

**INSIDE**

<i>A Seemingly Unstoppable Force</i> .....	2
<i>Enlisting A Natural Enemy</i> .....	3
<i>Giving The Beetles A Boost</i> .....	3
<i>New Successes, New Challenges</i> .....	4
<i>More Questions To Answer</i> .....	5

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# Science

## FINDINGS

*"Science affects the way we think together."*

Lewis Thomas

## A Barrage of Beetles: Controlling Leafy Spurge Through Beetle Inundation



Rob Progar

Researchers found that releasing 50 flea beetles per flowering stem reduced the density of leafy spurge by as much as 80 percent within the first year. Above, field crew count the number of leafy spurge stems in a study plot along the Jordan River in Idaho.

*"I want to find this at another place; have you met with it, or heard of it?"*

—William Oakes, 1827;  
a note attached to a leafy spurge  
sample preserved in the Torrey  
Herbarium at Columbia University.

Vern Kershner remembers a time when his property and that of his neighbors weren't choked thick with the yellow-headed tops of leafy spurge.

"There wasn't any there in the '50s, '60s or '70s," says the 72-year-old Idaho rancher. "Then one ranch started getting some in the upper end of the valley, and it started moving down the creek."

In the course of a decade, Kershner saw the landscape of his 6,000-acre ranch along Boulder Creek in southwest Idaho change from productive grazing land to a perennial battleground against a foreign invader that just won't quit.

"If it moves into the next watershed, where I have my hay grounds, that's when I'm really going to have problems," he says.

Fortunately, a team of researchers, led by Rob Progar, a research entomologist with the Pacific Northwest Research Station, has discovered a way to halt the invasive weed in riparian areas. The team's approach capitalizes on a voracious flea beetle from the weed's homeland that eats only leafy spurge.

### IN SUMMARY

Leafy spurge is an invasive weed that has appeared along streams throughout much of the country. Riparian ecosystems are particularly sensitive areas that can be threatened by nonnative invasive species. These areas also can be damaged by herbicides commonly used in uplands to control invasive plants.

In a collaborative effort by the U.S. Forest Service, Bureau of Land Management, and Agricultural Research Service, researchers found an effective way to use an insect to control the weed. Flea beetles (*Aphthona* spp.) are a natural predator of leafy spurge in its native range in Europe and Asia. The researchers released huge numbers of the flea beetles that inundated patches of leafy spurge along three streams in southwestern, central, and eastern Idaho.

They found that releasing 50 beetles per flowering stem reduced the biomass, crown, and stem density by 80 percent and seedling density by 60 percent, compared to untreated plots.

Land managers are now applying this inundative method of biological control to other situations, such as to prevent leafy spurge outbreaks after wildfires, as well as exploring the method's effectiveness against other invasive weeds.

## A SEEMINGLY UNSTOPPABLE FORCE

The first record of leafy spurge (*Euphorbia esula* L.) in North America dates to 1827 in Newberry, Mass., where it is believed to have been introduced through contaminated soil from ships' ballasts. A native of Europe and Asia, leafy spurge has since been found in 35 states and all the Canadian provinces.

Botanically, leafy spurge is the perfect invasive plant. Its extensive root system can reach more than 30 feet into the soil, outcompeting the root systems of other, more desirable plant species. Mowing or hand-pulling are futile because even leafy spurge root fragments can generate new plants. And its seeds—about 140 per flowering plant—can be expelled up to 15 feet away and lie dormant, yet viable, for 8 to 12 years.

When damaged, leafy spurge stems and leaves exude a milky discharge that contains the toxic compound ingenol. This compound repels many wild and domesticated grazers, although not sheep or goats.

One 2004 study estimated that leafy spurge had caused \$120 million in lost land and business productivity within the northern Great Plains states of the United States. Ecologically, the habitat disruption from leafy spurge infestations has led to reduced populations of birds, such as the grasshopper sparrow (*Ammodramus saviarum*) and savannah sparrow (*Passerculus sandwichensis*), and is

one of the biggest threats to the endangered western prairie fringed orchid (*Platanthera praeclara*). Bison (*Bos bison*), deer (*Odocoileus* spp.) and elk (*Cervus elaphus*) are negatively affected when leafy spurge takes over grazing land.

The application of herbicides has been a relatively successful, albeit expensive means of controlling leafy spurge. However, herbicides are not permitted in environmentally sensitive areas where they may contaminate the water and harm fish and other aquatic organisms. The inability to use herbicides in riparian areas has resulted in conflicts between federal land management agencies and private landowners such as Kershner.



Riparian areas are especially sensitive to invasion by nonnative species. Seeds and root fragments are easily transported downstream where they can establish new colonies.

Rob Progar

## KEY FINDINGS

- Inundating a selected area of leafy spurge along a riparian zone with 50 flea beetles per flowering stem of spurge resulted in a 60 to 80 percent reduction of leafy spurge in a year's time.
- Releasing 10 flea beetles per flowering stem of leafy spurge within a selected riparian zone produced no significant change in spurge density compared to nontreated, control areas.
- Releasing the same amount of flea beetles in the same areas a year after the initial release did not result in any significant reduction in leafy spurge from the first year's reduction.
- *Aphthona* flea beetles are ideal biological control agents for inundative treatments because they reproduce in high volumes (about 100 eggs per adult female), they stay concentrated in and around their food source, and they are easily collected within a short time (up to 1 million over a few days).



Bugwood, Inc.

*Aphthona* flea beetles are natural predators of leafy spurge within its native range in Europe and Asia.

### Purpose of PNW Science Findings

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Rhonda Mazza, editor; [rmazza@fs.fed.us](mailto:rmazza@fs.fed.us)

Cheryl Jennings, layout; [cjennings@fs.fed.us](mailto:cjennings@fs.fed.us)

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"I'm a believer that if it's there, zap it," Kershner says. "But it has to run on a different set of rules than I have to. Meanwhile, we're getting leafy spurge seed coming down the creek whenever we have high water," he says referring to the federal land upstream from his property.

It's a frustrating predicament for public land managers as well. Waterways are a perfect conduit for rapidly spreading the weed. Wayward seeds or root fragments can establish new outbreaks miles downstream from their origin. But it's within these same transmission zones that land managers have the least amount of flexibility or power to control the weed.

Realizing the enormity of the problem, Progar and his colleagues with the Forest Service, Bureau of Land Management (BLM), and Agricultural Research Service set off to discover an effective way to treat leafy spurge along sensitive riparian corridors.



Rob Progar

Flea beetles are collected with a sweep net.

## ENLISTING A NATURAL ENEMY

Progar and his colleagues knew of one natural treatment for leafy spurge that wouldn't violate any clean water regulations; however, it wasn't very effective in wet environments, such as riparian areas.

The flea beetle (*Aphthona* spp.) is the leafy spurge's natural predator in its native range within Europe and Asia. The beetle has been approved for use as a biological control agent against leafy spurge within the United States since the 1980s, after the U.S. Department of Agriculture's Animal and Plant Inspection Service extensively tested the insect and found it not to have negative effects on this country's native flora and fauna.

*Aphthona* flea beetles attack leafy spurge in two ways. Adults lay their eggs at the base of leafy spurge stems in mid-summer. In about eight days, the eggs hatch, and the larvae work their way down to the roots where they begin to feed until going dormant for the winter. When soil temperatures rise in the spring, the larvae resume feeding on leafy spurge roots for another few weeks before pupating. They then emerge from the soil as adults to feed on the leaves and stems of the spurge plants.

"In areas where the beetles have established themselves, the results have been remarkable," Progar says. "I've seen fields covered in leafy

spurge, and then 10 years later, you can barely find a (leafy spurge) plant."

But *Aphthona* flea beetles don't have 10 years to do their jobs in riparian areas. The larvae drown easily, so the beetles' lease on life is limited to about one year in flood-prone riparian zones.

Researchers needed to find a way to accelerate the damage *Aphthona* flea beetles could inflict on leafy spurge so the plants would be significantly affected in spite of their limited exposure to the beetles.

"Basically, we had to figure out how to make a biological control act more like an herbicide," Progar said.

## GIVING THE BEETLES A BOOST

One way to magnify the effect of a biocontrol agent is by simply increasing the number of biocontrol agents released. This inundation approach has been used successfully to treat invasive insects. With the screw-worm fly, for example, high numbers of sterile males were released into an area to mate, but not reproduce, with their female counterparts.

If an insect pest could be controlled by over-running its environment with predators or other inhibiting factors, why not try the same approach against problematic plants?

To test this theory, Progar and his colleagues set up test sites in 2005 along three riparian areas in Idaho: one in the northeast, one in the middle of the state, and one in the southwest corner. Each test site contained nine 80-square-foot plots spaced about 160 feet apart.

Three plots served as the control and received no beetles. Three plots received 10 beetles per flowering stem of leafy spurge, and three plots received 50 beetles per flowering stem. When researchers returned the following year, the results were striking

"The sites with 50 beetles per stem had a dramatic reduction in the number of stems and in the overall biomass of leafy spurge," Progar says.

The inundated sites saw a 60 to 80 percent reduction in leafy spurge, whereas there was no statistical difference between the 10 beetles-per-stem sites and the untreated sites.

Each subplot received an identical treatment the second year into the study; however, no sizeable change was observed between the second and third year. This suggests that the greatest benefit of an inundative release is realized within the first year, Progar says.



## NEW SUCCESSES, NEW CHALLENGES

**I**t didn't take long for people familiar with these research findings to start incorporating the methods. Joey Milan, a co-researcher with Progar on the project, began using inundative releases along the riparian areas on Bureau of Land Management land in Idaho, where he serves as the State of Idaho's invasive weed biocontrol specialist.

"We were blown away by the results," he said. "Usually results we'd see in ten years, we were now seeing in two years. We could facilitate things a lot more quickly."

Janet Valle oversees invasive weed control for 24 national forests and across several states as the pesticide cooperative noxious weed coordinator for the Northern and Intermountain Regions of the U.S. Forest Service. She has watched leafy spurge's gradual expansion across Idaho.

"It's slowly been marching across private lands and now onto the Targhee National Forest," Valle says, noting that it's making its way toward Yellowstone National Park, the Grand Tetons, and the Jedediah Smith Wilderness. "What can we do to slow the tide? What can we do to put a line in the sand and say, 'This is where we're going to try and hold it, where we'll try to slow it down?'"

During the last few years, Valle and her fellow noxious weed partners have released more than 6 million flea beetles across the state. Her efforts have expanded beyond riparian areas. She now has crews drop "bug bombs" from helicopters into mountainsides or remote locations where other access is difficult. Although the helicopter drops have yet to incorporate the inundation methodology, Valle says she is using inundative releases on uplands as a biological pesticide against large leafy spurge infestations.

A collaborative union of county, state, and federal agencies, as well as school districts and nonprofit organizations, have banded together in effort called "Hold the Line." Kim Ragotzkie, a former federal wildlife biologist, coordinates the team.

"It's a neat project, but it's challenging sometimes because there are a lot of moving parts, and it can be hard to coordinate," Ragotzkie says. "Everyone has another job on top of this, so things get pretty busy."

Nevertheless, Hold the Line still manages annual *Aphthona* collections, gathering as many as 7 million flea beetles in a single outing. The group tries to time the collections to when the adults emerge from the soil and mate so the females are full of eggs. Each female can produce up to 100 eggs.



Volunteers with the "Hold the Line" effort sort and divide the flea beetles collected at one location so the beetles can be released in the study areas.

Another important function of Hold the Line is its monitoring efforts. The group periodically returns to release sites and can report back to land managers where their efforts seem to be having the most impact and where other techniques might be warranted.

Some of the initial successes of Hold the Line have created an unexpected problem: a declining food supply to support the massive quantities of insects needed to support inundative releases along riparian corridors.

"The beetles are eating themselves out of house and home," Valle says.

Although it's fortunate that the *Aphthona* flea beetles are exclusively interested in leafy spurge—and not any of the 53 related spurge species native to North America—it also means the insects' viability is intimately

linked to the one thing they're set out to destroy.

Hold the Line's primary collection site was a 150-acre patch of land that was saturated with waist-high spurge. "We used to collect the beetles by the pound," Progar says.

Three years later, spurge still exists at the site, but only smaller shoots about 5 to 6 inches tall. This summer's collection netted only about 300,000 beetles. This has prompted Milan, the BLM biological control specialist, to begin scoping out future insectaries, even if it means going out of state to find them.

"We're running out of these big areas of leafy spurge where we're collecting the insects (in Idaho)," he says. "But I'm optimistic that we'll be able to find suitable areas in other parts of the United States."



A Forest Service field crew releases flea beetles in a riparian area overgrown with leafy spurge.

Rob Progar

Rob Progar



## MORE QUESTIONS TO ANSWER

**P**rogar and his colleagues' work has other entomologists and land managers talking about its ramifications.

"What makes (Progar's) paper cool is that it's the perfect 'proof of concept' paper," said Carol Randall, a Forest Health Protection entomologist with the U.S. Forest Service and co-author of the field manual *Biology and Biological Control of Leafy Spurge*. "Now we have a new way of thinking; it's opened up a lot of different areas for exploration."

For example:

- What other weeds would respond to an inundative biocontrol approach?
- What's the threshold for inundation? Would 30 beetles per flowering stem produce results sufficiently similar to the 50 beetles per flowering stem used by Progar?
- Would the treatment be more effective if it used a species of *Aphthona* flea beetle that was better adapted to riparian areas?

"Is there another way of being successful and getting over the hump?" Randall asks.

The inundative technique is now being used to try and get ahead of leafy spurge outbreaks in recently burned areas. "Leafy spurge basically has free range in an area consumed by fire," Progar says. "They get a burst of nutrients from the fire with virtually no competition from other plants, plus all the biocontrol agents were killed, too, so it comes back bigger and stronger than ever."

Milan also has seen promising results by releasing flea beetles at the perimeter (as opposed to the epicenter) of spurge sites, where the larvae can decimate the shorter, younger plants before moving to the larger, deeper roots of the more mature plants.

It's exactly this type of experimenting and reapplication of the study's findings that excites Progar.

## FOR FURTHER READING

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## LAND MANAGEMENT IMPLICATIONS



- Inundative release of *Aphthona* flea beetles is an effective non-chemical method of addressing leafy spurge in riparian areas. This method was as effective as an herbicide when it was applied with the regularity and intensity of traditional chemical applications.
- Other biological control agents are being reexamined to determine how effective they may be when inundative amounts are applied to invasive vegetation.



Rob Progar

The "bug blast" effect. The area in the foreground is nearly free of leafy spurge, thanks to the voracious flea beetle.

"That's what it's supposed to do," he says, noting that he's in the finishing stages of a study evaluating inundative release of a stem-boring weevil (*Mecinus janthus*) on Dalmatian toad-flax (*Linaria dalmatica*) on burned areas. "It's supposed to be a springboard for people to take and use and try in different directions. It comes down to 'How can we get more bugs out there in different ways?'"

*"The spread of this weed has been so threatening that the county agent recently requested the cooperation of the Department of Agriculture in an effort to rid the district of the noxious weed."*

—New York Herald, February 9, 1921

## WRITER'S PROFILE

Paul Mezmarich specializes in environmental communication. He is owner of Otter Creek Communications and can be reached at [ottercreekcomm@gmail.com](mailto:ottercreekcomm@gmail.com).



U.S. Department of Agriculture  
Pacific Northwest Research Station  
333 SW First Avenue  
P.O. Box 3890  
Portland, OR 97208-3890

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## SCIENTIST PROFILE



ROB PROGAR is a research entomologist with the PNW Research Station. Some of his current projects include: (1) developing reliable methods based on semiochemicals for

predicting, detecting, monitoring, or mitigating unwanted insect disturbances to support management strategies for productive and sustainable forest ecosystems, (2) evaluating the relationship between fire-caused injury and tree survival and identifying methods to increase tree survival following controlled burning, (3) the use of biological control to mitigate the impacts of invasive plants and insects, and (4) modeling the response of arthropod species and feeding guilds to climate patterns.

*Progar can be reached at:*  
USDA Forest Service  
Pacific Northwest Research Station  
Forestry and Range Sciences Laboratory  
1401 Gekeler Lane  
La Grande, OR 97850

E-mail: [rprogar@fs.fed.us](mailto:rprogar@fs.fed.us)  
Phone: (541) 962-6578

## COLLABORATORS

Tom Barbouletos, USDA Forest Service,  
State and Private Forestry

George Marken, USDA Forest Service,  
Rocky Mountain Research Station

Joe Milan, USDI Bureau of Land  
Management

Matt Rinella, USDA Agricultural  
Research Service

Ranchers and landowners in southwest  
and northeast Idaho

Southern Idaho Biological  
Control Program