these areas. Cattle will only utilize the grass in those areas of the pasture that are not heavily infested with leafy spurge. The influence of leafy spurge infestation on carrying capacity for cattle is shown in figure 3 (Williams et.al., 1996). When about 50% of the pasture is covered by leafy spurge patches, the carrying capacity of the pasture is about 40 of normal.

Figure 2. Influence of leafy spurge canopy cover on forage utilization by cattle. (Hein et.al. 1992)

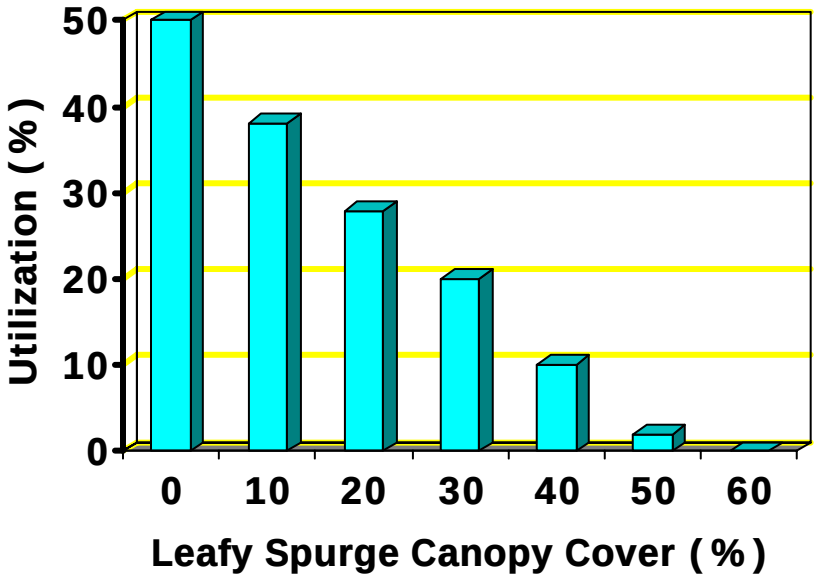


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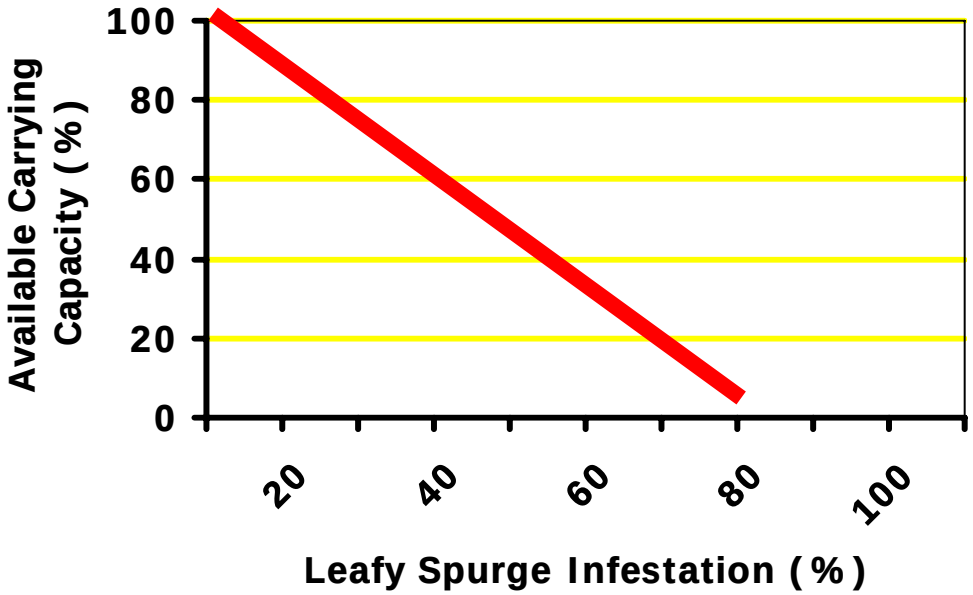
Figure 3. Influence of leafy spurge infestation on cattle –grazing capacity. (Williams et.al., 1996)



Leafy spurge infestations also have, in most instances, a negative impact on wildlife habitat. Studies conducted in the Theodore Roosevelt National Park in North Dakota documented a pronounced reduction in use by native ungulates of leafy spurge infested sites (Trammell and Butler, 1995). They reported that leafy spurge infested sites had a reduction in use of up to 83%, 81% and 79% by bison, elk and deer, respectively.

Consequences of Ignoring the Problem

The economic impact of leafy spurge infestations varies greatly from ranch to ranch however ignoring the problem is almost never the best option. In a recently published manual (Merritt, et.al., 2000) published by USDA-ARS TEAM Leafy Spurge Area-Wide IPM Program it was stated that, "If you've got leafy spurge, you're either losing money or aren't making as much as you could and ignoring the problem will only make matters worse." An analyses of loses a rancher could expect from a leafy spurge infestation is shown in table 1. If a pasture had a sustainable carrying capacity of 0.2 AUM per acre but is infested with total of 100 acres of relatively dense established leafy spurge patches, a rancher could expect to loose 192 AUM's of cattle grazing over a 10 year period. Assuming that an AUM of cattle grazing is worth $15.00/AUM the economic loss over the ten year period is $2880.00. In short, in this example, choosing to ignore the leafy spurge problem will result in a direct loss of $2.88 per acre per year in lost grazing. An estimated carrying capacity of .2 AUM's / acre or 5 acres per AUM is conservative for sites that are typically infested with leafy spurge (river bottoms) in Montana. A carrying capacity of .4 AUM's / acre or 2.5 acres per AUM is probably more realistic estimate resulting in an economic loss in cattle grazing capacity of $5.70 per infested acre.

Table 1. AUM loss from a 100-acre leafy spurge infestation over 10 years.[ab]
(adapted from Merrmitt et.al. 2000)

Carrying Capacity	Lost AUM,s		Lost Cattle Grazing[d] ($/year/acre)
	Period[c]	Year/acre	
Low (5 acres/AUM)	192	0.19	$2.88
Average (2.5 acres/AUM)	384	0.38	$5.70
High (1.7 acres/AUM)	576	0.56	$8.40

[a]Assumes initial patch density of greater than 40%. A 40% patch density translates into essentially no cattle grazing within the patch.
[b]Estimates are conservative as this analysis does not take in account of additional losses in grazing due to patch expansion. It is estimated that these patches will increase in size 1 to 2 radial feet per year. AUM's lost from 100-acre leafy spurge infestation over 10 year period.
[d]AUM's valued at $15.00.

In addition these estimates are low as they do not take into account any losses associated with expansion of leafy spurge patches. One should assume that without control these patches will expand at the rate of 1 to 3 radial feet per year (Stroh et.al., 1990).

Assuming patch expansion of 2 radial feet per year the value of the lost cattle grazing in the above example rises to $3.05 per acre of infestation (Snell et.al., 2000).

Control of Leafy Spurge Infestations

Control of leafy spurge is a major concern for most land managers in the northern Great Plains or intermountain states. Although there are a number of management options (chemical, cultural and biological) available to land managers, each has its limitations on applicability and effectiveness such that any one method will probability not be practical in all situations. Efficient management of leafy spurge infestations will in most cases involve an integrated approach utilizing all tools available. Eradication of young and isolated leafy spurge plants is possible and will usually involve some form of chemical control. As patches get older and the root systems become more firmly and deeply established they become virtually impossible to eradicate. These pervasive root systems contain extensive nutrient reserves and are able to block the downward movement of herbicides below the root crown. Strategies for dealing with these established leafy spurge patches should be focused on not allowing these patches to grow in size and management of these patches to increase native forage production and utilization within these patches. Herbicides will not eradicate these established patches but can be utilized in managing weed production in these patches (Lym and Messersmith, 1990). In order to achieve affective control of old established patches they must be treated 5 to 6 out of 10 years (Alley et.al., 1983). Based on this level of treatment (application rate of 5 to 6 time per 10 years) the annualized treatment cost of herbicides is between $10.00 and $15.00 per acre per year. Herbicides may be the most affordable and quickest tool for containing and controlling isolated plants scattered here and there. But, if leafy spurge infestation is fairly extensive (patches are fairly large and extensive), the cost of herbicides will usually exceed the benefits returned (annual application costs of $10.00 to $15.00 per acre with a potential benefit of $3.00 to $5.00 per acre). The cost of chemical control may exceed in some instances the original cost of the land (Lavigne, 1984).

Biological control (insects) may provide land managers the best opportunity to eradicate these established patches of leafy spurge (Story, 1992). They are economical as they do not require a large investment in time and money to establish. Once established, leafy spurge bio-control agents are self sustaining. However, like other management tools, they are not the perfect solution. The biggest problem is that it will take a number of years before populations of insects are satisfactory to begin making a significant contribution to leafy spurge control. In most cases it at best is a long term solution. Control of leafy spurge with insects will not solve the problem as quickly as necessary and ranchers must consider other control options in the meantime. Also, in certain conditions, using insects to control leafy spurge has provided only marginal results (Bangsund et.al. 1996).

Another form of biological control that has proven to be cost effective is sheep and/or goat grazing (Alley and Messersmith, 1985). Sheep grazing of established infestations of

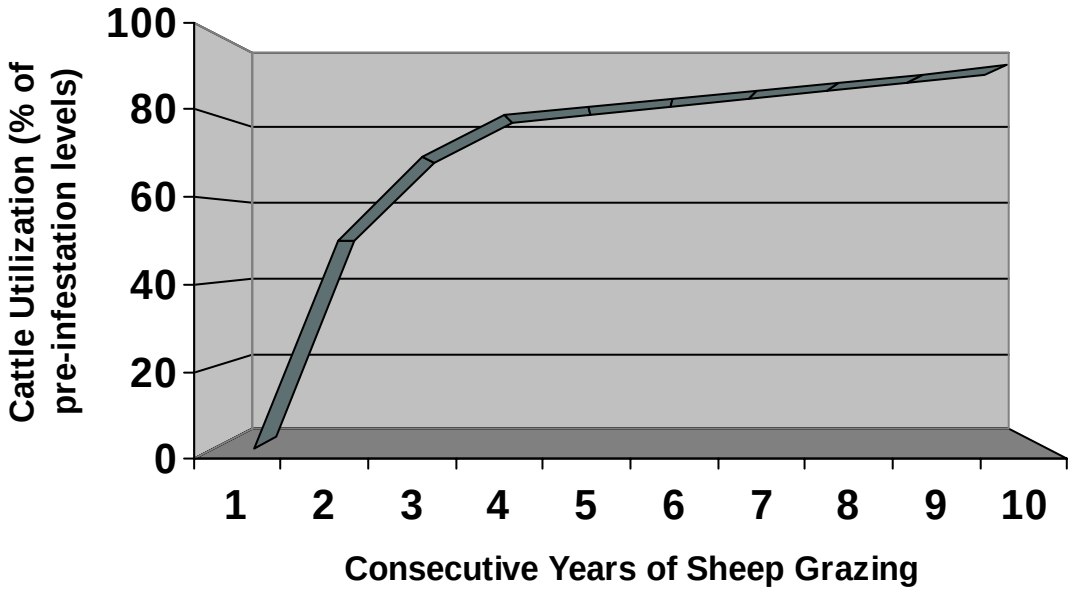
leafy spurge can have a two fold benefit: 1) It will decrease the density and/or canopy of leafy spurge and thereby increasing grass production and utilization by cattle within the leafy spurge patches (prior to sheep grazing cattle avoid grazing in these patches and therefore do not normally utilize any of the grass within these patches) and 2) sheep can directly generate revenue which may provide positive returns.

Controlling leafy spurge infestations will require a significant commitment on the part of the land manager. A long-term commitment is required to reduce existing infestations, stop the spread and start reclaiming lost grazing land. It will take an integrated approach utilizing all tools available. If the scale of leafy spurge infestation rules out herbicides than the use of sheep and/or goat grazing should be considered as the cornerstone of an integrated weed management program. When sheep grazing is incorporated into a weed management program, land managers need to assure that any agreement made with sheep owners provide for access to sheep grazing for several years.

Using Sheep Grazing To Control Leafy Spurge Infestations

Sheep grazing is often the most economical and ecologically sound tool available to manage invasive plants such as established patches of leafy spurge. Although sheep grazing will reduce density and biomass of leafy spurge, eradication is not likely (Lacey et.al., 1985). Like using herbicides sheep grazing will not eradicate the weed, but can be used to control or manage the infestation. North Dakota State researchers (Bangsund, et.al., 2000) modeled the affects of sheep grazing on leafy spurge infestations. They estimated that a site with virtually no cattle grazing because of leafy spurge infestation will have a carrying capacity of about 70% of pre-infestation levels after 3 consecutive years of sheep grazing (figure 4).

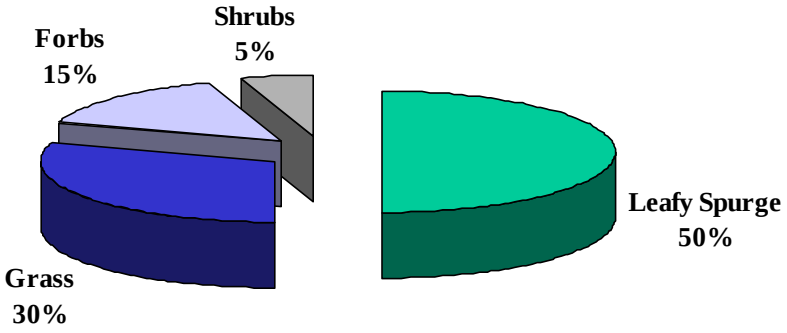
Figure 4. Grass Consumption by cattle within leafy spurge infestations controlled with sheep. (Bangsund, et.al., 2000)



Diet Selection:

Sheep and goats selectively and extensively graze leafy spurge. Research conducted at Montana State University (Landgraf et.al., 1984 and Bartz et.al., 1985) showed that following a brief adjustment period (1 to 3 weeks) sheep will selectively consume about 40 to 50 percent of their diet as leafy spurge (figure 5) even when a substantial amount of grass and other forbs are present (range composition up to 70% grass in study sites). In addition, sheep that had been exposed to leafy spurge the previous year, initially, tend to consume leafy spurge more readily (Olson et.al., 1996). But, the advantage with experienced sheep is short lived. After 3 to 4 weeks, sheep that had never been exposed to leafy spurge will readily and selectively consume the plant. When implementing a management system that utilizes sheep grazing to manage leafy spurge infestations it is essential that during the adoption period, management should focus on encouraging the sheep to begin consuming leafy spurge plants. This may involve initially holding sheep on heavier infested areas.

Figure 5. Predicted diet of sheep grazing leafy spurge infested pastures.
(Adapted from Landgraf et.al., 1984 and Bartz et.al., 1985)



Sheep will selectively graze leafy spurge plants consuming 50 to 95% of the leafy spurge biomass, allowing desirable grasses and forbs to grow and be productive for cattle and wildlife consumption. Since cattle and most wildlife avoid leafy spurge infested areas these grasses would not have been available to cattle without first removing the above ground leafy spurge growth. In many instances sheep grazing will actually increase rather than decrease the forage available for cattle and wildlife grazing.

Sheep Performance:

Leafy spurge meets of exceeds the nutrient requirements of mature sheep and goats throughout the growing season. The nutrient composition of leafy spurge is superior to grass and is fairly similar to alfalfa (table 2).

Table 2. Crude protein content (DM) of grass, leafy spurge and alfalfa.

	Grass[a]	Leafy Spurge[b]	Alfalfa[a]
Initial Standing Crop	6	12	15
Grazed Regrowth	18	20	20
Final Standing Crop	8	8	14

[a]Adapted from NRC 1985
[b]Adapted from Bartz et.al. 1985.

Grazing trials conducted by Montana State University showed that there is no detrimental affects of consuming leafy spurge on ewe or lamb performance (Bartz et.al. 1985). In fact, lamb gains were higher in the ewe / lamb pairs grazing leafy spurge infested pastures (table 3). In more controlled experiments, no negative affects were found on rumen digestion and metabolism in sheep when leafy spurge comprised 50% of the total daily diet (Thomas et.al. 1994).

Table 3. Average daily gains of lambs grazing pastures with differing levels of leafy spurge infestation. (from Bartz et.al. 1985)

Leafy Spurge Infestation	Average Daily Gain
Control (0%)	0.4
Light (10 – 20 %)	0.5
Heavy (> 20%)	0.6

Stocking Rates:

In designing a grazing program for leafy spurge management, the goal is to have enough grazing density to manage the leafy spurge but minimize the utilization of grass that may be available to cattle. Since in most cases leafy spurge infestations has resulted in marked reductions in cattle carrying capacity of the site, sheep grazing can be added without affecting cattle carrying capacity. When grazing cattle and sheep on leafy spurge infested sites the dietary overlap is generally very low (less than 20%).

The rule of thumb, used by most Montana resource managers is that one to one and one-half ewe and her lambs can clean up about one acre of leafy spurge per month (Wayne Peirson, personal communication). North Dakota State researchers (Merritt, et.al., 2000) recommend an average stocking rate of about 1 to 2 sheep per acre of leafy spurge for a four month grazing season, with lighter stocking rates in western and heavier stocking rates in eastern North Dakota. The differences between the stocking rates being

recommended in Montana and North Dakota are probably more related to differences in site productivity than to differences in grazing philosophy. The appropriate stocking rate to use when utilizing sheep grazing as a tool for leafy spurge management is probably very closely related to the estimated stocking rate (AUM's) of that site prior to leafy spurge infestation. The big difference is the number of AUM's of cattle grazing that site will support. Sheep stocking rates for sites with a pre-infestation carrying capacity of .2 AUM/acre is probably about 1 sheep per acre of spurge per month. On the other hand when pre-infestation site productivity is .6 AUM/acre or higher the sheep stocking rate of 1 to 2 sheep per acre of leafy spurge for a four month grazing season as recommended by North Dakota land managers, may be more appropriate.

Stocking rates should be based on the actual infested acreage rather than pasture size. This will minimize any potential conflicts between cattle grazing and sheep grazing. Over time, as leafy spurge densities decline, sheep/goat stocking rates can be reduced and cattle numbers increased.

Sheep grazing and Leafy Spurge Seed Distribution:

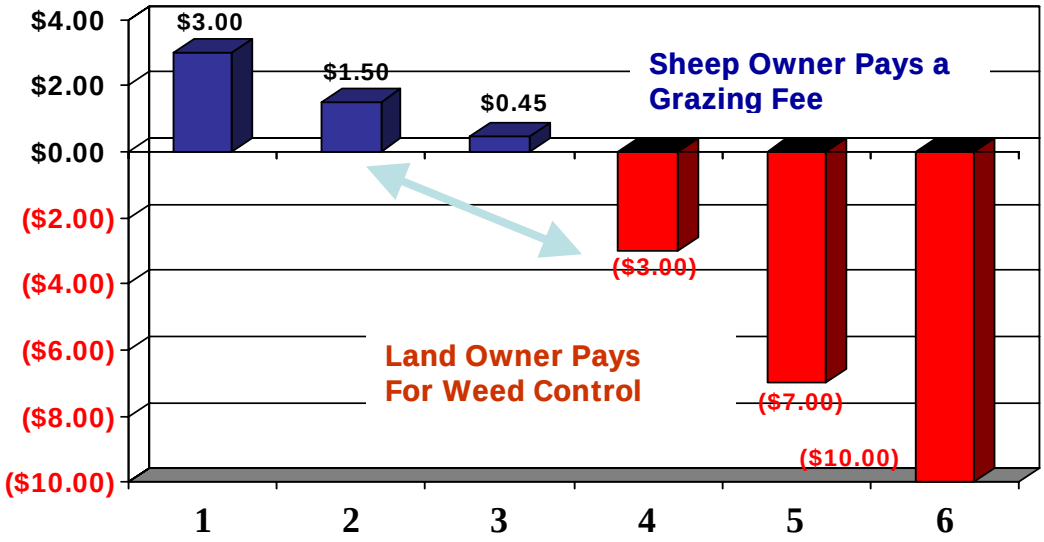
One concern often expressed when considering utilizing sheep grazing to control leafy spurge is whether sheep can disperse leafy spurge seed either in their fleece or by ingesting and passing viable seed in their feces. The risk of spreading leafy spurge through contamination of fleeces is minimal (Olson, et.al., 1997). Sheep are generally in short wool when grazing leafy spurge and thus not likely to pick up many seeds. Any seeds picked up will quickly become embedded in the fleece and once embedded will remain in the fleece through shearing.

Although seed passage rate and viability of leafy spurge seeds consumed by sheep is extremely low some may be viable (Olsen et.al., 1997) and thus strategies should be implemented to eliminate the potential of distributing leafy spurge. Research at Montana State University (Lacy et.al. 1992) showed that less that 20% of seeds ingested by sheep escape digestion. Most of the undigested seeds were passed in the initial 4 days after ingestion and all were passed by day 9. Viability of seeds recovered following ingestion by sheep deceased from 40% on day 1 to zero on the 5'th day and thereafter. Land managers using sheep to manage leafy spurge infestations should attempt to graze the leafy spurge plants so they do not flower or if it does set seed it is recommended to not move the sheep to a non infested area until 5 days after the sheep have been removed from the seed source.

Economics Of Of Using Sheep Grazing To Control Leafy Spurge

The appropriate compensation package for sheep grazing weeds is one of the more controversial issues in this type of program and is likely the main reason sheep are not included in many weed management programs. In many instances, when sheep grazing is included in the weed management program, land owners tend to view it as an additional source of income rather that a more economical tool for weed control. Consequently, the resulting grazing strategies focuses more on economical sheep production that weed management. Grazing stratigies for sheep production and weed control are not that dissimilar, but they are different. If the goal of the sheep grazing program is to optimize weed control and cattle forage availability, a higher level of management intensity will be required. Compensation packages being used varies from the sheep producer paying the land owner a grazing fee for forage consumed to the land owner paying the sheep producer for weed control (figure 6). It should be noted that the primary objective, and thus design of the grazing strategy usually follows the compensation package.

Figure 6. Economics of grazing sheep on leafy spurge.



1) Sheep owner pays full AUM rate. [$15.00 ($/AUM) ÷ 5 (# sheep/AU)]
2) Sheep owner pays for grass sheep eat. [Sheep's diet is about 50% spurge – 50 % grass: ($3.00 × 50%]
3) Sheep owner pays only for "cow grass." [Only about 30% of the grass consumed is available to be utilized by cattle—remainder is within spurge patches: ($1.50 × 1/3)]
4) Land owner pays for direct benefit in improved cattle carrying capacity.
5) Land owner pays based on next best alternative – sheep owner pays full AUM rate [$11.33 (spray cost/acre) -$3.00 (grazing fee/sheep/month)]
6) Land owner pays based on next best alternative (chemical control). [Cost of spraying is $30.00 / acre and must be repeated every three years: $30.00 ÷ 3)]

In a sheep production system, sheep readily graze and perform well on leafy spurge. Thus, in a sheep production system leafy spurge can be viewed as a viable forage just as grass. Also, research has shown that in addition to leafy spurge, sheep will eat about 50% grass with about 1/3 of this grass being available to other livestock. Given this, land managers have, in many cases, viewed sheep grazing as a resource or source of supplemental income. Typical scenarios include charging the market rate for grazing (scenario 1 in figure 6); charging for the grass the sheep eat (scenario 2 in figure 6); or charging for the grass the sheep eat that would be available to other livestock grazing – lost grazing realized by the landowner (scenario 3 in figure 6). It should be noted that in each of these scenarios that weed control is a byproduct. The primary objectives of these scenarios is sheep production – maximizing lamb and wool production while minimizing input expenses. There is little economic incentive to the sheep producer to concern himself with weed control as he is paying for the forage being utilized.

Scenarios 4, 5, and 6 (figure 6) reflect management strategies that focus on week control rather than sheep production. They include compensation packages based on the next best weed control alternative – chemical control (scenario 6); a scenarios where the landowner is responsible for the cost of weed control based on the next best alternative and the sheep producer is responsible for the normal market value of grazing (scenario 5) or a rate based on the direct benefit the landowner receives from sheep grazing/weed control on carrying capacity of other livestock (scenario 4).

The most realistic scenario is probably somewhere between the sheep owner paying the land owner a grazing fee for the grass the sheep eat ($1.50/sheep/month; scenario 2) and the land owner paying the sheep owner for weed control based on the direct benefit received in improved cattle grazing ($3.00/sheep/month; scenario 4). The other more extreme scenarios (scenarios 1,5 or 6) result in a situation that is either not economically feasible to the landowner or the sheep producer.

The optimum compensation package will vary between ranches, but in all situations should reflect the goals of the grazing program – sheep production or weed control.

Grazing Plan:

Controlled or strageic grazing by sheep and/or goats can be a highly effective weed management tool with precise application based on an understanding of plant-herbivore interactions. Effective grazing programs for weed control require a clear statement of the kind of grazing animal, timing, and rate of grazing necessary to reduce noxious plants and maintain healthy rangeland ecosystems (Mosley 1996). A successful grazing prescription should: 1) cause significant damage to the target plant (Walker et al. 1992); 2) limit irreparable damage to the surrounding vegetation (Walker et al. 1992, Olson and Lacey 1994); 3) be consistent with sheep production goals (Olson and Lacey 1994, Mosley 1996) ; and 4) be integrated with other control methods as part of an overall pest management strategy (Sheley et al. 1996).

The goal in designing a sheep grazing plan that is used as a tool for leafy spurge management is to remove the yellow. Ideally sheep should begin grazing leafy spurge as soon as it reaches about 3 to 4 inches in height. This will prevent the majority of leafy spurge plants from going to seed and prevent dense canopies of cover to develop which will in turn allow cattle grazing of grasses within infested areas.

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