

Science

FINDINGS

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“Science affects the way we think together.”

Lewis Thomas

Herbicides: An Unexpected Ally for Native Plants in the War Against Invasive Species



David Stephens

In the Gifford Pinchot National Forest, researchers found that by adjusting the herbicide application rates, invasive plant species could be controlled without significantly impacting native plant species.

IN SUMMARY

Herbicides are primarily used for protecting agricultural crops from weeds and controlling vegetation competition in newly planted forest stands. Yet for over 40 years, they have also proven useful in controlling invasive plant species in natural areas. Nonnative invasive plant species, if not controlled, can displace native species and disrupt an ecosystem by changing soil chemical and biological properties. However, before an herbicide may be applied in a U.S. national forest, toxicological and ecological assessments and field testing are required to ensure it won't negatively affect the landscape or people.

In the Gifford Pinchot National Forest, scientists with the U.S. Forest Service Pacific Northwest Research Station established experimental plots to test effects of aminopyralid (a plant growth-regulating herbicide) on both the nonnative and native meadow plant species. When applying less than the manufacturer's maximum labeled rate, researchers found the herbicide reduced the cover of Canada thistle and other nonnatives without strongly affecting native species.

Aminopyralid, along with aminocyclopyrachlor and clopyralid (also plant growth-regulating herbicides), were also tested in a growth chamber trial for their effectiveness in controlling the germination of Scotch broom, a large invasive shrub that often reduces survival of young Douglas-fir. Spraying the soil with each type of herbicide controlled up to 90 percent of the germinating Scotch broom seedlings.

“As natural selection acts by competition, it adapts the inhabitants of each country only in relation to the degree of perfection of their associates...”

—Charles Darwin,
On the Origin of Species

Visit Gifford Pinchot National Forest's Cave Creek meadow in late spring and it is not the blue-eyed grass' delicate bluish-purple flowers that catch your eye. Instead it is the tens of thousands of Canada thistle stems filling the meadow. These stems

are just a fraction of this plant's biomass; underground is an enormous rhizome network that sends shoots skyward each year.

Similarly, eye-catching yellow flowers of Scotch broom can obscure a young Douglas-fir plantation as the nonnative invasive shrub chokes out the newly planted tree seedlings. Though these landscapes are managed for different purposes, each is vulnerable to an invasion of nonnative invasive plants. Whether the takeover is at the expense of native species or future wood production, the management decision is the same: How to hold off the advance of invasive plant species?

Not all plants introduced to the United States become invasive, but those that do have common traits—rapid growth, prolific vegetative spread or seed production, and the ability to adapt to a variety of landscapes—all of which enable them to outcompete native species. “Many of these invasive species are Eurasian plants which are incredibly competitive, and if you give them a little break, they gain a foothold in the landscape,” says Dave Peter, an ecologist with the Pacific Northwest Research Station in Olympia. “Even an intact native community ultimately might not be able to completely prevent an invasive species from entering the ecosystem.”

Because invasive species cross property lines and jurisdictions, all landowners, whether in urban or rural settings, face the challenges of controlling invasive plant species. “The reason why Green Diamond invests in controlling Scotch broom on our timberlands is because if the plant is left unchecked, it will take over an entire area and choke out the young Douglas-fir seedlings,” says Rick Brooker, a forester with the Shelton, Washington-based Green Diamond Resource Company.

“As the largest custodian of public forest lands in the Pacific Northwest, the U.S. Forest Service has a great responsibility to manage invasive plants on our landscapes so we aren’t sources of infestations of other lands,” says Shawna Bautista, the pesticide use and invasive plant coordinator for U.S. Forest Service’s Pacific Northwest Region. “We also have a responsibility to restore and improve habitats that we manage. The weeds cause very serious

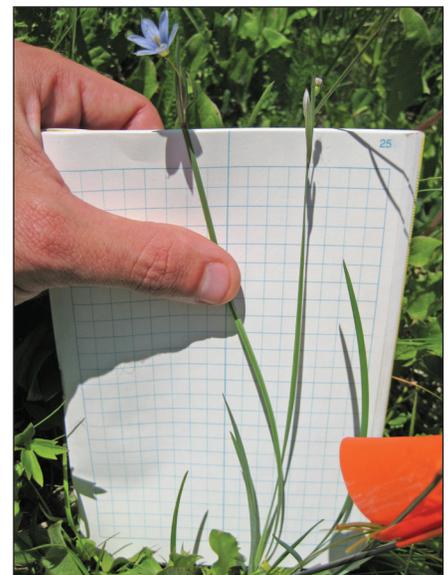
KEY FINDINGS	
•	Even at a low application rate, aminopyralid proved effective in reducing the cover of Canada thistle (<i>Cirsium arvense</i>) by 69 percent while reducing the cover of native species by only 29 percent. The threatened mountain blue-eyed grass (<i>Sisyrhincium sarmentosum</i>), which is being outcompeted by the Canada thistle, wasn’t affected by application of the herbicide.
•	Testing the herbicide at various concentrations revealed that the low application rate had no detectable effect on the total number of plant species in the meadow community; however, the number of plant species declined proportionally with increases in the application rate.
•	Applying aminopyralid, aminocyclopyrachlor, and clopyralid to a simulated Scotch broom (<i>Cytisus scoparius</i>) seed bank controlled up to 90 percent of the seedlings.
•	Because aminopyralid, aminocyclopyrachlor, and clopyralid all effectively controlled Scotch broom germination, land managers can consider the herbicide that is most cost-effective and appropriate for their given area and where the herbicides are registered for use.

ecological, as well as economic, impacts.” In the state of Oregon, the control expenditures and loss of timber revenue from Scotch broom alone total over \$40 million annually.

Land managers have a variety of tools available to control invasive plant species—mechanical (mowing or girdling), manual (hand-pulling or mulching), chemical (herbicides), and biological control (goats, insects, or diseases). The cost and type of landscape being invaded and the target invasive plant determine which removal method is most appropriate. To remove the Canada thistle growing in the Cave Creek meadow, manual and mechanical methods would prove ineffective against the volume of biomass residing belowground, even if the area were accessible by equipment and volunteers. And the resulting disturbance to the ground by applying these methods would disrupt the ecosystem, potentially increasing soil erosion and other environmental effects, explains Vanelle Peterson, senior research scientist with Dow AgroSciences. Plus, the effects of these methods are short-lived, which means that reentry into sensitive native habitat would increase, continually harming the growing site. Controlling Scotch broom via mechanical means is nearly impossible because of the hardiness of the shrub, and its long-lived seed bank: a single plant can produce up to 10,000 viable seeds each year, and the seeds can germinate decades after being buried.

For this reason, herbicides are an effective tool when combating invasive plant species. “Because we manage such a huge landscape, we must be able to treat many acres on a minimal budget, and in many cases, herbicides are the most economical way to do it,” Bautista says. Though the use of herbicides is permitted on national forests, each herbicide must

be field-tested, and an environmental analysis must be completed and approved before the herbicide can be included in the Integrated Weed/Pest Management Plan established for each national forest. This is in addition to the review process already required by the Environmental Protection Agency (EPA) before an herbicide is registered. Green Diamond may not have the same lengthy internal review process for approving the use of EPA-registered herbicides on its timberlands, but Brooker has the same concern about the impacts an herbicide will have on the young trees. He and Bautista welcome new research that allows them to apply herbicides more effectively.



David Stephens

The mountain blue-eyed grass, a native iris found in the Gifford Pinchot National Forest’s Cave Creek meadow, is a threatened plant species and is negatively affected by faster growing invasive (nonnative) plant species.

Purpose of PNW Science Findings

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THISTLE TAKEDOWN

“We have a problem meadow” is how Tim Harrington, a research forester with the Olympia-based Pacific Northwest Research Station, recalls Bautista broaching her research question: Was there an herbicide that could control the Canada thistle growing in a riparian meadow without affecting the threatened mountain blue-eyed grass?

Harrington knew of such an herbicide, aminopyralid, which is a soil-active compound registered for use primarily in natural areas, forests, rangelands and pastures. It is also registered for use in riparian areas because it doesn’t affect water quality. Aminopyralid breaks down in the soil and has a 35-day half-life, so it is nearly undetectable in the soil after a year. With Canada thistle “there is virtually no other way to control this plant except with a soil-active herbicide because of the massive biomass belowground,” Harrington explains.

Though many nationwide field studies have shown the herbicide’s effectiveness, aminopyralid isn’t yet approved for use in the Gifford Pinchot National Forest, nor were data available to show its effects on the blue-eyed grass. Even with the 8- to 10-year development time and the minimum of 120 laboratory studies that companies, such as Dow AgroSciences, invest in developing an herbicide, the studies don’t cover all the possible uses out in the field, Peterson explains. To fill that data gap, Harrington and Bautista conducted a study. According to Harrington, this was the first study to test aminopyralid’s use in the Pacific Northwest in a forest meadow setting on a native herb, though other studies have been done to look at the effects of aminopyralid on native herbs in the West and Midwest.

While it might seem counterintuitive to apply an herbicide in the presence of a threatened plant species, aminopyralid primarily targets dicots, such as Canada thistle. (Typical characteristics of these broad-leaved plants include a taproot system, branched leaf veins and flower petals in multiples of four or five.) “We strongly suspected the blue-eyed grass wouldn’t be harmed because it is a monocot (i.e., a grasslike plant),” Peter says, “So there was really good reason going into this study to think that it wouldn’t be harmed.”

In 2009, Harrington and Peter established 36 plots (6 by 6 m), each containing a similar composition of Canada thistle and native species. Peter says that across all the plots, 67 species were represented. There were 56 dicots (34 native and 22 nonnative) and 11 monocots (6 native and 5 nonnative). The blue-eyed grass plants were flagged so they



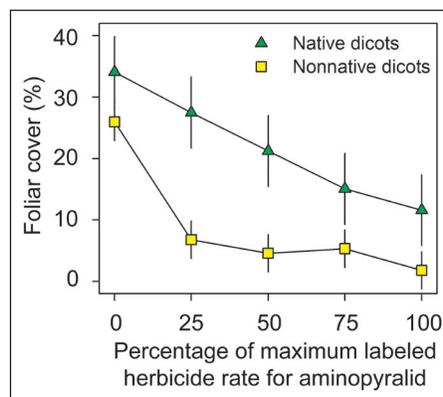
David Stephens

At 1- and 2-year intervals after treatment, researchers visited the plots to assess the cover of the Canada thistle and the associated native and nonnative species in both the nontreated and herbicide-treated plots. The mountain blue-eyed grass was unaffected by the herbicide application.

could be monitored throughout the study. Of these 36 plots, 24 were randomly assigned for treatment in 2009 and 12 for treatment in 2010. The reason for the replication was to conduct a followup study on a smaller scale to see if the same results were observed the following year, Peter explains. Each plot was divided in half: one part sprayed with aminopyralid and the other left nontreated for comparison.

Harrington applied aminopyralid as a foliar spray at sunrise during calm winds to minimize the chance for herbicide drift into the

nontreated plots. Instead of applying aminopyralid at the maximum application rate, which Dow AgroSciences recommends to ensure results on hard-to-control species like Canada thistle, Harrington decided to test whether low rates would be just as effective. His reasoning: low rates would pose less risk to nontarget native plants while still achieving the desired results of controlling the Canada thistle. The plots designated for treatment were randomly assigned an application of 25, 50, 75 or 100 percent of the herbicide’s maximum labeled rate. At 1- and 2-year intervals after treatment, Harrington and Peter evaluated the plots to assess the cover of the Canada thistle and the associated native and nonnative species.



Though the applied herbicide targeted all dicot plant species, the invasive meadow dicot plant species saw a greater decrease in foliar cover across the plots than the native meadow dicot species.

Analysis of the percentage of foliar cover for each species revealed that aminopyralid controlled the meadow’s nonnative dicots, including Canada thistle, oxeye daisy (*Leucanthemum vulgare*), and red sorrel (*Rumex acetosella*). The lowest application rate of aminopyralid reduced the collective cover of all the invasive dicots by 69 percent while reducing the cover of the native dicots by only 29 percent. Common yarrow (*Achillea millefolium*), a native dicot, had reductions in cover following application of the aminopyralid, but this reduction wasn’t observed in every species.

“A few of the native dicot species [selfheal (*Prunella vulgaris*) and thymeleaf speedwell (*Veronica serpyllifolia*)] increased in cover

after the treatment. I was expecting all of the dicots either to be controlled or at least not see a cover increase following the herbicide application,” Peter says. Predictably, as the

application rate of aminopyralid increased, the overall species richness decreased.

In 2009, Canada thistle cover was reduced by 88 percent, but because of the cooler spring

temperatures in 2010, only a 56 percent reduction was seen. This was due to the plants being immature in development, as the herbicide is found more effective when the plants are in a prebud to early-bud stage of development.

STAGING AN ASSAULT

Because Scotch broom consumes twice as much water as a Douglas-fir seedling and persists on the landscape, it is a shrub that Brooker and other foresters want controlled. “A few Scotch broom plants will quickly take over an area because it has an effective ballistic seed dispersal method,” Harrington explains. “It has been estimated that one plant can disperse seeds up to 16 feet.”

On Green Diamond plantations composed of Douglas-fir, Scotch broom is typically controlled by an aerial application of clopyralid, as Douglas-fir is unaffected by over-the-top applications of this herbicide.

Harrington’s research into controlling Scotch broom came about from a request from Peterson to compare the effectiveness of Dow Agroscience’s herbicides, aminopyralid and clopyralid. When these herbicides are absorbed into seeds, “they promote cell division and growth similar to auxin, a naturally occurring plant growth-regulating hormone, but in this case, they cause rapid unbalanced cell division and growth,” Harrington explains. If seedlings manage to germinate, they are misshapen and quickly die.

Harrington decided to test whether spraying the seed bank before germination could decrease seedling emergence and survival. Instead of conducting the study in the field, he selected a growth chamber method to observe the germination more closely. An herbicide called aminocyclopyrachlor, another plant growth-regulator herbicide, was also tested.

Scotch broom seeds, collected around Olympia, Washington, were sown in forest soil collected from a site near Matlock, Washington. For the next 90 days, the researchers counted the number of seedlings that emerged and subsequently died. Applications of aminopyralid and clopyralid resulted in an average seedling mortality of 67 percent versus 4 percent in



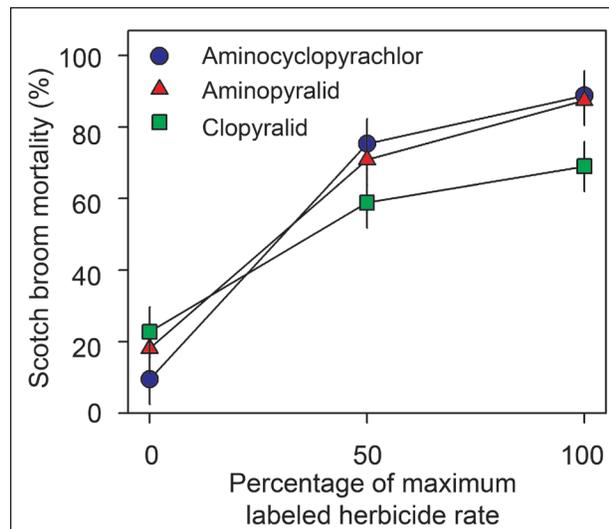
James Dollins

Scotch broom seedlings emerging from soil treated with clopyralid herbicide. Note the swollen taproot, deformed stem, and missing root hairs indicative of injury from a growth-regulator herbicide.



James Dollins

Nontreated seedling of Scotch broom soon after emergence.



Applying herbicides to the simulated Scotch broom seed bank before germination effectively controlled up to 90 percent of seedling germination.

nontreated containers. Applications of aminocyclopyrachlor controlled, on average, 86 percent of the seedling germination compared to 15 percent mortality for nontreated seedlings. When Harrington compared the cost of apply-

ing each herbicide to the resulting seedling mortality, aminopyralid proved the most cost-effective at \$0.54 per percentage of emerged seedlings controlled followed by clopyralid (\$0.95) and aminocyclopyrachlor (\$1.29).

SHARPENING A TOOL

Herbicides are a blunt instrument, Peter says, and Harrington sees his research as honing the effectiveness of this tool. “Herbicides can be applied in an innocuous way where there’s almost no impact upon the environment, particularly if you use low rates, a spot treatment method, and have firm objectives about what you are trying to accomplish.”

For Peterson, this is welcome news because it demonstrates herbicides can play a role in protecting natural areas. “At Dow AgroSciences, we don’t want to harm the native ecosystem, but we want to get rid of the invasive weeds which are a threat to the survival of native species.”

Land managers consider the entire native ecosystem before applying herbicides, as their use can have unintended consequences. With the abundance of Canada thistle reduced in the Cave Creek meadow, the nonnative Kentucky bluegrass proceeded to capture its growing space instead of the native meadow species. This is useful information for land managers,

Bautista explains, because “we need to know what the community response will be when applying aminopyralid. In another meadow where we have a mixture of native and non-native species, we know how the grasses will respond with a reduction in the invasive plant species. We will also know which broad-leaved plants are susceptible and tolerant to this particular herbicide. This will help us evaluate whether this herbicide is the right tool for the right place.”

Brooker is taking a similar approach to Harrington’s findings, reviewing them this summer to determine whether they can be incorporated into site-preparation treatments this fall.

“The only way forward, if we are going to improve the quality of the environment, is to get everybody involved.”

—Richard Rogers, architect



LAND MANAGEMENT IMPLICATIONS



- Removal of the Canada thistle resulted in already present Kentucky bluegrass (*Poa pratensis*), a nonnative species, reclaiming the growing space.
- Because a lower herbicide application rate proved effective in controlling the nonnative invasive plant species, land managers have the flexibility to select the most appropriate rate for their objectives.
- Aminopyralid is an effective herbicide against invasive dicot (broadleaf) species and is already approved for consideration to use on national forest lands in the Pacific Northwest Region. Spraying a Scotch broom seed bank with aminopyralid and clopyralid is a cost-effective measure for controlling Scotch broom.
- Aminocyclopyrachlor could be considered for use in controlling Scotch broom in non-forested areas.

FOR FURTHER READING

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PESTICIDE PRECAUTIONARY STATEMENT

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state or federal agencies, or both, before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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SCIENTIST PROFILES



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