BIOLOGICAL CONTROL of Leafy Spurge

A comprehensive, easy-to-read manual on how to use biological control as an effective leafy spurge management tool.

A product of the USDA-ARS TEAM Leafy Spurge Area-Wide IPM Program
Leafy Spurge

If you've had any experience with leafy spurge, you already know it's a pretty tough customer. A native of Europe and Asia, leafy spurge emerges early in the spring and gets a head start on other vegetation in a race for space, sunlight, nutrients and water. Prolific seed production and an extensive root system give the plant a huge competitive advantage and make consistent, long-term control difficult. Deep tap roots—which can exceed 20 feet in depth—store reserves of nutrients to see the plant through hard times, while lateral roots form a network that enable it to rapidly reproduce and spread. And, perhaps worst of all, leafy spurge is highly adaptable and can thrive in a variety of conditions and situations.

In short, this exotic invader is extremely competitive and quite capable of completely displacing desirable plants.

The economic and environmental impacts of leafy spurge are significant. It invades a variety of land types, reduces range productivity and species diversity, threatens sensitive species, degrades wildlife habitat and reduces land values. Infestations in Wyoming, Montana and the Dakotas alone are estimated to cost agricultural producers and taxpayers more than $144 million a year in production losses, control expenses and other impacts to the economy.

Biological Control

Biological control, or biocontrol, can be defined as a reduction in the abundance or competitive advantage of a weed or insect pest through the use of natural enemies such as parasites, predators or pathogens.

Introduced weed species are prime candidates for biological control. The concept is simple: Find natural enemies of the target weed in the weed’s homeland. Such enemies are selective, or host specific, and well-adapted to establishing long-term relationships with the target weed that result in reduced weed densities. In fact, the absence of natural enemies are why weeds like leafy spurge flourish and spread so quickly when introduced into a new environment. It’s interesting to note that many weeds like leafy spurge are not considered a problem in their homelands, where natural enemies are abundant and control infestations.

The use of biological control is nothing new. Leafy spurge has proven to be a formidable opponent. No type of land is immune from infestation, and rangelands are particularly susceptible.

The Chinese used predatory ants to control insect pests in stored foods and citrus groves more than 2,000 years ago, and numerous efforts followed. A lot has been learned since then, but the reasons why people were interested way back then remain true today: Biocontrol is easy to use, inexpensive, self-sustaining, target specific and well-suited to incorporate with other management tools.

The Chinese used predatory ants to control insect pests in stored foods and citrus groves more than 2,000 years ago, and numerous efforts followed. A lot has been learned since then, but the reasons why people were interested way back then remain true today: Biocontrol is easy to use, inexpensive, self-sustaining, target specific and well-suited to incorporate with other management tools.

The key is STARTING. Biological control is not a cure-all or overnight solution, and it won’t work every time in every situation. It is, however, a long-term, sustainable and inexpensive approach that should ALWAYS be considered when formulating a leafy spurge management plan.

But it won’t work unless you give it a try, and the sooner you try, the sooner it can start working for you.

Good luck!

The Problem

An extensive root system, capable of storing nutrient reserves and producing numerous shoots, makes leafy spurge extremely versatile and persistent. Biological control, quite literally, gets to the root of the problem.

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Meet the Flea Beetle

Researchers have been working with leafy spurge biocontrol since 1964, when the Hyles hawk moth—a colorful but generally ineffective agent—was released. The most exciting development in leafy spurge biocontrol, however, didn’t occur until 1985, when the first of six Aphthona flea beetles was approved and used. Aphthona flea beetles, as the name implies, are small, flea-like beetles that feed exclusively on leafy spurge. Ranging in size from 2 to 3.5 mm, flea beetles are gregarious and tend to congregate for feeding and mating. Flea beetles can and do fly, but most often move about by using strong hind legs to hop like fleas. In well established populations, adults are clearly visible when feeding on spurge in the summer.

Meet the Flea Beetle

Aphthona species approved and released for leafy spurge biocontrol, two have been particularly successful. A. nigriscutis, first released in 1989, and A. lacertosa, first released in 1988, have had a dramatic impact in some areas. Other species—A. abdominalis, A. cyparissiae, A. czwalinae and A. flava—have not been as successful at establishing populations or reducing leafy spurge infestations.

Flea Beetle Biology

Flea beetles over-winter as larvae in soil near spurge roots. As soil temperatures warm up, generally in April or May, the larvae “wake up” and begin feeding on spurge roots. The larvae pupate during a one- to two-week period, generally in late May to mid-June, then emerge from the soil as adults. Adults live 45-65 days, during which time they feed on spurge leaves and stems and reproduce. Females lay eggs in the soil near the base of leafy spurge stems. Females lay 50-500 eggs, with some variation according to species. Eggs hatch in 14-19 days, and the newly emerged larvae seek out spurge roots and begin feeding. This is an extremely sensitive life stage for the flea beetle, and the availability of young, tender spurge roots near the surface (within the top two to three inches of topsoil) is critical to survival. Larvae gradually move to larger roots and buds or shoots as they develop, and progress through three larval stages (called instars). As cool weather approaches, the larvae—now in the third and final larval stage—move into deeper soil, where they spend the winter.

Damage to Leafy Spurge

Adult flea beetles feed on leafy spurge leaves and bracts in the summer, but the most significant damage is caused by root-feeding larvae. Feeding by the adults (see page 10 for a photo) and larvae (photo below) stress the host plant, and create wounds that allow naturally occurring soil-borne plant pathogens to invade the plant and cause additional damage. The stress and damage caused by the adults, larvae and pathogens results in delayed emergence, thinner stands, shorter and weaker plants, delayed maturity and flowering, and decreased seed production. In short, the weed’s competitive advantage is reduced, giving native grasses and other desirable plants a chance to reestablish and thrive.

Flea beetles typically take several years to impact leafy spurge infestations, but the payoff can be well worth the wait. Researchers have documented leafy spurge canopy cover reductions of up to 95 percent and stem density reductions of 250-plus stems per square meter to fewer than five stems per square meter.

It is important to understand that flea beetles do not eliminate leafy spurge. When flea beetles work, they establish a natural balance with the weed, reducing it to a non-impact plant and tolerable member of the plant community.

Later, in a separate section of this manual, we’ll discuss another critically important aspect of biological control: The stress and damage caused by biocontrol agents makes the weed far more susceptible to other leafy spurge management tools, like grazing and herbicides (see page 16). That’s why biocontrol works so well when integrated with other management tools.

A

Although some variation can be expected depending on geography, climate & seasonal conditions, elevation and other factors, the chart below gives a good general idea of the flea beetle life cycle.

A

The Cycle

A. nigriscutis (upper left) and A. lacertosa (lower right) are the all-stars of leafy spurge biocontrol efforts. Adult flea beetles, like the nigriscutis and lacertosa pictured, feed on spurge leaves in the summer (see page 10 for a picture of adults feeding on leaves), then lay eggs in mid-to late summer. Larvae hatch from the eggs (small photo, left) and feed on spurge roots (upper right) until fall, then overwinter in the soil around spurge roots. In the spring, larvae resume feeding on spurge roots, pupate (small photo, right), then emerge as adults ready to continue the life cycle. Flea beetles spend about 90 percent of their lives underground.
The Objective
This section focuses on obtaining insects, selecting release sites, and releasing flea beetles. It is, without a doubt, the most important part of this manual. Without these techniques, you guarantee that flea beetles will work, following these simple guidelines will greatly enhance your chances of successfully establishing a population.

Where to Get Insects
One of the most commonly asked questions about biological control is, “Where can I get flea beetles?”
There are usually several ways to get flea beetles, but it’s best to start by looking locally. Flea beetles from local sources may be better adapted to local conditions, and won’t have to travel as far or be transported far prior to release. Many county weed officers and Extension agents will have releases of more than one species. Different flea beetles have different habitat preferences, and there is some overlap between the species. Here’s a brief summary of habitat preferences for the two most successful species.

- A. nigriscutis – Prefers warmer, drier sites and lighter soils. Works well on hills, which generally have shorter leafy spurge.
- A. lacertosa – Has a broader range of tolerances than A. nigriscutis. Can tolerate cooler, moister sites, and does better on dense leafy spurge. It works on hills & more likely to work in draws.

Site Selection
Choosing good release sites is the most important aspect of using biological control. By planning ahead and choosing good sites, you can eliminate many common obstacles to flea beetle establishment and help the insects get off to a good start.

- Shallow roots: Shallow roots (top three to five inches of topsoil) can be present to improve flea beetle establishment.
- Soil moisture: Well drained soils are best. Avoid areas that are subject to spring flooding or winterkill. Moderate moisture is best for leafy spurge.
- Density: Moderate (60-90 stems per square yard) densities of spurge are best. Infestations that are too dense may retard larval development in the spring and inhibit adult activity. Places where you most want or need control may not be the best places to make an initial release – flea beetles will eventually work their way into dense stands, but it’s best to start in patches with moderate densities in the edges of dense stands, or on hill sides up-slope from heavily infested draws and drainages.
- Exposure/Aspect: Flea beetles generally do best on south facing slopes. North-facing slopes should be avoided as starting points. Some slope to provide drainage also enhances the site.
- Shade: Flea beetles are sun lovers, so avoid densely shaded areas as starting points. Flea beetles will work their way into shady, moist areas, but sites with shade are not good places to try and start a population.

Obviously, you won’t be able to satisfy all of these requirements all of the time. But satisfying as many as possible will help increase your chances of successfully getting a population established.

Habitat Preferences
Different flea beetles have different habitat preferences, but there is some overlap between the species. Here’s a brief summary of habitat preferences for the two most successful species.

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Mark Your Sites
Although it is absolutely necessary, marking your release sites is strongly recommended. Knowing the exact location of release sites makes it easier for you to monitor establishment and success.

The easiest way to mark sites is by erecting a steel or fiberglass fence post at the release point, then marking the location on a map (aerial topographic map is best). Some people also use a GPS device to determine latitude and longitude.

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Taking “before and after” photos is also a good idea. The photos will provide a visual chronology of your leafy spurge biocontrol program. Be consistent – take your photos from the same place every year, and at the same time of year (the same day if possible). The before and after photos on pages 12 & 13 provide good examples of how photos can help document your program.
Using this “Flea Beetle Release Site Information Form” is not a requirement for using biological control, but it is a good idea.

Using the form will allow you to keep track of your sites and compare success between different sites. It will also get you thinking about the kinds of things that make a good release site. In addition, information on the form might help identify factors that are limiting your success with biocontrol.

You might want to consider taking pictures of all your release sites and attaching them to these forms, then keeping a file of the forms. That way, you’ll have permanent written and photographic records of your release sites.

To use: Copy this form at 145 percent on 8.5x11 inch paper.

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**Flea Beetle Release Site Information**

- Site location: 
- Township/section/range: 
- Latitude & longitude (if known): 
- Release date: 
- Number released: 
- Species of flea beetle released: 
  - O A. lacertosa (black) 
  - O A. nigriscutis (brown) 
  - O Mixed 
  - O Date collected/obtained: 
  - O Where collected/obtained?
- New release site? 
  - O yes  
  - O no 
  - If no, list date & type of insects used in previous release(s): 

**Physical Characteristics**

- Elevation = 
- Soil Type 
  - O Sandy 
  - O Loamy sand 
  - O Loam/sandy loam 
  - O Silt loam 
  - O Silt/sandy loam 
  - O Silt loam 
  - O Silty Clay Loam 
  - O Silty Clay 
- Soil Drainage 
  - O Well-drained 
  - O Moderately well-drained 
  - O Poorly drained 
- Topographic Position 
  - O Upper slope 
  - O Back slope 
  - O Toe slope 
  - O Riparian 
  - O Upland 
  - O Draw slope 
  - O Draw bottom 
  - O Flood plain 
- Risk of Spring Flooding 
  - O None 
  - O Low to moderate 
  - O High 
  - O Standing water? 
- Annual Precipitation 
  - O < 10 inches 
  - O 10-15 inches 
  - O 15-20 inches 
  - O > 20 inches 

**Cultural Characteristics**

- Current land use 
  - O Pasture/grazing 
  - O Recreational 
  - O Roadside/Right of way/etc. 
  - O Idle cropland 
- Other: 

**Biological Characteristics**

- Spurge Height 
  - O .25 meter 
  - O .5 meter 
  - O 1 meter 
  - O > 1 meter 
- Spurge density 
  - O 0-25 stems/meter squared 
- 0-100 stems/meter squared 
- 100+ stems/meter squared 
- Size of Infestation 
  - O One acre or less 
  - O 1-10 acres 
  - O 10 or more acres 
- Vegetation Type 
  - O Prairie/grassland 
  - O Shrub/grassland 
  - O Woodland/grassland 
  - O Other 
- Other Vegetation Present (if known): 

**Other Control Efforts**

- Herbicides 
  - O Applied within last two years? 
  - O Applied within last 10 years? 
  - O Herbicides used: 
- Other treatments in last two years: 
  - O Grazing? 
  - O Cattle? 
  - O Sheep and/or goats? 
  - O Mowing? 
  - O Burning? 
  - O Insecticides? 

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**Flea Beetle Release Form “Cheat Sheet”**

**Things to Remember**

1. Have your release sites picked out **B**EFORE you get flea beetles.
2. Things to think about when picking release sites include:
   - ...Sunny, warm and dry is better than shady, cool and moist!
   - ... Dense patches of spurge are not good places to make releases. It’s better to make releases on the edges of dense patches, or at thin spots inside of dense patches.
   - ... South facing slopes are better than north facing slopes.
   - ... Avoid areas that are prone to standing water.
3. Don’t wait until the last minute to find a source for flea beetles. If possible, have your source lined up several weeks before you want to collect and redistribute.
4. Once you get your flea beetles, release them **A**S **Q**UICKLY **A**S **P**OSSIBLE. It’s a good idea to keep your flea beetles in a cooler with blue ice until they can be released.
5. Things to think about when releasing flea beetles include:
   - More is **A**L**W**AYS better. Try to release a minimum of 1,000 flea beetles at each “drop.”
   - Don’t scatter or sprinkle!
   - Make releases as early in the season as possible so females can lay eggs at the new release site.

This is an extremely dense — but not uncommon — leafy spurge infestation. In situations like this, it’s best to look for openings (like those marked with the red arrow) in dense patches to make flea beetle releases. Some people have had success by cutting a “hole” in heavy patches of spurge several weeks prior to releasing flea beetles.
Monitoring
Monitoring release sites will enable you to determine if flea beetles are established, and if they can be harvested and used to start populations at new release sites. Monitoring consists of identifying areas that show signs of flea beetle activity and assessing populations.

Remember, flea beetles are a resource, and should be managed as a resource. A small investment of time for monitoring and managing your “herd” will ultimately pay big dividends – you’ll be able to harvest insects and move them around to start new sites, resulting in quicker reductions of leafy spurge across a wide area.

What to Look For
There are two things to look for when monitoring release sites:
- Damage caused by larvae, and damage caused by adults.
- Larval Activity: Symptoms of larval activity are most noticeable in the spring or early summer a year or more after making the initial release. These symptoms are most noticeable in circles, called “craters,” at or near the original release point. Symptoms of larval activity include:
  - Stunted leafy spurge plants.
  - Reduced or delayed spring emergence, and delayed flowering.
  - Thinning stands. In some cases, dead cane (stems from last year’s plants) may be all that remains inside the crater.
  - Larvae can be observed in the late spring/early summer around leafy spurge roots and shoots. To look for larvae, find a spurge plant that looks less than healthy, then dig its roots up. You might be able to see the small, white larvae in and around the roots. Searching for larvae can be tedious unless populations are high.
- Adult Activity: The easiest way to look for adult activity is by sweeping and counting. Adults and feeding damage may also be visible. Light feeding appears as pitting or “shot holing” of leaves, while heavy feeding results in ragged, shredded leaves. Heavy feeding is a sure sign of a well established population.

Can They Be Harvested?
Assessing populations to determine if flea beetles can be harvested should begin shortly after adults emerge, and should continue through the month of July.

Optimal weather conditions for assessing populations include warm to hot temperatures, sunshine, dry vegetation, and calm to light winds. Flea beetles will be much more difficult to catch on cold, wet, windy or cloudy days. Favorable conditions are most likely to occur between 10 a.m. and 6 p.m.

The best way to determine if a population can be harvested is by sweeping and counting. Here’s how:
- Select a day with favorable conditions.
- Make sweeps at original release points and in areas with signs of flea beetle activity.
- Using a standard 15-inch sweep net, walk at a comfortable pace while sweeping with broad, arcing strokes. Sweep only the top half of the vegetation – this will save wear and tear on your sweep net and will result in less plant debris, rocks, sticks, etc., in the net.
- Make 1-10 sweeps, then stop to count the number of flea beetles per sweep. If you are able to collect 1-2 flea beetles per sweep (or about 500 in five minutes), then the site can be harvested.

A Tip
If you don’t find flea beetles at the original release site, look around. Flea beetles sometimes move from the original release site to a more preferable location.

Harvesting
Since flea beetles are generally slow to move from initial release sites to new areas, you’ll want to help them out by harvesting beetles from established sites and moving them to new sites. Harvesting and redistributing flea beetles is an important part of managing your flea beetles – the more sites you have, the more likely you’ll be to see significant reductions of leafy spurge.

First of All...
Once you’ve determined that there are enough flea beetles to harvest, DO NOT DELAY!! Flea beetles sometimes reproduce so rapidly and reduce patches of spurge so drastically that populations crash. Don’t be concerned about over-harvesting – there will always be enough beetles left to maintain the population.

Look Early & Often
To maximize your efforts, you’ll want to start harvesting flea beetles as soon as possible after they emerge. Emergence will vary depending on geography, climate and other environmental factors, and from year to year and site to site, so monitoring to see when they are emerging is extremely important. To avoid losing potential harvest, start monitoring your sites early in the season. Check periodically – every three days or so, for example – to see exactly when your flea beetles start to emerge. Once you’ve determined that flea beetles are emerging, you can begin your harvest and redistribution efforts.

In short, check early and check often to avoid any potential harvest loss.

When to Harvest
The recommended harvest period for most of the Great Plains is mid-June to mid-July, with some variation depending on soil temperatures, geography and other factors. Harvesting during this period will ensure that you are collecting flea beetles and getting them to new release sites in time to lay plenty of eggs. If you harvest late in the season, increasing the number of beetles released at each site can help increase the number of eggs laid the following spring.

The same guidelines used for assessing populations can be used for harvesting. The perfect day will be warm to hot with plenty of sunshine, dry conditions and calm to light winds. Flea beetles will be much more difficult to harvest on cold, wet, windy days.
These before and after pictures provide good examples of what can happen when flea beetles successfully establish a population. Note that the five sites pictured vary widely in regard to geography, soil type, moisture, etc.

1 Site: Bridger Mountains, Montana
Habitat: High elevation, high moisture forest
The Story: Aphthona nigricutis was released in 1994 and quickly eliminated spurge on a hillside interspersed with grass and conifers.

2 Site: Forget Me Not Lake, Minn.
Habitat: Low elevation prairie grassland, moist soil
The Story: A previous landowner had battled spurge for 15 years with a mixture of Tordon and 2,4-d at this site, located 10 miles west of Minot, N.D. New landowners wanted to try biological control, and released flea beetles in 1998 (one release of 10,000 flea beetles at each of the red flags). The site was monitored and assessed in 1999; moderate numbers of flea beetles were found but not collected. These photos provide a great example of what multiple releases can do.

3 Site: Ward County, North Dakota
Habitat: Prairie grassland with heavy clay soil
The Story: Hundreds of millions of flea beetles have been collected at this famous site in the Katie Olson National Wildlife Refuge, which was started with a release of just 80 insects in 1988.

4 Site: Valley City, North Dakota
Habitat: Prairie grassland with heavy clay soil
The Story: Rancher Glenn Rugg, who runs cattle on a 14,000 acre spread in Fallon County, Montana, has tried everything to control leafy spurge. After buying his ranch in 1941, Rugg quickly realized he had a problem. “When I looked down the road 20 or 30 years, I could see that spurge was going to take my place over and put me out of business,” Rugg says. Now, after 50 years of fighting leafy spurge, Rugg is a firm believer in biocontrol. “I’m sold,” he says. “A lot of people want spurge to disappear tomorrow, but that isn’t going to happen. Flea beetles may take a while, but they’re a permanent, long-term and low cost solution.”
Sorting

Sorting flea beetles allows you to remove weed seeds and other debris from your sweep net collections, but is not a requirement. The mesh-type sorter (left) requires about an hour of time and $25 to $30 in materials to build; simpler devices can be constructed from PVC pipe or cardboard canisters. Another advantage is that sorted, or “clean,” flea beetles can be easily counted (left) – 10 ccs or mls is about 1,000 beetles. Sorting & counting makes it easier to keep track of how many flea beetles you are releasing.

Unsorted

Sorted

days, but you may not have a choice. If you have to harvest on a cold, wet windy day, you’ll have to work a lot harder, as the flea beetles will be lower on plants. It’s best to avoid such days if possible.

Harvest on as many days as possible during the recommended harvest period.

How to Harvest

• Use a strong sweep net with a stiff frame.
• Sweep with a firm stroke and broad arc while walking at a comfortable pace. This will prevent flea beetles from falling or jumping off of plants before you can sweep them up. Again, sweep only the top half of the vegetation to save wear and tear on your sweep net, and to minimize the collection of plant debris, etc.
• Periodically dump the contents of your sweep net into a cloth bag, pillowcase or a bucket with a lid.
• Sweep areas with leafy spurge, and look for other potentially good areas as well. Pay special attention to areas with dead cane – such areas may have had such high numbers of larvae that no new shoots were produced, and flea beetles may emerge from these areas in enormous numbers.
• Sweep an area once, then let it sit undis- turbed for 5-15 minutes before sweeping again. This will give flea beetles that fell to the ground a chance to climb back up on vegetation.

Sorting & Counting

Sweep net collections can be dumped in a bag or bucket and moved to new release sites as is, or can be sorted and counted. Sorting and counting takes a little extra time, but offers some benefits: It reduces the chances of moving leafy spurge and other weed seeds to a new area, and you can count your flea beetles.

A simple sorting device can be easily constructed by drilling several 3/16th-inch holes in a piece of PVC tube (12 to 18 inches long) with removable end caps. Using the sorter is just as easy: Remove a cap, empty your sweep net contents into the tube, replace the cap, then put the tube in a laundry bag, pillow case or other light-colored fabric bag. The sun-loving flea beetles will climb toward the light and out through the holes while other insects and debris are left behind. Remove the tube after 20-30 minutes, and you’ll be left with a bag of “clean” flea beetles. The TEAM Leafy Spurge web site at http://www.team.ars.usda.gov shows diagrams for constructing a tube sorter as well as the popular “funnel” sorter.

Counting is also relatively easy, and will enable you to know how many flea beetles you are releasing. Plastic 35 mm film containers work great – a film container one-quarter of the way filled is about 1,000 flea beetles. Other small containers can also be used, with 10 cc or 10 ml equaling about 1,000 beetles.

If you plan on moving flea beetles long distances, you’ll need to think about packaging. The least expensive way to package flea beetles is with a paper bag. Lunch bags work well for small quantities of flea beetles, and grocery sacks work well for larger quantities. Flea beetles are escape artists – make sure the bags have good seams, fold the top three or four times, then tape or staple the top to prevent escape. Unwaxed paper cups or cans also work well, but are more expensive.

Plastic containers, like milk jugs, should be avoided, as condensation can build up and damage the flea beetles.

Regardless of the type of container used, fill it 1/3 to 1/2 full with leafy spurge vegetation (no rocks, and definitely no seeds!) for the flea beetles to perch and feed on during transportation.

Again, make sure the container is sealed tight and stapled or taped to prevent escape. And don’t punch any air holes!!!

Is It Working?

Reductions in spurge density will depend on the flea beetles and their ability to prosper under the soil types, moisture and weather conditions, and plant densities at the sites where they were released. How quickly reductions occur will depend on these and other factors as well as the number of beetles released and number of releases made. Results may be observed as quickly as a year after the initial release, but significant reductions generally do not occur for five years.

Will It Work?

Keep in mind that flea beetles will not always be successful. Following the guidelines in this manual, especially for site selection, will greatly enhance chances of success, but there’s always a chance that flea beetles might not work.

Sites that aren’t living up to your expectations in terms of leafy spurge repression should be carefully evaluated to identify possible remedies. First off, you need to determine if biocontrol is going to work at the site in question. It’s possible that changing one or more of the implementation techniques might help improve flea beetle establishment. Perhaps the initial release was made in a patch of spurge that is too dense or shady, or maybe the insects were harvested too late in the season. Maybe supplemental releases, or releases of a different species, will help “jump start” the population.

In some cases, site characteristics can be manipulated to improve flea beetle establishment.

Storing & Transportation

The most important thing to keep in mind while storing and transporting your flea beetles to a new release site is DON’T GIVE UP!!! Containers should be stored in a cool, dry place out of direct sunlight. A cooler with blue ice is a good idea if the beetles are going to be stored for a couple of hours or longer. If you’re using a cooler, make sure paper bags or containers don’t get wet.

Flea beetles should ALWAYS be released as soon as possible after they’ve been harvested. They can, however, be stored overnight under moderate refrigeration (40-45 degrees).

It’s possible that flea beetles will simply not produce the results you want at the site in question. They might not work well enough to control spurge on their own, or they might not work at all.

If you find yourself in this situation, it is important to take some sort of management action. Leafy spurge won’t go away by ignoring it, and the problem will only get worse with time. At this point, you need to evaluate what tools can be used to most effectively and affordably provide relief against leafy spurge infestations.

Don’t be afraid to seek input from outside sources, especially from people who may have had similar experiences. Consult with neighbors or other ranchers who have had leafy spurge problems, and with experts from county Extension Services and weed control offices.

Make a few phone calls. Learn about the other options that are available.

But no matter what you do, DON’T GIVE UP!

- 14 -

- 15 -
IPM, IPM and more IPM

Under ideal circumstances, biological control will maintain leafy spurge densities below economically significant levels. Ideal circumstances, however, are not always possible, and flea beetles aren’t going to work every time at every site. In these situations, integrating biocontrol with other management tools, or simply using other tools, may be required.

In short, despite its great potential, biological control is not a “silver bullet.” There are no cure-alls for leafy spurge – no single tool will work every time in every situation.

The solution is Integrated Pest Management, which combines, or integrates, different tools to provide more effective leafy spurge control than any single tool could produce. It’s a technique that offers many advantages; most importantly, it gives landowners and land managers the flexibility needed to devise the best approach for a specific situation.

Why It Works
IPM works because it combines the best elements of different tools.

In most IPM scenarios, traditional tools – like herbicides, grazing or mowing – are used to reduce spurge densities and open up the canopy, enhancing population establishment and giving flea beetles a chance to build the numbers needed for spurge control. In addition, the stress and damage caused by one tool weakens the target, making it more susceptible to damage caused by other tools.

Herbicides
Herbicides are the most commonly used leafy spurge management tool, and are the preferred tool for containing/preventing the spread of infestations and for eradicating new invasive weeds. Unfortunately, herbicides are generally expensive – use on large infestations may not be economically feasible – and non-selective. In addition, herbicide use may be restricted by environmental regulations or inaccessibility to infestations.

Research has shown that herbicides and biological control can be complementary if properly used. Timing is the most important factor. Fall applications (after Aug. 15) are compatible with flea beetle survival, and can enhance population establishment. Spring and summer applications, however, will remove the top growth needed by adult flea beetles to complete their life cycle, and should thus be avoided.

It should be stressed that herbicide use SHOULD NOT BE ABANDONED because you’re using biological control. Using herbicides to contain patches of spurge while flea beetles are establishing will result in quicker resolution of your problem.

Grazing
Multi-species grazing can be used to control leafy spurge while improving range health and increasing ranch profitability. In addition, the stress and damage caused by one tool weakens the target, making it more susceptible to damage caused by other tools.

A Great Tool – Do It!
This section is for Extension agents, weed supervisors, land managers and others who are interested in leafy spurge biocontrol field day activities. Field days are a great way to:

• Provide hands-on experience with techniques for collecting/packaging/redistributing flea beetles, for monitoring flea beetle populations and for evaluating flea beetle release sites.
• Provide leafy spurge flea beetles.
• Provide information on biocontrol and IPM.

Well-planned field days get people involved and generally work very well. The point is, DO IT!

Plan Ahead!
The key to a successful field day is planning ahead, and there are several things to consider months before the event.

One of the most important considerations is knowing where to get your insects. Successful sites from previous years should be productive unless leafy spurge densities have been reduced enough to limit flea beetle populations. Have some back-up harvest sites just in case.

Date & Time
Field days should be scheduled during the recommended harvest period, and early enough so that female flea beetles will have time to lay plenty of eggs at the new release site.

As for the time, follow the guidelines for harvesting: Give the morning dew a chance to dry, and you’re using biological control. Using herbicides to contain patches of spurge while flea beetles are establishing will result in quicker resolution of your problem.

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Who?
You'll also need to decide if your event is open to the public or restricted to invited or pre-registered participants only. This decision will depend on landowner cooperation, personnel available to help with the event, the number of insects available and needed, and other factors. Again, there are advantages and disadvantages: A restricted event allows you to regulate the number of people on a site and plan for a specific number of insects; a public event eliminates the chance for forgetting interested parties. You'll have to decide which type of event works best for you, and more importantly, your target audience. If participants don't have much experience with biocontrol, a hands-on event is a good idea. A simple distribution is easier if participants already have a good understanding of biocontrol.

Communications
Communications is an important part of your event, and there are several things to consider:
• Make sure you coordinate your event with the appropriate landowners or land managers! Ask about any rules that may exist (avoiding certain areas or driving off of roads, for example), and be sure rules are followed at the event.
• It's a good idea to inform neighbors so that there are no surprises.
• Make sure your target audience knows about your event. Newspapers, radio stations, extension bulletins and posters/flyers are helpful for advertising public events. Postcards, phone calls or direct contact might be more appropriate for restricted events. Your communication efforts should include all of the necessary information: 1) Date(s) and time(s), with information about back-up plans in case of bad weather; 2) Duration of event; 3) Directions to the site; 4) Supplies that will be provided; 5) Supplies participants need to bring; and 6) Species of flea beetles available.

Supplies
The following list of supplies is recommended for field day events. Depending upon resources available, you may provide some supplies yourself with participants responsible for other supplies. Make sure participants know what they need to bring in advance of the event:
• Sweep nets
• Pillowcases or bags
• Paper bags/cartons
• Stapler, staples, tape
• Sorting devices
• Measuring vials
• Coolers, blue ice

Field Days...
...are a great way to assemble crowds! Distribute insects and provide information. Planning ahead is important! For example, you'll want to make sure participants come prepared to store and transport their insects in coolers with blue ice (below).

Safety
Field day organizers should be prepared for any mishaps that may occur. Here are a few things to keep in mind:
2. Wood licks – Wear light colored clothing, tuck pants into socks and check frequently for licks. Insect repellent can help discourage licks and mosquitos, but should be used with care when sorting or packaging flea beetles.
3. Leaky spurge latex – Is an irritant. Don’t rub your eyes if you have latex on your hands.
4. Remember, cell phones are necessary in case of emergencies!

Q – Where do flea beetles come from?
A – Aphispona flea beetles are natives of Europe and Asia, and are widely dispersed across a large geographic area – they’re found as far east as China and as far west as France. There is also a North American leafy spurge flea beetle, but it appears to have little impact. Ironically, leafy spurge is generally not a problem in its native lands, where flea beetles and other enemies maintain infestations at economically unimportant levels. In fact, entomologists looking for new biocontrol agents overseas often have difficulty finding large patches of spurge.

Q – Will flea beetles eat crops or other economically valuable plants if they run out of leafy spurge?
A – No. All imported biocontrol agents, including Aphispona flea beetles, are quarantined and rigorously tested before being imported and released. If any potential for damage to crops or economically important plants is identified during this extensive process, the candidate agent will not be approved or imported. This process has shown that Aphispona flea beetles are very host-specific and feed only on a narrow range of hosts restricted to the spurge family.

For a step-by-step description of the quarantine and host-specificity testing process, see the TEAM Leaty Spurge web site at http://www.team.ars.usda.gov/

Q – What about other biocontrol agents?
A – To date, 15 different insects (including six Aphispona flea beetles) have been tested, approved and released for biological control of leafy spurge. Significant success at controlling leafy spurge, however, has been achieved by only the A. nigriscutis and A. lacertosa flea beetles. Other insects have either failed to establish populations, or have established limited populations that have not had a significant impact on spurge infestations.

Following are brief descriptions for a few of the other leafy spurge biocontrol agents.
The long-horned beetle (Oberea erythrocephala) and clear-winged moth (Chamaesphecia spp.) are “stem-miners” that cause damage in two
ways: Adults lay eggs in stems, then the larvae hatch and burrow down the stem — weakening the plant — and into the root crown, where they feed and cause additional damage. *Oberlea* could potentially be important in moist, sandy soils where flea beetles don’t work well. The gall midge (*Spargia esula*) is a tiny gnat that lays its eggs in leafy spurge flowers, which produces a gall that prevents seed production.

While these agents have generally not produced significant spurge control, their long-term impact is not yet known. Some might play important roles in certain situations or when used in combination with other agents.

In addition, researchers are always looking for new biocontrol agents, particularly those that can fill niches or habitats not occupied by agents that are currently available.

**Q – Where do I get flea beetles?**

A – There are always plenty of unharvested flea beetles like those shown below. Prosser surveys the results of a grid release taken in June 2000 at a TEAM Leafy Spurge study site near Sentinel Butte, N.D. — a site that was established in 1999. The photos shown below are a visible reduction of spurge can be expected by the summer of 2001 with significant (75 percent plus) reductions in 2-4 years. Unmanaged spurge can literally take over the range, as shown in these two panoramic photos from the Ekalaka, Montana, area. TEAM Leafy Spurge made grid releases of flea beetles at both sites during June of 2000; a visible reduction of spurge can be expected by the summer of 2001 with significant (75 percent plus) reductions in 2-4 years.

**The payoff** comes when flea beetle populations explode and take out the spurge. These photos were taken in June 2000 at a TEAM Leafy Spurge study site near Sentinel Butte, N.D. — a site that three years earlier was nearly as bad as the photos shown below. 1) The spurge was covered with flea beetles, which were completely defoliating some plants within hours. Large patches of dense spurge disappeared in a span of 3-4 weeks. 2) TLS program coordinator Chad Prosser surveys the results of a grid release made in 1999. All of the spurge — and most of the flea beetles — seen in the picture will be gone next year. 3) Larval feeding killed this plant before it could produce seed. 4) A close-up of *A. lacerata* and one *A. nigriscutis* working on a spurge plant. Note the ragged, pitted leaves and extensive stem damage.

**Q – How large of a patch of spurge is needed for flea beetles?**

A – This is a common question. As mentioned earlier, it’s always best to start looking locally. Flea beetles obtained from local sources won’t have to be stored and transported far, and are more likely to be adapted to local conditions. If you are unable to locate local sources through your county Extension agent or weed officer, contact your state department of agriculture or nearest USDA-APHIS PPO office. Phone numbers for potential sources of insects can be found on page 19 and on the TEAM Leafy Spurge web site at http://www.team.ars.usda.gov

**Q – Where do I get flea beetles?**

A – Flea beetles have proven they can survive the long, harsh winters common in the northern Great Plains by establishing populations and controlling leafy spurge. There is some speculation, however, that a lack of snow cover to provide insulation, combined with extended periods of extremely cold weather, can adversely impact flea beetle populations. Additional research into the topic is needed.

**Q – Will harvesting flea beetles this year reduce next year’s population or retard leafy spurge repression?**

A – No. There are always plenty of unharvested flea beetles on well established sites, and normal population development will continue even with extensive collection efforts. Likewise, harvesting flea beetles will not impact the population’s ability to repress or control leafy spurge. This lesson is often difficult to understand, and is too frequently learned too late. The summer of 2000 provided some excellent examples. Some ranchers and land managers let populations go unharvested in 1999, thinking it would provide more flea beetles for the following year. Many of those populations, however, wiped out their food source by eliminating patches of spurge. Those populations subsequently crashed, and there weren’t any beetles to harvest at those sites in the summer of 2000 — the spurge was gone, and so were the beetles. **The lesson:** Manage your flea beetles as a commodity — move them around and work to establish new sites!

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The "TEAM"  TEAM Leafy Spurge is a USDA-ARS research and demonstration program focused on the Little Missouri River drainage in Wyoming, Montana and the Dakotas, and other spurge-infested drainages in the region. Its goal is to research, develop and demonstrate ecologically based Integrated Pest Management strategies that can be used to achieve effective, affordable and sustainable leafy spurge control.

TEAM Leafy Spurge is built on three important concepts:

- **Integrated Pest Management (IPM)** - IPM combines management tools to provide more effective control than any single tool could produce. Biological control provides the foundation; biocontrol agents like the flea beetle are used with other tools – multi-species grazing, herbicides, etc. – for effective, affordable and ecologically sustainable control. IPM offers the flexibility landowners need to devise different strategies for different situations.

- **Teamwork** - TEAM Leafy Spurge has assembled some of the nation’s most experienced leafy spurge researchers into a focused, goal-oriented team. This collaboration allows participants to share expertise, data and resources to more effectively work toward a common goal.

- **Regional Approach** - TEAM Leafy Spurge focuses on multi-species management strategies for different situations. The regional approach allows landowners and managers to target specific areas where leafy spurge is a problem.

**The Approach**

TEAM Leafy Spurge research and demonstration projects are designed to build on existing data and explore promising new areas of leafy spurge research. These projects cover a range of topics, including biological control, multi-species grazing, herbicides, range management, and the integration of various control tools.

Most research is conducted by weed specialists, range scientists and entomologists. Research is directed at gaining a better understanding of how and why biocontrol agents work, how biocontrol interacts with other management tools, and how different tools can be used alone and in combination to improve spurge control. Research is also being conducted overseas, where entomologists are looking for new biocontrol agents and other research explores the economic and environmental damage caused by leafy spurge.

TEAM Leafy Spurge demonstration sites (Sentinel Butte, N.D.; Ekalaka, Mt.; Buffalo, S.D. and Devil's Tower, Wyo.) give ranchers, landowners and land managers a first-hand look at results produced by various IPM strategies. Tours of the sites are periodically held to provide updates about new and improved management strategies.

**The Bottom Line**

Leafy Spurge is a formidable opponent that cannot be controlled or eliminated by any single entity or management practice – a collaborative, integrated and area-wide approach is essential to solving this costly problem. TEAM Leafy Spurge exists to promote these concepts, and to serve as a clearing house for proven management strategies.

**TEAM Leafy Spurge**

- **Gerry Anderson**, program director (406/433-9416; ganderson@sids.ars.usda.gov), or Chad Prosser, program coordinator (406/433-9403; crosser@sidney.ars.usda.gov), USDA-ARS Northern Plains Agricultural Research Laboratory, 1500 N. Central Ave., Sidney MT 59270; Lloyd Wendel, co-principal investigator, USDA-APHIS, Mountain Research Station, 1730 Samco Rd., Rapid City, SD 57702 (406/844-4264; lloyd.e.wendel@aphis.usda.gov).

**Biological Control**

- **David Hirsch**, USDA-APHIS-PPQ, 3509 Miriam Avenue, Suite A, Bismarck, ND 58501; (701) 250-4473 david.c.hirsch@usda.gov

- **David Kazmer**, USDA-ARS, Northern Plains Agricultural Research Lab, 1500 North Central Ave., Sidney MT 59270 (406/433-8440; dkazmer@sids.ars.usda.gov).

**Insect Control**

- **Montana** - USDA-APHIS, 1629 Ave. D/Suite 5-A, Billings MT 59103 (406/657-6282); Jerry Marks, Montana State University Extension Service, 126 West Spruce St., Missoula MT 59802-4204 (406/721-4095; acxgm@montana.edu).

- **South Dakota** - USDA-APHIS, 3509 Miriam Ave., Suite A, Bismarck ND 58501 (701/250-4473); Dave Nelson, state entomologist, North Dakota Dept. of Agriculture, 600 E. Boulevard/6th Floor, Capitol Building, Bismarck ND 58505 (701/328-4765; dnelson@state.nd.us).

- **USDA-APHIS PPQ, PO Box 250, Pierre SD 57501 (605/224-1713); Ron Mohring, weed pest supervisor, South Dakota Dep. of Agriculture, 523 E. Capital, Pierre 57501 (605/773-3796; ron.mohring@state.sd.us).**

**Web Sites**

- **NDSU-Dep't of Agribusiness and Applied Economics** (http://agecon.lib.unm.edu/) for information on other socio-economic impacts of leafy spurge, the economics of integrating sheep & cattle, and the feasibility of sheep cooperatives.
- **NDU Extension Service** (http://www.ext.ndsu.nodak.edu/extpubs/) features a wealth of information. Extension Service bulletins with pertinent information can be found in the agricultural economics, animal science, entomology, plant science and water quality sections of the directory.

**Multi-Species Grazing**

- **Tim Fallier**, North Dakota State University/ Hettinger Research Extension Center, Box 507, Hettinger, ND 58639 (701/667-4327; fallier@ndsuext.nodak.edu).

**General Weed Control**

- **David Kazmer**, USDA-ARS, Northern Plains Agricultural Research Lab, 1500 North Central Ave., Sidney MT 59270 (406/433-8440; dkazmer@sids.ars.usda.gov).
- **Rod Lym**, North Dakota State University/Dep. of Plant Science, Loftgard Hall, Fargo N.D. 58105 (701/231-8996; lym@plains.ndsu.edu).

**Partnerships!!!**

TEAM Leafy Spurge is funded by the USDA-Agricultural Research Service, and managed in conjunction with the USDA APHIS. Other TEAM members include the U.S. Forest Service, National Park Service, Bureau of Land Management and Reclamation, U.S. Geological Service, state departments of agriculture and other state agencies, Cooperative Extension Services, land grant universities, county weed managers, landowners and ranchers. A non-partisan ad hoc committee provides management and direction.

**Need more info? Someone on this list of experts should be able to help.**

- **Ron Moehring**, USDA Forest Service, Rocky Mountain Research Station, 1730 Samco Rd., Rapid City, SD 57702 (605/394-2670; jackbutler@fs.fed.us).
Remember, PREVENTION is always the best way to manage leafy spurge and other invasive noxious weeds. Be vigilant in efforts to monitor your land – quickly identifying then eradicating infestations of new invaders is much easier and far less costly than managing established infestations.

It also is important that people WORK TOGETHER to manage leafy spurge and other noxious weed invaders. Creating partnerships and working together enables ranchers, landowners and land managers to share resources and expertise and more effectively work toward a common goal. The war against leafy spurge and other noxious weeds, quite simply, cannot and will not be won individually – a collaborative, integrated and area-wide approach is absolutely essential. That means everyone, from landowners and land managers to legislators and a diverse array of state and federal agencies, must be actively involved.

Also recognize that leafy spurge and other noxious weeds are NOT JUST AN AGRICULTURAL PROBLEM. These weeds increase production costs – which ultimately contributes to higher food prices – sap tax resources, reduce land values and threaten precious environmental resources. The problem is shared by all, and as such, will require teamwork and collaboration to devise a shared solution.

A message from TEAM Leafy Spurge

Gerry Anderson & Lloyd Wendel
Co-Principal Investigators, TEAM Leafy Spurge

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