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EC02-174 Leafy Spurge

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Noxious Weeds of Nebraska

Leafy Spurge

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Leafy Spurge

Leafy spurge is an invasive weed that infests over three million acres in the northern Great Plains and the prairie provinces of Canada. It is commonly found in rangelands, pastures, roadsides, rights-of-way, and woodlands *(Figure 1)*. Leafy spurge can reduce rangeland and pasture carrying capacity by as much as 75 percent because it competes with forages and cattle avoid grazing areas infested with this weed. In North Dakota where leafy spurge infests about 900,000 acres, estimates of direct and indirect losses exceed $100 million each year. In Nebraska, the direct loss in forage value attributed to leafy spurge has been estimated at more than $2 million annually. Estimates of direct and indirect losses in Nebraska exceed $16 million per year.

Biology

Leafy spurge shoot emergence begins in early March in Nebraska *(see Life Cycle on page 9)*. Stem elongation and vegetative development increases rapidly as temperatures increase in April and May. Shoots increase in number until early summer. Yellow bracts that subtend the flowers are most conspicuous from mid-May to mid-June (*Figures 1* and *2a*). Seed maturation continues for 30 days after the last flower appears. Flower production and seed development are continuous from late May through August and can extend into the fall under favorable growing conditions.

The aggressive nature of leafy spurge is related to its phenomenal ability to reproduce both by seed *(Figure 2b)* and by adventitious shoot buds located on the crowns and roots (*Figures 2d, 2e,* and *5*). Effective seed dispersal mechanisms, high seed viability, and rapid seedling development enable new infestations to become established easily. Prolific vegetative reproduction maintains dense, long-lived infestations.


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b


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Figure 1. Leafy spurge infestations located in a (a) pasture, (b) shelterbelt, and (c) sub-irrigated meadow in the Sandhills.

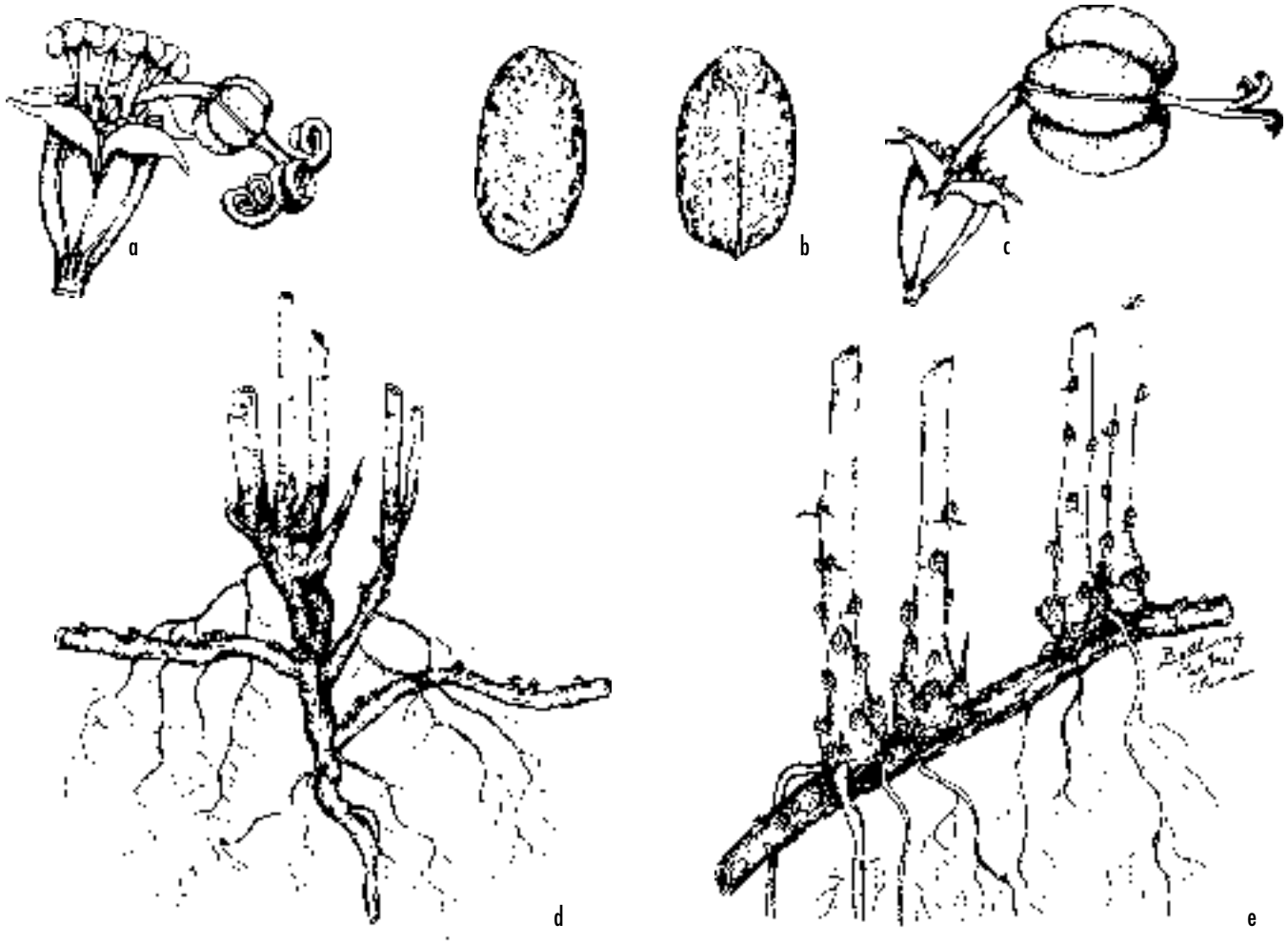

Figure 2. Selected leafy spurge plant portions: (a) cyathium containing one pistillate flower and several staminate flowers; (b) side and front view of seed; (c) cyathium with three-lobed fruit; (d) crowns; (e) adventitious shoot buds located on roots.

Seed and Seedlings

The leafy spurge fruit is a three-lobed capsule or schizocarp that splits into three, one-seeded nutlets (*Figures 2c* and *3a*). Seed yields can range from 25 lbs to 3500 lbs per acre, depending on site productivity and level of interference from associated plants. Each flowering stem can produce as many as 250 seeds. Once seeds are dispersed, they can remain viable for eight years. Leafy spurge seed germination in the field can occur throughout the growing season when moisture is adequate. Typically, early spring is the most favorable time for seed germination, which occurs at temperatures between 68°F and 86°F.

Leafy spurge seedlings can emerge through several inches of soil, but optimum emergence depth ranges from 0.5 to 2 inches. Within 48 hours after emergence, the seedcoat is sloughed, exposing

History

Leafy spurge is native to Eurasia. The first documented occurrence of leafy spurge in North America was in Newbury, Massachusetts in 1827. It is speculated that the arrival of leafy spurge along the eastern seaboard was facilitated by movement of seeds or vegetative plant parts in ballast deposited by ships from Europe. It was likely introduced to the north central region of North America through other mechanisms, such as with contaminated crop seeds imported from Russia and Europe. Early records of leafy spurge infestations suggest that wheat and oat seeds brought by Mennonites migrating from Ukraine and Russia during the late 1800s also could have been contaminated with the weed seed.

In the 1890s cereal explorers with the United States Department of Agriculture's Bureau of Plant Introduction sent several kinds of seed grain from Russia to the north central United States. Large quantities of smooth bromegrass seeds were imported from northern Europe and Russia for distribution in the northern United States. Contamination of these seeds with leafy spurge and other exotic weed seeds was likely because of the rudimentary methods available for cleaning crop seed during the late 19th century.

a

b

c

Figure 3. Leafy spurge (a) umbel with three-lobed fruits, (b) adventitious buds located on root and crown, and (c) shoots arising from common root system.

Figure 4. Seeds are round to oblong, smooth, gray with a dark line on one side and about 1/8 inch long.

the cotyledons. Seedling roots can extend to 2 feet and stems can reach a height of 6 inches within 60 days after the cotyledons expand. Adventitious shoot buds develop on seedlings at or just below the soil surface about 10 days after emergence or when the seedlings reach the 6-leaf growth stage. New shoots will arise from these buds once seedlings reach the 10-leaf stage even if the shoot is removed. Thus, leafy spurge makes the transition from seedling to perennial soon after germination. In disturbed areas, free from competing vegetation, leafy spurge seedlings will flower the first year.

Seed Dispersal Mechanisms

Leafy spurge seeds are spread several ways. As the drying capsules shrink and split, there can be sufficient force to throw the seeds as far as 15 feet. Also, seeds of leafy spurge can float on water and germinate while floating. This increases leafy spurge establishment in sub-irrigated meadows and along streams and rivers.

Animals act as seed dispersal agents. Sharptail grouse and mourning dove will eat leafy spurge seeds. Viable seeds have been found in droppings of sharptail grouse, but not in dove droppings; however, dove dispersal may occur when seeds are regurgitated when nestlings are fed. Leafy spurge seeds can remain viable as they pass through an animal's digestive tract. Man has played a major role in leafy spurge seed dispersal. Seeds have been widely dispersed as a contaminant in crop seed, feed grain, and hay. Contaminated tillage and harvest machinery can distribute seeds or plant fragments if not cleaned before leaving an infested site.

Buds and Shoots

Leafy spurge has two types of vegetative buds. Axillary buds occur along shoots and cause branching and adventitious buds arise on roots and crowns (*Figures 2e* and *3c*). In established infestations, most shoots arise from adventitious buds on the crowns. Dormancy of leafy spurge adventitious shoot buds is caused by the presence of high concentrations of indole acetic acid (IAA). When shoots are removed or the crown is damaged, concentrations of IAA decrease and dormant buds begin to develop into shoots.

Roots

The root system of leafy spurge is composed of the main axis or long-roots and laterals or short-roots. Long-roots constitute the permanent root system and have the capacity to regenerate roots and shoots. New vertical roots arise on the old roots, which allows root penetration to great depths. Individual long-roots may live for up to four years in the field and may reach 15 feet in length. Short-roots do not persist or produce buds. Regeneration of stems from buds on crowns and roots and limited translocation of herbicides to these plant parts contribute to this weed's resistance to

control. Although the upper portion of the plant can be killed by herbicides or tillage, buds below the treated zone can continue to produce new shoots.

Identification

Leafy spurge stems are woody, hairless, erect, pale green, occur in clumps, and can grow to a height of 3 feet. Leaves are alternate, narrowly linear with smooth margins, about 1/4 inch wide, 1 to 2 inches long, and are not hairy. Flowering axillary branches are common. Flowers are inconspicuous, greenish yellow, and occur in numerous small clusters with each cluster subtended by a pair of large yellow heart-shaped leaves (bracts) arranged in a conspicuous umbel (*Figures 3a and 5c*). Flowers are borne in a cup-shaped cyathium containing one pistillate and 11 to 20 staminate flowers *(Figure 2a)*. The margin of the cyathium bears four, two-horned nectiferous glands. Fruits are three-lobed capsules with one seed in each lobe *(Figure 2c)*. Seeds are round to oblong, smooth, gray with a dark line on one side and about 1/8 inch long *(Figure 4)*. A characteristic of leafy spurge, unique to plants in the Euphorbiaceae family, is the presence of a milky white juice or latex that readily oozes from cut stems, leaves, or roots. This latex contains compounds that are poisonous to cattle and horses, but not sheep and goats. The bright yellow bracts and white milky sap simplify identification of this noxious weed.

Control Methods

There are three approaches to weed management: prevention, eradication and control. Prevention is the process by which a weed species is not allowed to become established in a given area. Weed seeds are not carried onto the area and existing weeds are not allowed to reproduce. Eradication is the complete elimination of all plants and seeds from an area. Control limits the extent of infestation

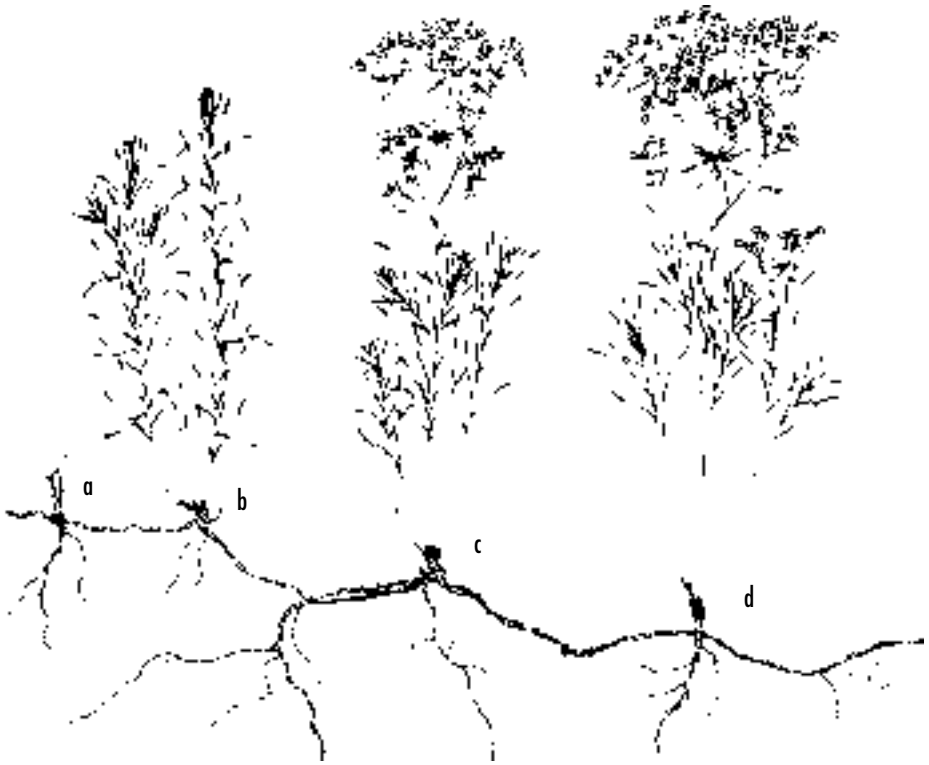

Figure 5. Illustration of selected leafy spurge phenological stages: (a) dormant adventitious bud stage; (b) late vegetative stage with terminal leaves on main shoot axis enclosing floral bud; (c) flowering to early fruit stage with determinant inflorescence consisting of branched rays that are subtended by a whorl of bracts (note secondary inflorescence arising from axils of leaves on primary stem); (d) flowering-late fruit stage with inflorescence arising from a late-flowering shoot.

Distribution

Leafy spurge is currently found in six Canadian provinces and 26 U.S. states. Despite early introduction into Massachusetts, leafy spurge is not considered a problem weed in the northeastern United States or eastern Canada. Leafy spurge is a serious problem in North Dakota, Iowa, Missouri, South Dakota, Minnesota, Colorado, Idaho, Montana, Wyoming, Nebraska, and the prairie provinces of Canada.

In Nebraska, leafy spurge currently infests at least 321,000 acres. It is most prevalent in the northeast and north central parts of the state, but also can be found in many other areas.

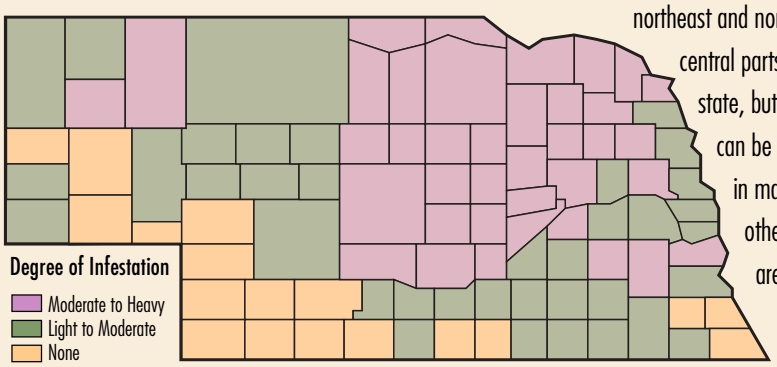

Figure 6. Distribution of leafy spurge in 2001 in Nebraska.

and enhances the competitive ability of desirable plants. Of these three approaches, prevention is the most cost effective.

Chemical

Herbicides often are assigned to groups according to their chemistry or molecular composition. A herbicide is usually selective within certain rates, environmental conditions, and application methods. Foliar-active herbicides are applied directly to the leaves or stems of plants where they are absorbed and moved into the plant. These herbicides may or may not remain active once moved into the soil. Soil-active herbicides are absorbed by the roots from the soil solution. Herbicides can be categorized as to whether they are applied before planting and weed or crop emergence (preemergence) or after weed or crop emergence (postemergence). The potential for ground or surface water contamination, suppression of desirable plants, and cost of repeated periodic application of herbicides to control weeds are some of the concerns associated with herbicide use. What, how much, and when to use these herbicides depends on the size and location of the leafy spurge infestation and land management objectives *(see Table 1, page 10)*.

Small Infestations. Excellent control of leafy spurge may be achieved by applying Tordon 22K (picloram) at 4 quarts per acre in the spring to early summer or Plateau (imazapic) at 12 ounces per acre in late summer or early fall. Some suppression of grasses, especially cool-season grasses such as Kentucky bluegrass, smooth bromegrass, timothy, and redtop bent, may occur where Plateau is applied at this rate. Areas containing leafy spurge regrowth should be treated before seed set. Repeated treatment of small infestations can lead to leafy spurge eradication. For best results, apply the herbicide to the established stand and a 25-foot wide strip around the perimeter of the infested area. Treating beyond the perimeter prevents leafy spurge from establishing from seed dispersed from the infested area.

Large Infestations. Eradication of large infestations of leafy spurge is not usually economical. Large infestations are most effectively managed to reduce seed production and movement of seed from the infested area. The objective is containment — to confine leafy spurge within the existing infestation. Reduction in leafy spurge stand density may occur with repeated annual applications of herbicides. The herbicides Tordon 22K, 2,4-D, and Plateau are commonly used to control large infestations of leafy spurge.

Spring is the best time to apply 2,4-D + Tordon 22K at 1 quart + 1 pint per acre (Grazon P+D at 2 quarts per acre) or 2,4-D alone at 2 quarts per acre to provide short-term control of leafy spurge and reduce seed production. Repeated annual applications of a combination of 2,4-D and Tordon 22K may decrease leafy spurge stem density. The optimum time of application is late spring when plants are at the late flowering stage.

Apply Plateau in late summer or early fall before a killing frost at 8 to 12 ounces per acre to control leafy spurge. The lower rate should be used on sites with sandy soils and the higher rate should be used on sites with higher clay content soils. A methylated seed oil (MSO) at 2 pints per acre must be included in the Plateau spray solution to increase herbicide uptake by leafy spurge. Fall Plateau application can cause cool-season grass injury, especially under drought conditions. However, usually it will not injure warm-season grasses (for example, big bluestem, indiangrass, little bluestem, blue and sideoats grama). Long-term leafy spurge control may occur after repeated, consecutive annual applications of Plateau.

Tree Understory. Control of leafy spurge in the understory of trees is best accomplished with 2,4-D (amine formulation), Plateau, or Roundup. Applying 1 quart per acre of 2,4-D amine at late flowering will reduce seed production. Applying Plateau at 8 ounces per acre or Roundup at 3 pints per acre in the fall before leafy spurge becomes dormant will suppress leafy spurge the following growing season. Roundup will injure grasses and forbs with live foliage at time of application. Tree injury may occur if these herbicides contact tree foliage or green bark.

Figure 7. The adult flea beetle, *Aphthona nigriscutis.*

Figure 8. The adult flea beetle, *Aphthona lacertosa.*

Figure 9. The clear-winged moth, *Chamaesphecia hungarica* adult.

Biology

Biological control of weeds is the planned use of living organisms to reduce a plant's reproductive capacity and density. Biological control agents used against leafy spurge include insects, goats, and sheep. Classical biological weed control involves importing or relocating natural enemies (usually insects) of exotic weeds from their native habitats to their naturalized habitats. This strategy seeks to reestablish weed and natural enemy interactions and reduce the weed popu-


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Figure 10. The spurge hawkmoth, *Hyles euphorbia,* (a) adult and (b) larvae feeding on leafy spurge foliage.


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b

Figure 11. The long-horned beetle, *Oberea erythrocephala,* (a) adult and (b) larvae feeding inside leafy spurge root.


a


b

Figure 12. The gall midge, *Spurgia esula,* (a) adult and (b) gall formed at apex of leafy spurge shoot by larvae.

lation to an acceptable level. Factors affecting whether a biocontrol agent will establish on or effectively control a plant include synchrony in the life cycles of host plant and agent, adaptation of the agent to a new climate and habitat, ability of the agent to find the host at varying densities, capacity of the agent to reproduce rapidly, and the nature, extent, and timing of the damage caused by the biocontrol agent.

Insects. Many species of insects have been tested, approved and released for biological control of leafy spurge in North America. Two of these — the *Aphthona nigriscutis (Figure 7)* and *A. lacertosa (Figure 8)* flea beetles — have successfully controlled leafy spurge.

Other insects either have failed to establish populations or have established limited populations that have not had a significant impact on spurge infestations. Other insects from native Eurasian habitats that have been evaluated to control leafy spurge in North America include the clear-winged moth, *Chamaesphecia hungarica (Figure 9)*; spurge hawkmoth, *Hyles euphorbiae (Figure 10)*; long-horned beetle, *Oberea erythrocephala (Figure 11);* and a gall midge, *Spurgia esula (Figure 12)*.

The clear-winged moth and long-horned beetle adults lay eggs in stems, then the larvae hatch and burrow down the stem and into the root crown, where they feed and cause damage. Spurge hawkmoth larvae feed voraciously on leafy spurge foliage, but have not been successful in controlling leafy spurge because they are readily preyed upon by other insects. The gall midge is a tiny gnat that lays its eggs in leafy spurge flowers on the terminal portions of reproductive stems. When the larvae develop, they cause a gall to form at the shoot apex, eliminating seed production by prohibiting flowering. Most of these insects have been released within the last 10 years and it is too early to determine how effectively they will control leafy spurge.

Biocontrol agents can be an effective way to manage large infestations of leafy spurge. On small infestations use herbicides instead of biocontrol agents, especially if the objective is to eradicate leafy spurge. In large infestations, herbicides and flea beetles can indeed be used together. The key is timing of herbicide application. Do not apply herbicides where attempting to establish a population of flea beetles on leafy spurge infestations. After establishment do not apply herbicides in the late spring or summer since the application removes leafy spurge foliage, which flea beetles need to complete their life cycle. Fall and early spring applications do not appear to disrupt flea beetle establishment.

Sheep. Sheep should begin grazing leafy spurge as soon as it is 3 to 4 inches tall. Grazing at this growth stage will prevent most leafy spurge plants from producing seed. To maintain control usually one to two sheep per acre of leafy spurge are required for a four-month grazing season. Sheep performance on a leafy spurge diet can be excellent because the weed is high in crude protein, is easily digested, and provides high quality forage for lactating ewes and lambs. Sheep may need time to acclimate to feeding on leafy spurge, especially where other forbs preferred by sheep are present. Mature stands should be mowed before grazing to improve palatability. Continuous intensive grazing by sheep will prevent leafy spurge vegetative spread and seed production. In Canada, eight years of intensive continuous grazing reduced leafy spurge stem densities 98 percent. However, within

two years after grazing ended, the leafy spurge started to reestablish from roots. Sheep should not be allowed in a non-infested area within nine days of leaving an infested area. This should provide enough time for any leafy spurge seeds to pass through their digestive tracts.

Mechanical

Mechanical treatments can be categorized according to the portion of the plant removed. Top growth removal consists of severing the aerial portion of the plant by mowing or shredding. In contrast, entire plant removal involves removing topgrowth and enough of the below-ground portion of the plant to prevent plant regrowth by plowing. Mowing during flowering and before seed fill will reduce leafy spurge seed production. Repeated mowing during the growing season for several years can reduce leafy spurge stands by depleting plant energy reserves. However, the root system of leafy spurge is so extensive that energy reserve depletion is difficult. Removing entire plants can be effective in cropland where tillage can be used, but it has limited applicability on rangelands and pastures.

Fire

Grasslands are fire-dependent ecosystems comprised of plants that not only tolerate fire, but require fire to promote growth and survival. Plant response to fire depends on several factors, including plant morphology, plant phenology, and season of burning. With creeping perennial herbaceous plants like leafy spurge, fire alone is usually no more effective than mowing. However, there may be an opportunity to reduce the competitiveness of leafy spurge by burning late in the spring when the plant is in the late vegetative to early flowering stage and native perennial warm-season grasses are initiating growth. Fire also can stimulate leafy spurge seed germination.

Integrated Weed Management

Herbicides have been the primary tools used to combat rangeland and pasture weeds. More recently, biological control has been touted as the desirable means to control invasive weeds. As


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Figure 13. Integrated strategy to revegetate leafy spurge-infested rangeland with native perennial warm-season grasses. The treatment sequence consists of (a) application of Plateau and Roundup in the fall, (b) burning plant residue in the spring, and (c) planting a mixture of grasses with a no-till drill after burning. Grass stands establish quickly in herbicide-treated areas as indicated by excellent grass stands (d) 6 weeks and (e) 12 weeks after planting.

d

e

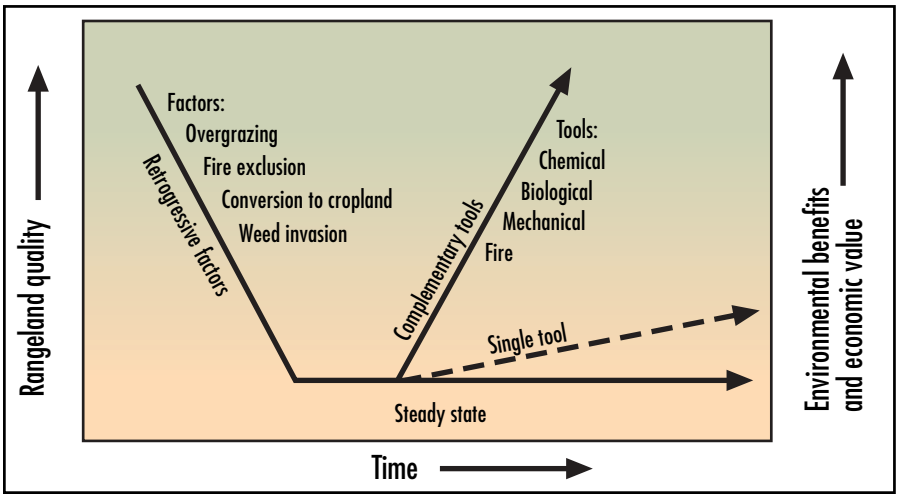


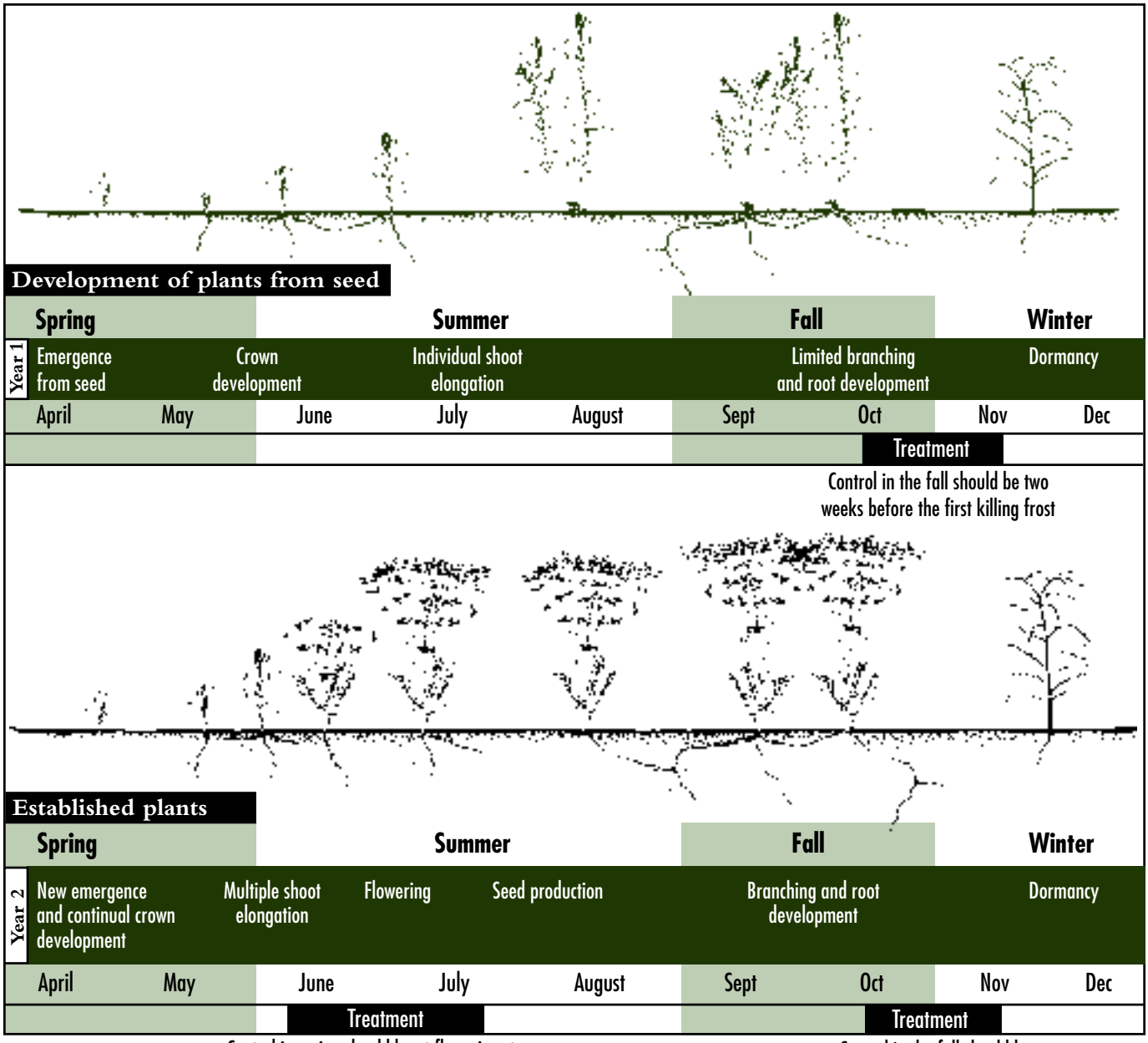
Figure 14. Generalized rangeland succession model for Great Plains grasslands. Retrogression leads to a steady state condition of low productivity. Reliance on a single technology results in slow grassland recovery rate. Sequential application of control measures accelerates improvement of rangeland productivity.

populations of invasive plants like leafy spurge continue to expand, there is growing recognition that using a single control method is usually not enough. The presence and spread of invasive plants is often symptomatic of underlying management problems that must be corrected before sustained progress is made toward controlling the weed and improving rangelands and pastures. Removing invasive plants with chemical or biological control measures may only open niches for other undesirable species to occupy or to be reinvaded by the same species unless desirable species are present to fill the vacated niches. In many instances rangeland and pastures have deteriorated to the point that desirable species are either not present, or are in such low abundance that plant community recovery is slow or will not occur without intervention.

Various technologies are available for managing leafy spurge, but acceptable long-term control will only be achieved when integrated weed management programs are implemented. Integrated weed management strives to use the most economically, ecologically, and environmentally effective combination of principles, technologies, and systems to meet management goals. Integrated weed management is accomplished by coordinated use of complimentary control measures to maintain weed damage below economic levels, while minimizing the hazard to humans, animals, plants, and the environment.

Approaches that include applying herbicide and establishing stands of perennial grasses have been successfully used to suppress leafy spurge and improve forage production on rangeland. In Wyoming, seedbed preparation consisted of multiple Roundup applications in spring and summer followed by tillage before planting introduced cool-season grasses. In North Dakota introduced cool-season grasses were planted in a tilled seedbed after Roundup and 2,4-D were broadcast applied. The planted grasses that were most effective in suppressing leafy spurge were 'Bozoisky' Russian wildrye and 'Luna' pubescent wheatgrass in Wyoming and 'Rebound' smooth brome and 'Reliant' intermediate wheatgrass in North Dakota.

Figure 15. Life cycle of the leafy spurge



In Nebraska, an integrated weed management strategy was developed that suppressed leafy spurge and eased planting and establishment of mixed stands of native warm-season grasses (big bluestem, little bluestem, indiangrass, switchgrass, and sideoats grama). Roundup plus Plateau at 48 ounces and 12 ounces per acre were applied together in the fall, and followed the next spring with burning the herbicide-suppressed vegetation and no-till planting the grasses *(Figure 13)*. Roundup controls cool-season grasses that were growing at the time of application, but provides no residual weed control. Plateau controls leafy spurge and provides residual control of annual grass and broadleaf plants after the native grasses are planted. This integrated approach controlled leafy spurge and more than doubled forage production.

A goal of integrated weed management should be to improve degraded rangeland and pasture communities so they are less susceptible to invasion by noxious weeds like leafy spurge. In many instances rangelands have deteriorated to the point that desirable species are either not present or in such low number that plant community recovery will be unacceptably slow without direct intervention. A generalized model describes rangeland and pasture degradation and improvement processes *(Figure 14)*. Integrated weed management systems applied in appropriate sequences will improve rangeland and pasture quality and decrease negative impacts of leafy spurge and other noxious weeds.

Table 1.
Herbicides for Leafy Spurge Control[1]

Herbicide	Product per Acre	Application Time[2]	Notes
2,4-D ester (4L)	2 qt	Bud stage in spring	Retreatment necessary. Annual applications gradually reduce infestation.
Grazon P+D	2 qt		
Plateau	8-12 oz	In fall 2 weeks before first frost	Do not apply herbicide in spring over area treated the previous fall with 8-12 oz/A. Use with MSO 1 qt/A.
Tordon 22K	2-4 qt	Fall or spring September to early October	Tordon is for use in non-crop areas and pasture and range. Glyphosate for use in trees or areas where grass stand is not a factor.
Glyphosate[3] + 2,4-D amine (4L)	1 qt		

[1]These recommendations were current as of Jan. 1, 2003. See "Guide for Weed Management in Nebraska" EC-130, for current information. It's available in print at local Cooperative Extension offices or on the Web at http://www.ianr.unl.edu/pubs/fieldcrops/ec130.htm.

[2]Best control will be obtained if treatments are made when plants are actively growing. Treatment in following years may be required. Dust on leaves may interfere with herbicides.

[3]Glyphosate is the active ingredient in many commercial products. The rates provided here are based on a 4 lb. ai or 3 lb. ae formulation.

Note: Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by University of Nebraska Cooperative Extension is implied.

A Message From the Nebraska Department of Agriculture

The State of Nebraska has had a noxious weed law for many years. Over the years, the Nebraska Legislature has revised this law.

The term "noxious" means to be harmful or destructive. In its current usage "noxious" is a legal term used to denote a destructive or harmful pest for purposes of regulation. When a specific pest (in this case, a weed) is determined to pose a serious threat to the economic, social, or aesthetic well-being of the residents of the state, it may be declared noxious.

Noxious weeds compete with crops, rangeland, and pastures, reducing yields substantially. Some noxious weeds are directly poisonous or injurious to man, livestock, and wildlife. The losses from noxious weed infestations can be staggering, costing residents millions of dollars due to lost production. This not only directly affects the landowner, but erodes the tax base for all residents of the state. The control of noxious weeds is everyone's concern and their control is to everyone's benefit. The support of all individuals within the state is needed and vital for the control of noxious weeds within Nebraska.

It is the duty of each person who owns or controls land in Nebraska to effectively control noxious weeds on their land. County boards or control authorities are responsible for administration of noxious weed control laws at the county level. This system provides the citizens of Nebraska with "local control". Each county is required to implement a coordinated noxious weed program. When landowners fail to control noxious weeds on their property, the county can serve them with a notice to comply. This notice gives specific instructions and methods on when and how certain noxious weeds are to be controlled.

The Director of Agriculture determines which plants are to be deemed as "noxious" and the control measures to be used in preventing their spread. In Nebraska, the following weeds have been designated as noxious:

Canada thistle (Cirsium arvense (L.) Scop.)
Leafy spurge (Euphorbia esula L.)
Musk thistle (Carduus nutans L.)
Plumeless thistle (Carduus acanthoides L.)
Purple loosestrife (Lythrum salicaria L. and L. virgatum - including any cultivars and hybrids)
Knapweed (spotted and diffuse) (Centaurea maculosa Lam. and C. diffusa Lam.)

Whether farmer or rancher, landowner or landscaper, it's everyone's responsibility and everyone's benefit to aid in controlling these noxious weeds. If you have questions or concerns regarding noxious weeds in Nebraska, please contact your local county noxious weed control authority or the Nebraska Department of Agriculture.

Leafy Spurge

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Nebraska Lincoln

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