Research FINDings

A Publication of FIND Outdoors • OCTOBER 2020

# What Lies Beneath: Estimating the Effect of an Invasive Insect on an Area's Water Cycle

This photo shows a healthy eastern hemlock (*Tsuga canadensis*), an evergreen that grows alongside rivers in the mountains. Their needles live for three years then die and fall off the tree.

Photo courtesy of Richard Webb and bugwood.org.

A closer look at the cones of an eastern hemlock. This tree is already infested by the hemlock woolly adelgid; notice the fuzzy, white egg capsules at the base of the needles.

Photo by Chris Evans, University of Illinois, and bugwood.org.

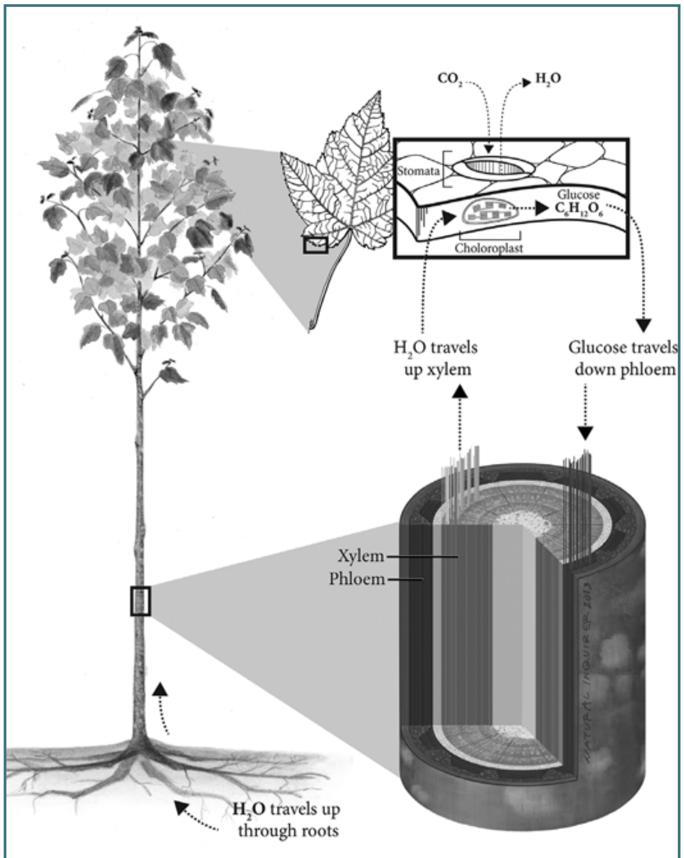
The cascade of effects that result from the presence of a tiny invasive species can be fascinating, surprising, and maybe more extensive than one would expect. In this case, scientists found that the effects were much like that of the proverbial iceberg – only a small percentage of the impact from this invasive insect, the hemlock woolly adelgid (*Adelges tsugae*), occurs above ground in the tree this species infests; the rest of the impacts lie below the surface in the groundwater, soil quality, and the surrounding plant and animal life.

## The Trees Breathe

Before we get to the pesky adelgid, though, we have to understand the cycle of water and carbohydrates through trees. Maybe you have vague memories of studying transpiration in school, or you remember a classroom experiment where you placed plastic bags over plants and watched the water condense on them. For those of you with clearer memories than mine, feel free to skip over this part.

Trees are essentially like giant straws when it comes to water moving through them. The beverage of choice is the water in the soil surrounding the roots. The water makes its way up the tree in the xylem, or the "straw" in this comparison, and reaches the branches and leaves. At the open end of the straw, or the top of the tree, are specialized cells on the tree's leaves or needles called stomata. These cells open during the day, allowing carbon dioxide in and oxygen and water vapor out. When these cells are open, more water moves up the tree from the roots; the stomata close at night, slowing the movement of water through the tree. I guess you could say the tree is sleeping in that respect – internal processes slow but don't stop altogether. This process is called transpiration.

In addition to the water flowing up through them, trees also have carbohydrates flowing down from the leaves to the rest of the tree. Remember photosynthesis? This point is where that process comes in. Photosynthesis uses light energy to combine carbon dioxide and water into carbohydrates. These carbohydrates are stored in the tree to protect its buds in winter and to grow new leaves or needles in the spring.




An illustration of the process of transpiration. Water travels up the xylem while carbohydrates travel down the phloem. Stomata are special cells in a leaf that allow carbon dioxide to enter and water vapor and oxygen to escape.

Illustration by Stephanie Pfeiffer.

## The Invader

Enter the hemlock woolly adelgid, an insect that is native to the west coast of the United States but was introduced to the east coast from Japan, perhaps accidentally imported on ornamental hemlocks. The first known specimens of hemlock woolly adelgid collected in the eastern United States were collected in 1951, but scientists are not sure when exactly the introduction occurred. The Japanese adelgid has proven to be invasive and has since spread up and down the eastern coast of the United States.

This tiny insect attaches at the base of the needles on eastern hemlocks. There they suck out the carbohydrates intended for the tree's use and lay their eggs. The "woolly" part of their name comes from the fact that their egg capsules resemble fuzzy, cottony balls at the base of each needle. Then the cycle repeats.

The eastern hemlocks, robbed of their carbohydrates, cannot protect their buds in winter any longer or grow new needles in the spring. Generally, within three years, starving for these sugars, the tree will die.

## The Research

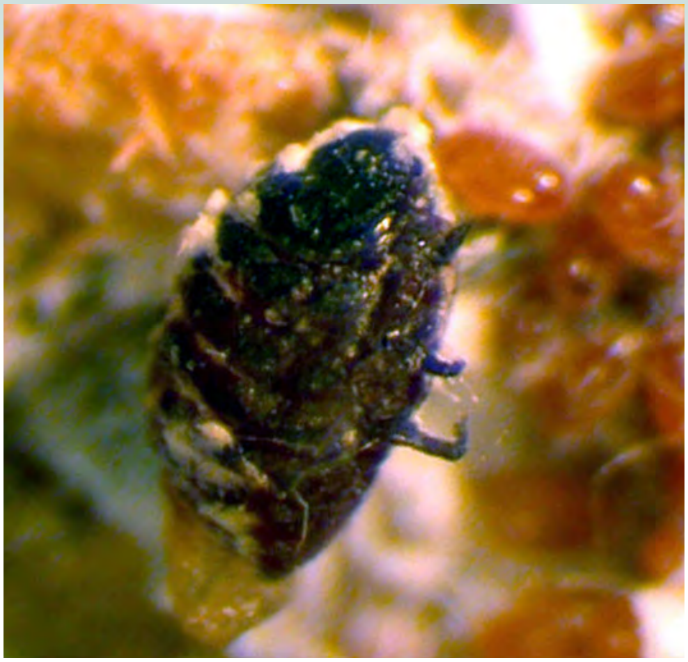
The eastern hemlock grows in such abundance in the forests of the southern Appalachian Mountains that they account for half of all living plant life along mountain streams in the region. When the hemlock woolly adelgid infests these trees, resulting in their deaths, scientists posited a new question. How would the absence of these trees affect the surrounding ecosystem? Enter U. S. Forest Service scientists Dr. Chelcy Ford Miniat, a tree ecophysiologist, and Dr. James Vose, a forest ecologist. Their question was how might the flow of water around mountain streams change if eastern hemlock trees surrounding those streams died.

In the mountains of western North Carolina at the Coweeta Hydrologic Laboratory, Drs. Miniat and Vose probed the xylem of eastern hemlocks in order to measure the amount of water moving through the trees' sapwood. They also recorded local weather conditions and relative humidity, as humidity – the amount of water in the air – affects the amount of water the trees are able to draw through them. High humidity leads to lower transpiration because the surrounding air can't hold much more water.

Using all of these data, Drs. Miniat and Vose were able to estimate how much the trees transpired at 15-minute intervals throughout the seasons. Here's where we find out the possible consequences of an invasion of the hemlock woolly adelgid.

## The Takeaway

Drs. Miniat and Vose discovered that the eastern hemlocks transpired day and night, but more during



Adult hemlock woolly adelgid.

Photo courtesy of Michael Montgomery, USDA Forest Service, and bugwood.org.

The sign of the adelgid's egg capsule is a white, cottony mass on the needles.

Photo courtesy of Michael Montgomery, USDA Forest Service, and bugwood.org.

The eggs hatch from the woolly egg capsules and have legs for a short time. They crawl to a suitable feeding site then settle there, staying in one place while feeding and developing.

Photo courtesy of Michael Montgomery, USDA Forest Service, and bugwood.org.

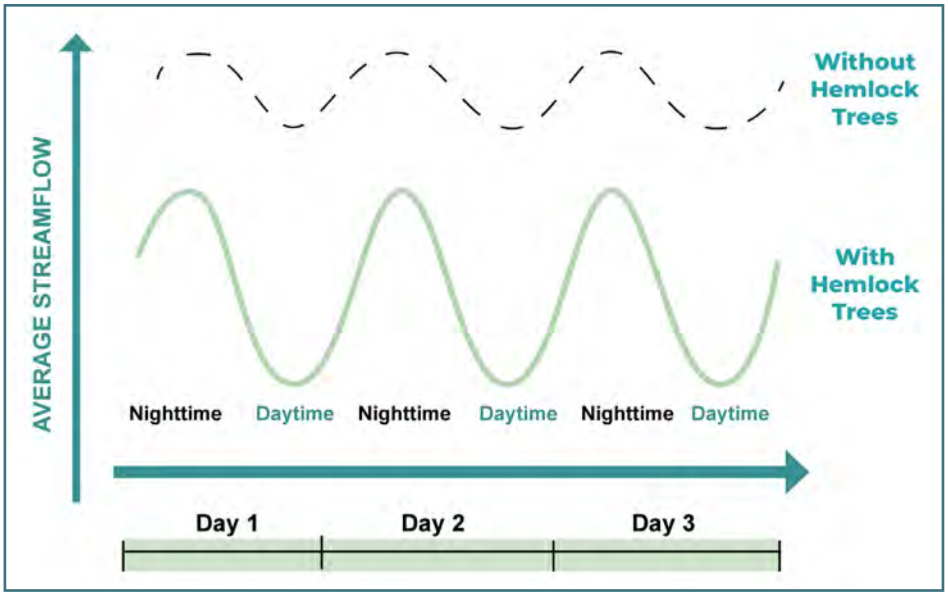
This tree has suffered crown damage as a result of an infestation of the woolly adelgid.

Photo courtesy of James Johnson, Georgia Forestry Commission, and bugwood.org.

the daytime. They transpired most during the spring. When these trees transpire, they're pulling water out of the surrounding soil, water that would otherwise continue to flow into the nearby mountain streams. So what happens when the eastern hemlocks, accounting for about half of the living plant life by the streams, die? In the immediate term, that water has nowhere else to go but into the streams. Instead of the streams being fed by soil water in waves of lower volume (during the day) and higher volume (at night), the streams experienced fewer changes in the flow of water over the entire 24 hours.

So what's the impact of this higher and more consistent flow of water into streams? More water may mean more sediment washing into the streams, affecting water quality. More water may also mean there's less soil, and possibly more degraded soil, being left behind, affecting soil quality. Additionally, more water may mean that organisms that depend on water and soil quality may be impacted as well. Plants may struggle to grow, and animals that feed on those plants may lose a food source. The cascade of possible consequences continues.

> The hemlock woolly adelgid, a tiny invasive insect, can create a whole iceberg's worth of lasting effects, from killing eastern hemlock trees to increasing the flow of streamwater to impacting the surrounding ecosystem.




The amount of streamflow during a typical cycle of day and night (solid line) and the amount of streamflow likely after the death of eastern hemlock trees in the area (broken line). This figure shows that there will be greater streamflow after the hemlock trees have died. The streamflow will also be more even across day and nighttime.

Illustration by Babs McDonald.

## And the Investigations Continue

Research continues at the Coweeta Hydrological Laboratory since the publication of this study. Long-term research centers on four prongs: evaluating strategies to control or eliminate the spread of hemlock woolly adelgid, understanding the impacts of the deaths of eastern hemlock trees on the ecosystem, creating monitoring techniques to track hemlock woolly adelgid and predict their spread, and creating and testing ways to restore eastern hemlock forests.

To learn more, visit https://srs.fs.usda.gov/coweeta/research/hwa/.

HEMLOCK RESTORATION INITIATIVE

The Hemlock Restoration Initiative (HRI) is a non-profit program funded by the NCDA&CS and USDA-FS Forest Health Protection program. HRI works with a wide variety of partners to restore North Carolina's native hemlocks on public and private lands through short- and long-term management strategies and landowner education. HRI has information and resources about protecting hemlocks on their website, savehemlocksnc.org.

FIND OUTDOORS ESTD 1978

Article adapted from: *Woolly Bully: Estimating the Effect of an Invasive Insect on an Area's Water Cycle*, published by *Natural Inquirer*. For additional information and online resources, visit http://www.naturalinquirer.org/Woolly-Bully-i-24.html.

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE