

Science
FINDINGS

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"Science affects the way we think together."

Lewis Thomas

Knocking Out Knotweed:
Research Pins Down a Rogue Invasive

Shannon Claeson

Bohemian knotweed, shown here along Wildcat Creek in the Chehalis River Basin, is among the most problematic invasive plants in the Pacific Northwest. The weed spreads quickly, grows fast, and damages native plant ecosystems along rivers and streams.

"If you know the enemy and know yourself, you need not fear the result of a hundred battles."

—Sun Tzu

Lush and verdant with heart-shaped leaves, *Polygonum × bohemicum* stirs in the breeze. To the uninitiated, it's just a sprawling and rather tall riverside shrub. But to anglers, farmers, and landowners, the plant is bad news. Bohemian knotweed or false bamboo, as it is also known, is among the most prevalent invasive weeds

in the Pacific Northwest and is notorious for spreading aggressively along riverbanks. It chokes streams and quickly edges out native plants that fish and wildlife depend on, eventually taking over and damaging the ecosystem it invades.

For the last nine years, government, nonprofit, and volunteer teams have battled infestations in Washington's Chehalis River Basin, a watershed rich with diverse plant and aquatic species and home to one of the healthiest salmon runs in the country. Every year, these teams spend exhausting days searching for

IN SUMMARY

Bohemian knotweed spreads aggressively along rivers. This invasive weed chokes waterways, displaces native plants, erodes riverbanks, and keeps tree seedlings from growing. Communities in the Pacific Northwest spend millions of dollars to eradicate it on the assumption that it harms fish habitats.

But knotweed is difficult to kill. It takes years of herbicide applications to destroy the weed, and a single fragmentation can sprout and start new infestations. Also, control programs typically don't evaluate whether native plants reestablish themselves after knotweed is cleared. Forest Service researchers wanted to understand whether eradication programs are achieving their goals and how knotweed affects aquatic life and fish habitat.

An analysis of leaf packs submerged in Washington's Chehalis River revealed that fallen knotweed leaves are low in nitrogen and phosphorus, and high in cellulose, fiber, and lignin. This low-nutrient and hard-to-digest leaf litter limits the productivity of aquatic fungi and macroinvertebrates—primary prey for juvenile salmon, trout, and other fish species. Researchers also found that although herbicide application cleared river banks of knotweed and allowed colonization by native plants, it also promoted secondary exotic invaders. Successful reestablishment of native plants following knotweed removal may require active restoration, such as post-treatment plant surveys, controlling secondary invasions, and replanting native species.

weeds and lugging backpacks of herbicide to treat infestations. But they are up against a master of survival. Stray fragments of knotweed stems or roots can start new infestations and undo their work.

Although scientists know a lot about knotweed's devastating effects on native plants, not much is known about its effects on aquatic life. Ecologist Shannon Claeson with the U.S. Forest Service's Pacific Northwest Research Station wanted to know how the weed affects fish habitat in Chehalis Basin streams. She also collaborated with knotweed teams to help them get ahead of the rogue weed's next move.



KEY FINDINGS



- Compared to native red alder, Bohemian knotweed leaves contained fewer nutrients and were harder for aquatic fungi and macroinvertebrate detritus feeders to digest.
- Herbicide application cleared riverbanks of knotweed, allowing colonization by native plants. But it also made way for secondary nonnative plant invaders.
- Knotweed eradication along small streams with intact forest cover led to the reestablishment of native plants. Along large, open rivers, knotweed eradication led to more exotic forbs and shrubs than native plants.
- Native plants that recolonized knotweed-treated areas were shade-tolerant perennials, as opposed to many of the exotic plants, which were sun-loving annuals.

ANATOMY OF AN INVASION

The story of a knotweed invasion begins way before the plant takes root in a new place. "You've got a nice stream going through the forest," Claeson says. "Along the stream are red alder trees, massive cottonwood trees, and some shrubs like salmonberry—a mix of deciduous and coniferous trees and shrubs that are typical of southwest Washington."

At different times of the year, leaves fall into this stream. "Most of the deciduous trees drop their leaves in the fall, but it doesn't occur all at once," Claeson says. "You end up with a diverse assemblage of leaves, seeds, and needles falling into the stream throughout the year."

When leaves fall into the water, fungi and bacteria get to work, colonizing the leaves and

breaking them down bit by bit. These minute organisms are what make the leaves slimy when they are in the stream, Claeson explains. Soon, macroinvertebrates such as tiny insects, crustaceans, and mollusks move in and feast on the bacteria and fungi, or on the leaves themselves. Juvenile salmon, trout, and other fish turn up to prey on the insects. The food web thrives as long as leaves keep falling into the stream.

Enter the knotweeds. A fragment of the weed may find its way to the stream in the clutches of a beaver reinforcing its dam. Floods can spread bits of root and stem. But Claeson says knotweeds in the Pacific Northwest are mostly spread by humans building or planting near a stream. When a bridge is being built, for example, workers or equipment might bring in gravel from a quarry contaminated with knotweed. "That's all it takes," Claeson says. "One little piece of root or stem can resprout."

That fragment grows and multiplies fast. It sprouts root-like rhizomes that creep horizon-

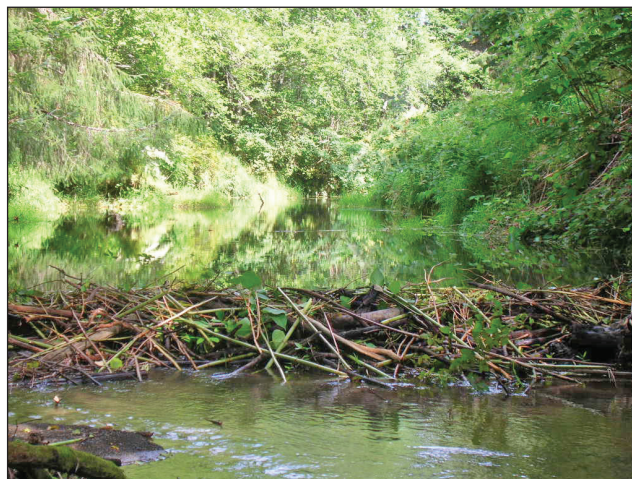
tally, growing roots and shoots. "It's not like a tree root that dies if you cut off the main stem," Claeson says. "These rhizomes can separate and grow new plants."

Knotweeds love water and like lots of sun, but they also thrive in shady areas. Shoots typically emerge in April and can reach their full height of 5 to 10 feet in just 3 months. The grown weeds have hollow, bamboo-like stems and many large, heart-shaped leaves about 16 inches long. Small patches burgeon into dense thickets that completely shade the ground. "Most of our native plants can't tolerate 100-percent shade," Claeson says. "Once it is established in an area, nothing else grows underneath it."

When autumn's first hard frost arrives, the knotweeds die back and drop their leaves within 2 to 3 weeks. "Then there is nothing else," Claeson says. "In the winter, there won't be any live plants aboveground." Because the knotweeds outcompete other plants, no other leaves fall into the stream until the following year when the knotweeds resprout.

Cathy Lucero

This can lead to erosion during the Pacific Northwest's rainy winters. "Normally you would have shrubs and forbs all along the stream holding the soil," Claeson says. "You don't have that with knotweeds." What was once a streambank thriving with different kinds of plants and trees is now exposed and dull with dead knotweed. What would happen to life in the stream without a constant supply of leaves? And how exactly does knotweed affect aquatic life?



This beaver dam is composed primarily of knotweed which began to sprout on site. The dam was washed out during a storm, spreading knotweed downstream.

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PROBING THE LEAVES

To find out, Claeson and colleagues compared the nutrients found in Bohemian knotweed leaves to those in red alder and black cottonwood, both native to the Pacific Northwest. They chose the Stony, Wildcat, and Porter Creeks in the Chehalis River Basin; these are forested creeks where salmon spawn and knotweeds have invaded.

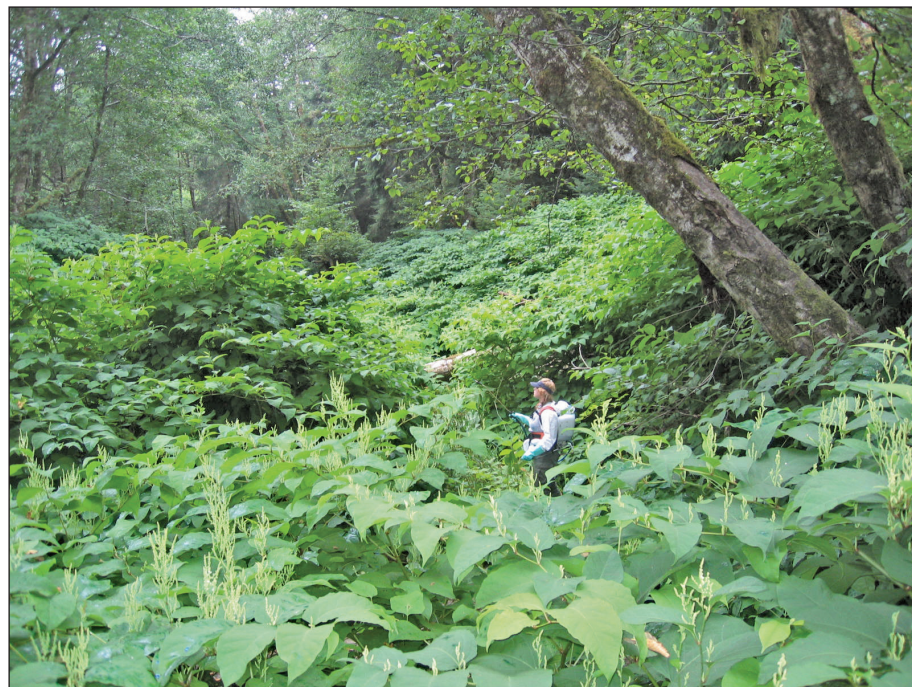
The researchers collected freshly fallen leaves and stuffed them in plastic mesh bags with holes large enough for insects to crawl in to. Then they randomly distributed more than 200 leaf packs at a stream to mimic leaf fall and collected leaf packs after different time intervals. The leaves were dried and analyzed, and insects were collected and counted.

Claeson and her colleagues noted a difference in the number of shredder insects found among the three leaf species. “There were significantly fewer shredders on the knotweed leaves compared to the red alder,” Claeson says. “Cottonwood was in the middle.” This suggests that the insects found the knotweed leaves the least enticing.

They found further interesting results when they analyzed nutrient content. “As expected, red alder had very high nitrogen and phosphorus levels, whereas knotweed and cottonwood were similarly low,” Claeson says. The researchers also found higher amounts of fiber and cellulose in knotweed than in cottonwood and alder leaves. Leaves rich in nitrogen and phosphorus typically attract more aquatic fungi and insect consumers, thus decompose faster. In contrast, leaves with higher amounts of fiber and cellulose are tougher, thus harder to break down.

“Knotweed does have lower leaf qualities compared to red alder, but it’s not as bad as we expected it to be,” Claeson says. “For example, it is not that different from native cottonwood leaves.” But there is a caveat. “This is only true in the properties we measured,” she says. “There were other things that we didn’t measure that can influence aquatic streams and riparian systems, like the timing of the leaf fall, quantity of knotweed, its regrowth, and soil stability.”

Claeson’s findings are consistent with another study that found that when knotweeds die back in the winter, their roots reabsorb nutrients stored in the leaves. So when knotweed leaves fall, their nutrient stores are depleted. This underscores the value of native plants like red alder, deerbrush, snowbrush, and Kincaid’s lupine, especially in the nitrogen-limited forests of the Pacific Northwest. These plants, called nitrogen-fixers, possess symbiotic bacteria that convert nitrogen in the



Todd Neal

Knotweed leaves can grow up to 16 inches in length and completely shade out smaller native plants.



Shannon Claeson

A bigleaf maple seedling grows among dead knotweed canes. Come spring and summer, knotweeds will sprout again in dense thickets, inhibiting the seedling’s growth.

atmosphere into forms that other plants and animals can use.

“But red alder and other deciduous and conifer seedlings have a really hard time growing under a knotweed canopy,” Claeson says. “Forty to sixty years down the line, as those mature red alder trees die and fall into the stream, you would normally have new trees growing up and taking their place. But with

knotweed, you won’t have that.” This poses a rather grim prognosis for stream ecosystems invaded by knotweed.

“The Chehalis River Basin is a relatively healthy and productive watershed in Washington State, which is why people work so hard to fight knotweed there,” Claeson says. “The problem is that knotweed is hardy and able to easily resprout.”

STAYING ALIVE

David Geroux knows this well. In kayaks and on foot, Geroux and his crew work exhausting 10-hour days from June to October surveying and treating knotweed patches in the Chehalis River Basin. “Although knotweed is a new invader to the area, we have found large patches throughout the system,” Geroux says. “It’s difficult to control because it’s fast-moving and we have to get permission from many private landowners to access all the lands we need to treat.”

Geroux manages the knotweed program for the Center for Natural Lands Management (CNLM), a nonprofit group that protects conservation lands in Washington State. CNLM’s knotweed program is part of a larger consortium of 20 government agencies, tribes, nonprofits, and private landowners called the Olympic Knotweed Working Group, which is working to eradicate knotweed and other invasive plants from waterways in the state.

Claeson consulted and collaborated with both groups to learn how to improve treatment programs. “We wanted to know if knotweed eradication programs were achieving their restoration goals,” Claeson says. “After eradication, it is assumed that native plant species just recover naturally.” Control programs usually don’t evaluate whether the reestablished plant assemblages matched their objectives.

So Claeson and her colleagues surveyed plant species and cover along the Stony, Cook, Elk, Porter, and Satsop streams. These sites had received 3 to 6 years of herbicide treatments to remove knotweed. For comparison, the researchers also surveyed reference sites near these streams that haven’t been invaded by knotweed.

Claeson found that although the removal of knotweed by herbicide application allowed native plants to colonize sites, it also ushered an increase in exotic invaders like blackberry and reed canary grass. Along small streams with an intact forest cover, the researchers found reestablished native plant assemblages. However, along large, open rivers, they found more exotic forbs and shrubs than native species in both the knotweed-treated and the knotweed-free sites. The native plants that recolonized knotweed-treated areas were primarily shade-tolerant perennials, as opposed to many of the exotic plants, which were sun-loving annuals.

These findings could change how knotweed groups run their treatment programs. For instance, the findings imply that maintaining overstory cover, especially along small streams, can inhibit the growth of exotic plants. It also provides organic material to sustain life in the streams and rivers.

Claeson also reports that large rivers with high levels of seasonal flooding, little overstory cover, extensive gravel bars, and wide floodplains will require greater restoration efforts. These open river areas promote the spread of exotic invasive species and may need to be replanted with native species to coax them back to health. “Knotweed does not overhang streams,” Claeson says, “So it doesn’t provide any shade that help maintain cool water temperatures.” Streams warm when they are constantly exposed to the sun, threatening fish that thrive in chilly waters.

Finally, Claeson recommends that knotweed groups perform post-treatment plant community surveys, in addition to measuring how

much knotweed they got rid of. “This way, knotweed groups will know whether they need to do more to achieve their restoration objectives,” Claeson says.

Claeson’s studies add to the body of knowledge that the Olympic Knotweed Working Group collects and tests every year. “It’s a very tough plant to eradicate so we are always trying to adapt,” says Cathy Lucero, who heads the group. Because of the findings, the group has recognized the need for native vegetation management after treating knotweed in difficult restoration areas. “This research helps define when planting is needed,” Lucero says. CNLM and other knotweed groups in



Shannon Claeson

What grows after knotweed has been eradicated? To find out, researchers surveyed plant species and plant cover in knotweed-treated and knotweed-free areas along five streams in the Chehalis River Basin.



Roger Tabor

Juvenile Chinook salmon primarily feed on macroinvertebrates, like tiny insects, crustaceans, and mollusks. Macroinvertebrates survive on bacteria and fungi, which favor nitrogen- and phosphorus-rich leaves.

western Washington now also monitor plant assemblages after completing treatments to determine if native plants are recovering on their own.

“Knotweed is a very good generalist and grows in different areas,” Geroux says. “It brings ecological damage and problems for private landowners who depend on a weed-free access to streams for their livestock,” Geroux says. His crew has found patches of knotweed in agricultural lands, spreading out from the waterways into the fields. In addition to new research on knotweed like Claeson’s, Geroux stresses that public awareness is key. Lucero agrees. “Each individual effort makes a difference,” she says, “We are all part of the solution.”

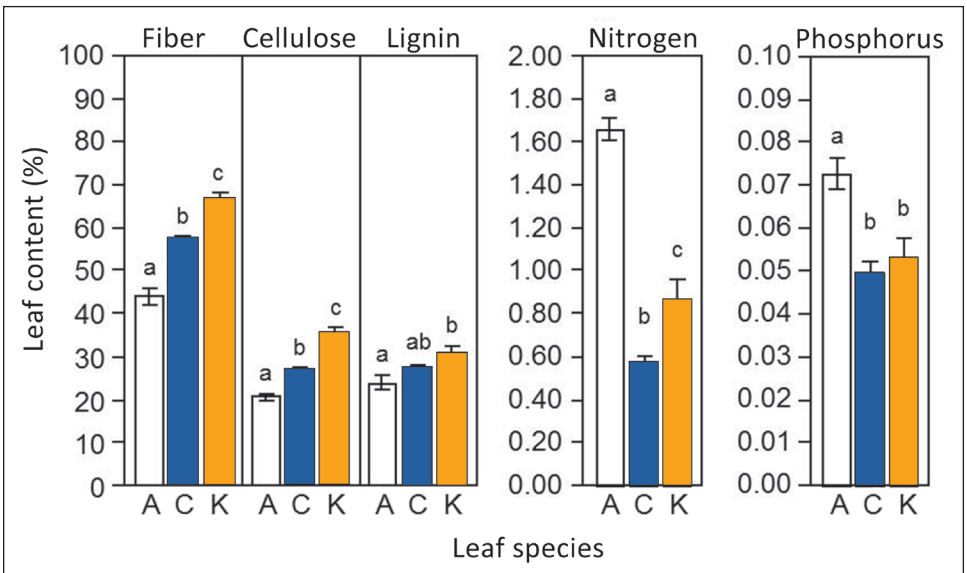
*“Coming together is a beginning,
keeping together is progress,
working together is success.”*

—Henry Ford

FOR FURTHER READING

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LAND MANAGEMENT IMPLICATIONS	
The banks of large rivers typically have little overstory cover, extensive gravel bars, and wide floodplains, and they experience intense seasonal flooding. These are ideal conditions for knotweed to spread, and thus greater restoration efforts are required to control it.	
Maintaining overstory cover, especially along small streams, may inhibit the growth of exotic plants and provide organic material to sustain aquatic productivity.	
Including post-treatment plant community surveys, in addition to measuring the reduction of target weed species, may help noxious weed control programs determine if continued management is needed to achieve restoration objectives.	
Successful reestablishment of native plants following knotweed removal may require active restoration, such as controlling secondary invasions by other exotic plants and replanting native species as conditions change over time.	



This figure compares the fiber, cellulose, and lignin proportions (mean $\pm$ 1 standard error), and nitrogen and phosphorus content of fallen (senesced) leaves of red alder (“A”), black cottonwood (“C”) and Bohemian knotweed (“K”) at the start of the experiment. Lower case letters denote significant pairwise comparisons among species

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