http://www.research.uky.edu/odyssey/spring10/hemlock.html

Little Hemlock Horror

Saving a Kentucky Treasure from a Sap-sucking Bug

By Alicia P. Gregory. Originally published in the Spring 2010 issue of Odyssey

The scent of moist earth and a rush of cool air on your skin tell you water is nearby. You look up, struggling to make out the sky. The dense canopy of 100-foot-tall trees allows little light to penetrate to the rocky soil. "When you walk into a hemlock forest, you can smell, feel and hear that you're in a different world," says Lynne Rieske-Kinney, in a warm, alto tone. "The air temperature is considerably cooler, the light is much more diffuse, vegetation on the forest floor is minimal. Hemlocks are very tall, very old trees."

William M. Ciesla, Forest Health Management International, bugwood.org

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The oldest recorded specimen of Eastern hemlock, an evergreen tree native to eastern North America, lived 554 years. Eastern hemlocks range from Minnesota to Alabama, but in Kentucky—specifically in the Appalachian Mountains of Eastern Kentucky—they are not widespread. "Instead of vast tracts of hemlock, we have fragmented pockets along streambeds, mountain ridges, road cuts, and ravines. Nevertheless, Eastern hemlocks are extremely important ecologically," Rieske-Kinney says, with a twinge of sadness that hints at the reason this University of Kentucky entomologist knows so much about these trees.

Lynne Rieske-Kinney, professor of forest entomology at UK since 1996, leads the fight against the sap-sucking foreign invader—the hemlock woolly adelgid—that threatens Kentucky's Eastern hemlocks.

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Hemlocks have an important impact on the forest because they regulate stream temperature and chemistry, and they control sedimentation. Their acidic needles alter the soil around the trees, affecting the pH of nearby streams. Invertebrates, including flies, leeches, worms, and crayfish, living in the water feed on the needles. "In Eastern Kentucky these hemlocks are often the only evergreen present, so they also provide cover and habitat for a number of different songbird species," Rieske-Kinney says.

Kentucky's hemlocks are under attack from a sap-sucking, foreign invader—the hemlock woolly adelgid. Just a millimeter in size, these flat, black insects pack a big punch. Within four to six years of infestation, most Eastern hemlocks will die. Rieske-Kinney, her colleagues, and graduate students are evaluating this threat by mapping the distribution of Kentucky hemlocks and adelgid-infested trees, and predicting where the adelgid will head next. Her strategy is to fight them with chemicals and predatory beetles. In a worst-case scenario, her team is also forecasting the future of Kentucky's forests without Eastern hemlock.

An adult hemlock woolly adelgid. At less than a millimeter in size, these insects pack a big punch—within four to six years they can kill a 100-foot-tall Eastern hemlock tree.

Michael Montgomery, USDA Forest Service, bugwood.org

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Bad things come in tiny packages

Trees are in her blood, Rieske-Kinney admits, but she's a realist: "We can't save all the hemlocks. "I grew up on a Christmas tree farm in Michigan. I was always outside, and actually I'm more interested in forests than I am in insects." She practically whispers this last part, half-joking, with a glance toward her open office door, as if it wouldn't be good for her entomology colleagues to overhear.

She earned her Ph.D. in entomology at the University of Wisconsin and did a postdoctoral fellowship at Colorado State before joining the UK entomology department in 1996. As a professor of forest entomology, Rieske-Kinney also holds an adjunct appointment in the Department of Forestry. "My slant toward insects is their interaction with plants. That's how I got into invasive species.” These exotic plants, animals and pathogens can result in loss of native species, degradation of soil, decreased groundwater levels, destruction of wildlife habitat, and increased risk of wildfires.

The hemlock woolly adelgid, native to Asia, is a Top 20 kind of destructive bug. It recently made the UK Invasive Species Working Group’s list of the “Top 14 Invasive Species in Kentucky.” Rieske-Kinney is on the steering committee of the group, which began in 2006—the same year the adelgid was first spotted in Kentucky.

“In the 1950s in Richmond, Virginia, the hemlock wooly adelgid hitchhiked in on a Japanese hemlock, a species that is fairly resistant to the adelgid,” Rieske-Kinney explains, leaning back in her chair. “Fast forward 30 years. Scientists suspect hurricane winds carried the insect to Long Island. It hopped over to Connecticut and became a raging forest pest, decimating large, contiguous tracts of Eastern hemlocks. It’s been working its way back south ever since.”

In March 2006 the adelgid was discovered in Kentucky in Harlan County by J.D. Loan, an exotic pest surveyor for the Office of the State Entomologist. His boss, John Obrycki, who has served as state entomologist and chair of the UK entomology department since he came to UK in 2003, says Loan could have easily missed this important first sighting. “He was taking a little road that winds up Pine Mountain, and he happened to see hemlocks beside the road. He got out and found the telltale signs of an adelgid infestation. I saw where those trees are located. It would have been extremely easy to just drive right by.”

So what are the chances of finding a bug the size of a pinhead in a 100-foot-tall tree? Rieske-Kinney states that just because you don’t find the insects at the base of the tree doesn’t mean they aren’t there. To explain where you have to look, she gives a crash course in adelgid physiology.

Adult adelgids do little more than sit and eat. In fact, once they start to eat, they never move again. They insert their mouthparts, a long proboscis, into the leaf cushion at the base of the tree’s needles. There they feed on a type of cell called the xylem ray parenchyma, which contains photosynthate—a chemical byproduct of the process of converting sunlight into carbohydrates and oxygen. She explains, “As it feeds and grows, the adelgid produces white flockulance”—something that looks like white, woolly sacs—“which serves to protect it from predators and extreme temperatures. Adelgids reproduce asexually, with two generations per year and up to 300 eggs at a time.” When these babies, called crawlers, travel to find their meal ticket, they are easily carried by the wind and brushed onto the feathers of songbirds as they fly from hemlock to hemlock.

Rieske-Kinney tucks her curly hair behind an ear as she says, “So far we have not discovered any native natural enemies that can regulate adelgid populations. Infestations are fatal because the insects remove photosynthetic material, resulting in needle loss, dead branches, crown thinning, and eventually tree mortality. On the forest level we’re starting to see all these browned canopies of dying hemlocks.” And the adelgid infestation is spreading at the alarming rate of 15 miles per year.

In work funded by the Kentucky Agricultural Experiment Station, the U.S. Forest Service, and the Kentucky Science and Engineering Foundation, Rieske-Kinney is leading the charge to stop the

The hemlock woolly adelgid attaches itself to the leaf cushion (at the base of the needle) to feed. It surrounds itself with white, woolly sacs that protect it from predators and temperature extremes. *Chris Evans, River to River CWMA, Bugwood.org*

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Kentucky State Entomologist John Obrycki holds a bucket containing thousands of *Laricobius nigrinus*. These predatory beetles, imported from the Pacific Northwest, will seek out and feed on the hemlock woolly adelgid. In combination with chemical treatments, the UK team is releasing these beetles to quell the adelgid infestation in key areas of Eastern Kentucky.

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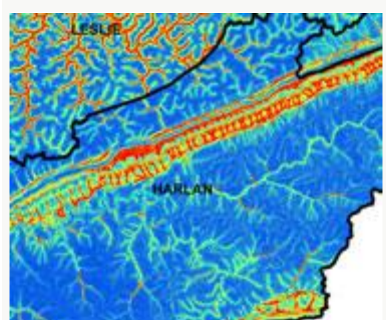

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infestation. The first step: locate hemlocks and track the spread of the adelgid.

Mapping Kentucky’s “hidden” resource and its nemesis

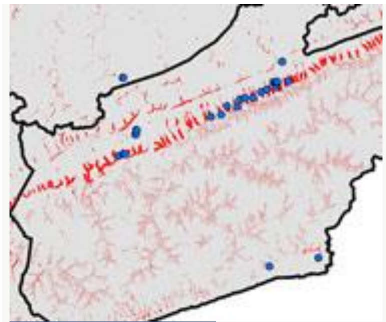
“When we started we really didn’t know how much hemlock was in Kentucky,” Rieske-Kinney says. “Since it’s not an economically important resource—like our hardwood timber—most of the databases grossly underestimate it.” So in 2006, her forestry colleague, Assistant Professor Songlin Fei, and the graduate student they co-advise, Josh Clark, set out to create an accurate distribution map of hemlock. Clark used remote-sensing technology (satellite imagery and digital environmental data), combined with on-the-ground GPS points of locations where the state entomology staff had recorded the presence of adelgids, to create two maps: one for the trees and one for the insect.

Clark, who earned his B.S. in biology from the University of Central Arkansas and is putting the final touches on his entomology master’s thesis, describes his work: “I built the insect models based on where the tree models predicted the hemlocks were. Those models located hemlocks using variables like slope, elevation, soil type, moisture index, surrounding vegetation, and distance to streams, roads, trails, power and phone lines, and urban areas.

“We are in the early stages of the invasion.” He scratches his bearded chin as he explains, “Because we know birds use corridors such as streams, roads and abandoned rail lines, and adelgids have been spotted in those areas, we can make an educated guess that the insects are being carried by birds. If we extrapolate that to the 13 counties where we’ve found the insect, we can project that similar areas should be highly susceptible to infestation. These maps will help people fighting the adelgid to see where to go first—the areas of highest susceptibility located closest to known infestations.”

Fighting the adelgid

So what’s the game plan? A two-pronged attack—injecting chemicals and releasing predatory beetles.



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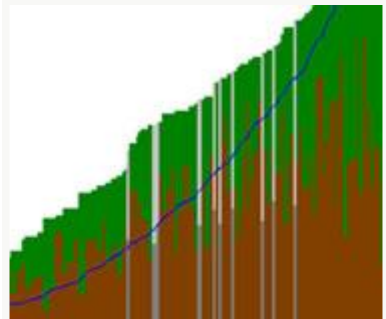

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Two dozen faculty, graduate and undergraduate students have spent a series of long, exhausting days tramping through the forest. Carrying two-foot-long metal injectors—that pump a chemical called imidicloprid into the soil at the base of a hemlock—and hauling water to mix with the chemical, this volunteer army, along with state park officials and land managers, has treated thousands of trees in the Pine Mountain State Forest, Blanton Forest, Cumberland Gap, and the Lilley Cornett Woods in Eastern Kentucky.

“The Forest Service supplies the chemicals, and we supply the injectors and the workforce,” Rieske-Kinney explains. “We inject the chemical around the perimeter of the tree and, theoretically, it protects the tree for three to four years. It effectively kills the adelgid, and we’ve also seen some striking regrowth of the branch tips, as soon as the next growing season. It certainly works, but it is labor-intensive and expensive.”

Obrycki echoes her words, calling chemical injections a stopgap measure. “It buys us time,” Kentucky’s chief entomologist says, shrugging. “We’re targeting trees by buildings and trails, trees that would be hazardous if they came down. But chemicals aren’t our only weapons against the adelgid. We’re also importing natural enemies.”

Across Tennessee, Georgia and Virginia where outbreaks are raging, there are “rearing facilities” that breed beetles to prey on the adelgid. “Scientists at these facilities have already done extensive testing in terms of what these beetles will and won’t feed on. These are very specific—they only eat adelgids,” Obrycki explains.

So there's no danger of a sci-fi-type beetle outbreak? Rieske-Kinney says, "Not likely. The days of biological control agents running amok are behind us, because today's screening methods are so much more effective than they have been in the past. These are adelgid-specific predators. And the only other species of adelgid in Kentucky, the pine bark adelgid, is very scarce because its host tree—the white pine—is not abundant here."

In Kentucky two species of beetles have been released: *Sasajiscymnus tsugae*, a Chinese beetle, and *Laricobius nigrinus*, from the Pacific Northwest. Obrycki explains: "We think the *Laricobius* is our best bet, because although the colder weather conditions in the Pacific Northwest help the hemlocks there, and that species of hemlock seems to be less susceptible to the adelgid, these beetles also seem to play an important role in protecting the trees."

But, he notes, predatory beetles don't make an overnight impact. "It can take five to 10 years for them to establish themselves, and in that time you hope that the infestation doesn't reach such a high level that the tree can't recover. That's why we're doing a combination of chemical injections and beetle releases."

Obrycki and Rieske-Kinney agree it's a balancing act. "The idea is to release the *Laricobius*, which is not a highly mobile insect, then use chemicals on the surrounding trees to reduce the adelgid populations," Rieske-Kinney says. "By the time the beetles establish themselves and disperse from tree to tree, the insecticide levels will be low enough that the beetles can handle it and go after the remaining adelgids. We're trying this along the leading front of the infestation. We think it's going to work." Other states have had success using beetles.

Since 2007, UK researchers have released 50,000 to 60,000 beetles. "That sounds like a lot—and it is a lot," Obrycki says with a wry smile, "but these beetles are small. They're maybe twice the size of the period at the end of a sentence. When you put them into a forest and they have unlimited movement, they eventually start to make a difference."

Imagine a forest without hemlocks

Only time will tell how many hemlocks can be saved, but time is not on the hemlock's side. "It's not a happy picture," Rieske-Kinney reveals, getting out two graphs. Both predict what the forest will look like in 20 years—one without the hemlock woolly adelgid and one with the adelgid infestation. "According to Heather's projections, we can expect to lose the majority of our hemlocks within a decade."

Rieske-Kinney's graduate student Heather Spaulding, like her mentor, is a Michigan transplant. She moved south for undergraduate work at Louisiana State University at Shreveport, and last December earned her master's in entomology from UK. Spaulding's forest models are striking.

"In two decades if we didn't have the adelgid, we'd see many tall trees with dense crowns. But with the adelgid in 20 years the structure is drastically different. Lots of relatively small trees and a sparse canopy with many gaps."

Obrycki adds, "In the short term, areas like the Pine Mountain State Park will suffer. Losing the natural beauty of those 400-year-old trees would be devastating for the park." But beyond the loss of beauty and potential loss of tourism, he stresses, is the frightening ecological future. "In some of the places where these hemlocks grow, it's a wonder anything grows at all." He measures out two inches with his fingertips and says, "There's this much soil on top of rock. What's going to take that hemlock's place in terms of keeping back that soil? And what's going to happen to the invertebrates and fish downstream when the water temperature rises?"

Rieske-Kinney uses the words "heartbreaking" and "disturbing" to sum up these projections. "The forest will go on, but it will be the end of our hemlock forests as we know them today. We're working to save as many trees as we can."