Biocontrol Comes of Age

Photo © by Vivian Kimball

by Annie Reid

Environmental science students from Westborough High School dig Purple Loosestrife root balls in a flooded cattail marsh in April.

Has biocontrol come of age? To see a class of high school students wading in a marsh of cattail and purple loosestrife, digging root balls in April or counting and measuring stems in September, you might begin to think so.

Biocontrol is the use of one organism – the biocontrol agent – to control another organism that is a pest to humans. In this case, the pest is the invasive wetland plant, purple loosestrife (*Lythrum salicaria*), and the biocontrol agent is loosestrife-leaf-eating *Galerucella* beetles. Both purple loosestrife and these beetles are originally from Europe.

The Westborough Purple Loosestrife Biocontrol Project began when a few members of the Westborough Community Land Trust (WCLT) read a newspaper article in 2008 about a high school teacher and class in Uxbridge who were raising and releasing beetles to control purple loosestrife. It inspired us.

Our first thought was that a similar project would fit the land trust's environmental and educational aims. By controlling purple loosestrife, we could improve the quality of the natural environment in Westborough, a town blessed with several ponds, five major swamps, and the headwaters of the Assabet and Sudbury Rivers. Purple loosestrife had invaded our wetlands over the past 20 years. With a biocontrol project like the one we had read about, we could also bring a real, hands-on environmental project to the next generation of environmentalists, the town's young people.

We instantly had second thoughts. A biocontrol project using a non-native organism is fraught with perils. The past provides scary examples of non-native plants or animals being introduced inadvertently or deliberately (for biocontrol or other purposes) and going on to cause major environmental harm.

An infamous case is the Indian mongoose *(Herpestes javanicus)*, introduced from Asia to the Hawaiian Islands in

the 1880s to control rats on sugar cane plantations. Things did not go as planned because the mongoose hunts during the day while the rats come out primarily at night. It turned out that the mongoose hunted many native Hawaiian ground-nesting birds and their eggs. These birds include Hawaii's state bird, the Hawaiian Goose or Nene (*Branta sandvicensis*), which is today a state and federal endangered species.

Even purple loosestrife could be considered an example of an introduced species gone wrong. The plant arrived on North American shores in the early 1800s, probably as seeds in the ballast of ships and as an import for people who wanted it in their gardens for medicinal or ornamental uses. It outcompetes native wetland plants here and has become a major invasive species.

A dramatic example that New Englanders are quick to bring up is the gypsy moth (*Lymantria dispar)*. Its caterpillars defoliate trees in the northeastern U.S. on a large scale during outbreaks. In 1869 E. Leopold Trouvelot, then an artist and amateur entomologist (and later an astronomer and faculty member at Harvard), first brought gypsy moth caterpillars from Europe to Medford, MA. There he tried to breed them to produce silk, but some escaped into his neighborhood and spread from there. By 1889 the Massachusetts State Board of Agriculture was already trying to eradicate the gypsy moth, but its efforts proved futile. Today, invasive gypsy moths have spread throughout the northeastern U.S. and parts of the midwest, southeast, and eastern Canada.

A less well-known part of the gypsy moth story involves a non-native tachinid fly, *Compsilura concinnata,* which was introduced as early as 1906 to control the gypsy moth. This fly is a parasitoid that injects its larvae into caterpillars of the gypsy moth (and many other

Purple Loosestrife typically dominates wetlands, forming dense monocultures. Bees love it (inset), but it suppresses many native plants and animals. Scenes similar to this one are common in many areas of Massachusetts. People brought this invasive plant from Europe in the early 1800s for ornamental and medicinal uses, and seeds are also likely to have arrived in ships' ballast.

insects), where the larvae feed and develop, eventually killing the caterpillars. Unfortunately, this *Compsilura* fly has recently been implicated in the decline in the northeastern U.S. of our showy native giant silk moths, such as the cecropia moth (*Hyalophora cecropia*), promethea moth (*Callosamia promethea*), and buck moth (*Hemileuca maia maia*). (These moths are not closely related to the domesticated Asian silkmoth, *Bombyx mori*, which humans have bred to produce silk for 4,000 years.)

Overcoming Reservations

The basic concerns about biocontrol are three. Two of them focus on the risks associated with introducing a non-native organism. The problem is often that a non-native organism is, or proves to be, a generalist where food is concerned. In other words, plants other than purple loosestrife might be at risk from a non-native biocontrol agent.

A generalist diet is much of the problem both with the inadvertently introduced gypsy moth caterpillars and the *Compsilura* fly that was intended to control them. Gypsy moth caterpillars prefer to feed on oaks (*Quercus* species) but also eat many other species, even conifers. The *Compsilura* fly uses gypsy moth caterpillars as hosts for its larvae, but also attacks 200 other North American insects in this way, including the lovely giant silk moths. The danger is that a non-native biocontrol agent for purple loosestrife might feed on more than one species of plant in its new environment. That is, it might not be adequately host-specific.

One precaution would be to use a biocontrol agent that is host-specific. We would need one that has been proven to specialize in eating only the purple loosestrife.

The second concern is long-term. Even biocontrol agents that are host-specific might eventually adapt and evolve to attack a broader group of organisms. We would want to know that a host-specific biocontrol agent had been tested with other plants, including those closely related to purple loosestrife, and found safe.

Finally, a third concern that we had to answer, both for ourselves and for others, was: Why resort to biocontrol at all? Why not use conventional weed control methods against purple loosestrife, such as pulling it up, mowing or chopping it down, or burning it? Or why not use herbicides?

To address these three concerns, we checked into the research that had been done. We learned quite a bit about what makes purple loosestrife so invasive and so hard to control, and about what makes the *Galerucella* beetles suitable as a biocontrol agent for it.

Starting with the third concern, we found out that conventional weed control methods such as pulling, mowing, chopping, and burning are not only expensive and labor intensive, but also don't work. Or rather, they might work only for small, isolated infestations in well-defined areas. Purple loosestrife is a perennial wetland plant that can sprout from pieces of roots or stems. Unless control efforts remove all parts of the plant from the ground, it just comes up again. And of course it also grows from seeds, which it produces in mind-boggling numbers – up to 2-1/2 million seeds per year for a bushy, multi-stemmed plant. Its seeds also last several years in the soil's seed bank.

Because purple loosestrife is a wetland plant, chemical control is also out. Herbicides aren't suitable for use in wetlands or near our water supplies.

Regarding the first and second concerns, we learned that researchers had started screening European insects as possible biocontrols for purple loosestrife in the 1980s. Investigators eventually focused on six insects: two leaf-eating *Galerucella* beetles, a root-mining weevil, a flower-feeding weevil, a seed-feeding weevil, and a gall midge. Finally, after six years of research in the U.S. on the safety and efficacy of the two *Galerucella* beetles, in 1992 the U.S. Department of Agriculture approved their use as a biocontrol for purple loosestrife. The two species, *Galerucella calmariensis* and *Galerucella pusilla*, are closely related and similar-looking. They are typically used together.

These *Galerucella* beetles are tiny, delicate-looking, tan beetles measuring only 3/16 of an inch long. There's no confusing them with the big inch-

Photos © by Garry Kessler

Galerucella *beetles are tiny, delicate-looking, tan beetles measuring only 3/16 of an inch long. They mate and lay eggs on purple loosestrife in the spring after overwintering in the nearby soil.*

long invasive Asian long-horned beetle (*Anoplophora glabripennis*), a generalist that threatens maple, elm, willow, birch, horse chestnut, poplar, ash, and other trees in the Worcester area and in the forests beyond.

The *Galerucella* live about a year and are active in spring and summer when purple loosestrife plants come up and bloom. The beetles overwinter in the soil in fall and winter when the purple loosestrife plants go dormant.

These beetles are very host- specific. They specialize in eating purple loosestrife in more than one life stage. The adult beetles eat purple loosestrife leaves, but it's their immature eating-and-growing stage – the caterpillar-like larvae – that does the major damage to purple loosestrife while feeding voraciously on new growth in the spring.

Not only do these *Galerucella* eat purple loosestrife, but their whole life cycle also revolves around the plant. Like 85 percent of insects, *Galerucella* beetles go through four life stages: egg, larva or caterpillar, pupa, and adult. First, the adult beetles lay their eggs on the stems of purple loosestrife in May-June. When the larvae hatch a few weeks later, their food supply is right there, and they eat the leaves and especially the new growth of purple loosestrife – the meristematic tissue.

When the larvae are ready to pupate, they go into the soil near their host plant. After a metamorphosis that's similar to the process of caterpillars becoming butterflies, new adult beetles emerge from the soil in July-August, when purple loosestrife is blooming. At this point, they may fly up to two-thirds of a mile to find purple loosestrife leaves to eat. Then at summer's end, as the purple loosestrife plants die back, the beetles go back into nearby soil to overwinter. Finally, when the beetles emerge again the next spring, they may disperse up to 10 miles to find purple loosestrife. They again eat purple loosestrife leaves and then get on with the business of mating and laying eggs before they die.

How readily might these *Galerucella* switch to new host plants? We learned

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Purple Loosestrife flowers produce abundant nectar that attracts bees and wildlife such as this Hummingbird Clearwing Moth, as well as Monarch and Black Swallowtail butterflies. Charles Darwin studied pollination in Purple Loosestrife in England in the mid-1800s.

that researchers tried raising *Galerucella* on closely related native plants, including *Decodon verticillatus*, often called swamp loosestrife or water-willow, and *Lythrum alatum*, known as winged loosestrife. They found that the *Galerucella* might sometimes nibble other plants, but the larvae do not grow to maturity or complete their life cycle on them. Basically, the larvae don't survive unless they have a diet of purple loosestrife.

Like many of our friends and fellow townspeople, we wondered what would happen if *Galerucella* beetles worked so well as biocontrol agents that they ate all the purple loosestrife in the local area. On one hand, we learned that the beetles disperse considerable distances to find their specific host plant – up to two-thirds of a mile when the new adults first emerge and up to 10 miles when the overwintering adults re-emerge – so they would likely fly off to new locations.

On the other hand, we also found that we could expect the beetle population to be regulated in a density-dependent manner, varying with the size of its food supply. If the beetles ate most of the purple loosestrife, there would be less food available and the size of future beetle populations would diminish. If the purple loosestrife population started to recover when there were fewer beetles, there would be more food and the beetle population would consume the bounty and increase rapidly.

We realized that *Galerucella* beetles would not eradicate purple loosestrife. The plant is probably here to stay. But we figured we might reasonably expect the *Galerucella* beetles to reduce the size and dominance of purple loosestrife populations. In our minds, this outcome would be satisfactory. In spite of its status as an invasive, purple loosestrife has its fans. For example, in addition

to its beauty and traditional medicinal uses, it produces abundant nectar and is valued by beekeepers and farmers who keep bees. It would be fine with us if purple loosestrife were to become one wildflower among many, as it is in its native Europe. We would be glad if it were no longer the "pretty purple plague," as one newspaper article dubbed it.

We were surprised to discover that the *Galerucella* beetles had already been in use in Massachusetts for at least a dozen years. In the mid-1990s the U.S. Fish and Wildlife Service started releasing them in two national wildlife refuges in eastern Massachusetts, Great Meadows and Parker River. Starting in 2000, the Massachusetts Wetland Restoration Program (WRP) began using them, and Mass Audubon and the Mass Department of Conservation and Recreation (DCR) started doing so in 2006. By 2008, the beetles had already been released in at least 43 sites in eastern Massachusetts. In our area of central Massachusetts, not only had the high school class in Uxbridge released *Galerucella*, but the conservation commission in neighboring Grafton had also done so.

We knew that the beetles were already out of the bottle, so to speak. It was clear that they would follow the loosestrife and eventually spread to Westborough. This knowledge made it easier for us to decide to hurry the process along by undertaking our own purple loosestrife biocontrol project.

Five years before this photo was taken, this marsh in the DFW Westboro Management Area was dominated by native cattails. Now it is mostly purple loosestrife. Initial monitoring data collected by Westborough High School students showed that purple loosestrife stems outnumbered cattail stems by 5 to 1.

Starting the Project

Our first step was to get various approvals and permissions. We discussed plans for the project with the Westborough Conservation Commission and sought permission from the landowners of the properties where we wanted to release the beetles. We obtained permission from Mass DCR, which controls the shoreline of Mill Pond, a SUASCO flood control reservoir built in 1968-70 at the south end of town and now lined with purple loosestrife. The Mass Division of Fish and Wildlife (DFW) gave us permission to release beetles at its Westboro Management Area in the north end of town. This area included a cattail marsh that purple loosestrife was taking over – a classic example of the struggle between a native wetland plant and invasive purple loosestrife. One of the town's conservation commissioners also offered the farm pond on his property as a release site.

These approvals and permissions entailed getting others. We needed approval from the Mass Historical Commission to make sure we would not be digging root balls at any historically important locations. Just to be on the safe side, we checked with the Mass Natural Heritage and Endangered Species Program (NHESP) and found them to be very encouraging. They had already used *Galerucella* beetles in various locations to prevent purple loosestrife from overwhelming endangered wetland species.

We sorely needed practical advice and guidance regarding the "how to" aspects of the project. The Mass Wetlands Restoration Project was already winding down in 2009, but pointed us to their guidelines and protocols for purple loosestrife

Photo © by Garry Kessler

The Purple Loosestrife biocontrol project is low tech and inexpensive. Each spring, Westborough High School students raise a new generation of Galerucella *beetles in simulated wetlands created by placing potted Purple Loosestrife plants in plastic wading pools half-filled with water. Net prevents the beetles from escaping.*

biocontrol. They recommended that we contact the regional watershed organizations with whom they had worked. They also assured us that we would be able to order "starter beetles" under their Massachusetts license.

We ended up working with the Neponset River Watershed Association (NepRWA), based in Canton, which was running its own large-scale biocontrol project with 50 volunteer "beetle ranchers" from the community. NepRWA kindly invited us to their training sessions and included our small order for starter beetles with their own much larger one (from the New Jersey Department of Agriculture). In return, we helped with some related tasks, such as dividing up shipments of thousands of chilled *Galerucella* beetles and placing them into hundreds of plastic cups containing 15-20 each. We also got good practical advice from a middle school teacher in Sudbury who had been raising and releasing *Galerucella* beetles with seventh-graders.

Back in Westborough, we were excited to find enthusiastic partners at Westborough High School (WHS). Ms. Anita Lotti, a chemistry teacher who also taught environmental science and advised the environmental club, was interested. The chairman of the science department was very supportive. As luck would have it, the high school had a small greenhouse on the third floor that was not in use.

Eventually, in the second year of the project, we also welcomed participation by a Girl Scout who raised beetles out-of-doors and supplied 30 percent of the beetles released that year as part of her Gold project (the equivalent of a Boy Scout Eagle project).

Combatting Purple Loosestrife

In 2011 we are in the third year of a planned 5-year biocontrol project. Each spring, Westborough High School students raise a new generation of *Galerucella* beetles. Westborough Community Land Trust volunteers release these beetles in wetlands during the summer when school is out. To monitor progress, students and land trust volunteers collect field data each spring and fall, using the same standard forms and protocols as do other purple loosestrife biocontrol projects throughout the state.

The project is low-tech and inexpensive. So far it has cost us less than $500 a year. The closely entwined life cycles of purple loosestrife and the *Galerucella* beetles determine the timing of various activities.

Every April, the students create a simulated wetland in the greenhouse by digging up purple loosestrife root balls, planting them in pots, and then setting the pots in plastic wading pools half-filled with water. After the plants have grown for about a month, students introduce starter beetles onto each plant and cover the plants with sleeve cages of netting to keep the beetles from escaping. These beetles eat some loosestrife, mate, lay eggs, and die. Larvae hatch, eat, grow, and pupate to yield a new, much larger generation of beetles. The new beetles begin to come out of the soil in midsummer, when purple loosestrife is typically in bloom. Land trust volunteers transport the potted plants to our release sites, remove the netting, and leave the pots in place for several weeks as beetles continue to emerge.

As expected, the greatest damage to purple loosestrife takes place each spring. In the wild, the new beetles overwinter in the soil and crawl back out in May to eat, reproduce, and die. Their larval offspring – yet another, even larger generation – destroy growing plant tissue as they eat their way to maturity.

Every spring and fall, WHS students and WCLT volunteers collect monitoring data for the project. We have set up square-meter quadrat frames at our release sites and use protocols and reporting forms (originally designed at Cornell University) from the Wetlands Restoration Project. Spring monitoring involves looking for *Galerucella* beetles, eggs, and larvae within the quadrats. Fall monitoring focuses on counting and measuring stems and inflorescences of purple loosestrife, cattail, and other plant species. Comparisons over five years should give us a formal view of the effects of the project.

Informally, we've seen some interesting progress so far. In spring 2010, the year following our first release, we noticed

Galerucella beetles eating and mating on purple loosestrife at many locations around town. We were excited to see that beetles had indeed overwintered and were busy reproducing in the wild. By late summer, the purple loosestrife on part of the Mill Pond shoreline, downwind from our release site, was visibly damaged. The plants were brown and stunted. We've noted the same effects in spring 2011. It's possible that the beetles we saw came from out of town as well as from our releases. But one way or another, biocontrol of purple loosestrife is underway in Westborough.

We are pleased to have received local funding for our biocontrol project, including a Staples Education Grant and a Westborough Civic Club grant. Ms. Lotti also obtained a grant from the Westborough Education Fund, which enabled her to outfit the students with hip waders and purchase other supplies for her class. We are grateful for donations of gently used wading pools and 3-gallon plant pots from families, individuals, Bigelow Nurseries of Northborough, and members of the Westborough Garden Club.

What do our student partners at WHS get out of the project, besides muddy feet? Their teacher, Ms. Lotti, sums it up best:

"The project gives students a unique hands-on way to apply concepts they have learned in class – biodiversity, ecology, and invasive species – to real life. They also gain real experience in collecting and analyzing field study data. And they develop a sense of what it might be like to work as an environmental scientist. The project is also part of their service learning – they're learning to take care

Photo © by Vivian Kimball

The greatest damage to Purple Loosestrife plants comes when the caterpillar-like Galerucella *larvae feed voraciously on growing plant tissue in the spring. The larvae are gold-colored and about ¼ inch long by the time they are ready to pupate in the soil and transform into adult beetles.*

Photo © by Anita Lotti

The Westborough High School environmental science class of spring 2011 was the third group of "beetle ranchers" in the Purple Loosestrife biocontrol project undertaken by the Westborough Community Land Trust and Westborough High School.

of their own community, to give back to their community."

We are taking local action to combat purple loosestrife, but a walk past just about any wetland in nearby towns reminds us that purple loosestrife is a regional problem. For this reason, the Westborough Community Land Trust recently joined the SuAsCo Cooperative Invasive Species Management Area (SuAsCo CISMA). This new organization brings together conservation colleagues from a variety of non-profit, municipal, state, and federal organizations and agencies to form new collaborations and exchange information for more effective invasive species control. Several members of this group have engaged in their own beetle ranching and purple loosestrife biocontrol projects, as well as control efforts targeting other invasive species.

We are hopeful that collective efforts at controlling invasive species will help to preserve the wonderful natural environments of New England for future generations. We've been interested to learn that research efforts are under way to find and test biocontrol agents for the woolly adelgid that is destroying our hemlocks and for the non-native phragmites that continues to spread through our wetlands.

Has biocontrol come of age? If high school students can do it, and if researchers can provide tested, host specific biocontrol agents for other high-profile invasive species, perhaps so.

***The Westborough Community Land Trust** (**WCLT**) is a member-supported, all-volunteer nonprofit organization dedicated to preserving open space and furthering environmental education in Westborough, MA. Annie Reid is an active member who writes a Nature Notes column for WCLT in the **Westborough News** and works as a freelance college textbook editor. Garry Kessler is an amateur nature photographer, past president of WCLT, and software engineer. The couple has lived in Westborough for more than 30 years. Vivian Kimball is a director of WCLT and graduate student in conservation biology. Anita Lotti has taught chemistry and environmental science at Westborough High School for 7 years.*