

Hemlock Trees and Aquatic Ecosystems

Eastern hemlock tree, *Tsuga Canadensis*, is an evergreen tree that grows along the east coast of the United States and parts of Canada. It is a keystone species that provides numerous ecosystem services including erosion and temperature control. They also improve water and air quality in forests, and provide crucial food, shelter, and habitat for more than 120 species of vertebrates, including native fish.



Hemlock trees are threatened by hemlock woolly adelgid, or HWA, an invasive insect with the potential to kill trees in less than a decade. With HWA spreading through the native range of hemlock trees, many of the species that rely on them could be in danger.

Hemlock Streams

Hemlock trees benefit aquatic ecosystems in many ways. The presence of hemlocks along streambanks stabilizes soil and prevents erosion, which helps ensure the stream remains fast-flowing. The roots of hemlock trees also help to filter out sediments and agricultural runoff before it reaches the stream, which improves water



quality downstream. Since hemlock trees do not use and store as much water during the spring and summer as deciduous trees, waterways with hemlocks are less likely to dry out.

The branches and needles of hemlock trees are able to form a dense canopy that provides shade and helps to regulate the temperatures of streams. The canopy also intercepts large amounts of rain and snow, which not only prevents sediments and nutrients from reaching the stream, but allows more water to be directly evaporated from the surface of the canopy back into the atmosphere.

Game Fish

The unique conditions created by hemlock streams are important to many species of fish, including native brook trout. Many of these are game fish that help support the multi-million-dollar sport fishing industries in New York and Pennsylvania, and contribute to local economies, conservation programs, and state fish and wildlife agencies. This industry also generates revenue from tourism, and has created thousands of jobs.

Brook Trout



Brook trout are native to the northeastern United States. They occur in clear, cool, well-oxygenated waters, including rivers, streams, and lakes. Young trout feed on plankton and eventually small insects, while adults have a varied diet of insects, worms, leaches, crustaceans, mollusks, or even small mammals.

Brook trout are the state fish of both Pennsylvania and New York, and have both economic and ecological value. They are highly prized game fish, and the money that anglers spend on related goods and services for brook trout fishing directly benefits state and local economies. As top predators, they are a keystone species that helps manage the populations of other species. They are also considered to be an umbrella species, as conserving brook trout indirectly protects the habitat of numerous other fish.

Additionally, their sensitivity to changes in water temperature and quality make them a good indicator of the health of waters. Because of this sensitivity, brook trout are frequently found in waters lined by hemlock trees, and are even called hemlock trout in some parts of their Appalachian range. The loss of these trees could lead to a decline in brook trout populations, which have already disappeared from some parts of their native range due to pollution, climate change and the loss of suitable habitat.

Brown Trout

Brown trout are native to Eurasia, but since their introduction to the United States in 1883, they have become naturalized in some parts of the country, including Pennsylvania and New York. In Pennsylvania, these fish have become the dominant trout species in many streams, replacing brook trout. They are found in cold-water streams, rivers, and lakes and feed on invertebrates and crustaceans.



Brown trout are used by wildlife and forest agencies as indicator species. Since water quality affects reproductive rates, the population data of brown trout can be used to measure pollution levels in streams. They can also be used to monitor for heavy metals in the water, including copper, lead, and cadmium. Brown trout are also an important sport fish that is managed and harvested by hatcheries across the country.

Though they do not require the water to be as cool or clean as brook trout, brown trout are also found much more frequently in hemlock streams than deciduous ones. Up to three times more brook trout and brown trout are found in streams lined by hemlocks as compared to deciduous streams. This may be because hemlock streams tend to have a greater abundance and diversity of insects and other invertebrates, which are a food source for trout. Other insectivorous fish have also been found in hemlock streams in high proportions.

Rainbow Trout



Rainbow trout are close relatives of Pacific salmon, and are native to the western United States. They have been introduced to many other states since the 1880s, but, unlike brown trout, they have not become naturalized in New York or Pennsylvania, and are stocked by fish hatcheries. They feed on invertebrates, crustaceans, and other fish.

Rainbow trout are the prey of many species, including great blue herons, kingfishers, mergansers, racoons, and black bears. They are one of the most popular game fish in the world, and their presence helps to stimulate local economies. These fish can also be used by researchers as a monitor species due to their sensitivity to some dissolved metals.

Rainbow trout are cold-water fish that can be found in the deep pools of hemlock streams with overhanging vegetation, which provides protection, cover, and shade. Like brook trout, they are sensitive to sedimentation, and require clean waters with low acidity. Additionally, these fish may be attracted to the diversity of insects and aquatic invertebrates found in hemlock streams.

Smallmouth Bass

Smallmouth bass are native to the Great Lakes, Hudson Bay, and Mississippi River basins, but their range has extended into the northeastern United States. They can be found in shallow, rocky areas of lakes, and in rivers and streams. Young fish feed on plankton and insects, while adult fish may eat crayfish, insects, and fish, including other smallmouth bass.



While juvenile fish are preyed upon by other fish, turtles, and ospreys, adult smallmouth bass are top predators which help to control populations of many invertebrates and fish. They are also a popular food fish, and fishing of smallmouth bass generates millions of dollars each year, much of which funds national resource management organizations.

Though smallmouth bass are warmwater fish, studies have found that the increased shade in riparian streams, where hemlock trees are typically found, increases the extent of useable habitat for young and adult bass. This also increases the potential for population growth of smallmouth bass in these areas. Additionally, the higher abundance and diversity of macroinvertebrates in hemlock streams provides young fish with more food.

Hemlock Woolly Adelgid

Hemlock woolly adelgid, or HWA, is an invasive insect native to Japan. First discovered in the eastern United States in Richmond, VA, in 1950, HWA is now found in 18 states including New York and Pennsylvania, and covers nearly half of the native range of the eastern hemlock tree. HWA feeds on the sap of the hemlock tree, which disrupts the flow of nutrients to twigs and branches and causes the needles to dry, turn grey and fall off.

Eventually, the tree's limbs will begin to die back, and if left untreated, the tree could die within 4 to 10 years of infestation, leaving pale, skeletal trees dubbed "grey ghosts" behind. Less severe infestations are also dangerous, as they can weaken the trees, leaving them susceptible to disease and other issues. The death of hemlocks, especially in old growth forests, can be devastating to the ecosystem and to the species that live there.



"Grey ghosts" in Pisgah National Forest, North Carolina

HWA's Impact

Some parks in the eastern U.S. have already experienced the loss of hemlock trees from HWA, including the Great Smoky Mountains National Park, or the Smokies. There are more than 800 acres of old growth hemlock forest in this park, more than anywhere else in the United States.

An additional 90,000 acres contain younger hemlock trees. First discovered in the Smokies in 2002, HWA has now spread throughout these hemlock forests, killing off entire stands of trees. Although pesticides can be used to treat infestations, they are only able to reach about 15% of the hemlock trees, leaving the rest to slowly die off.



Grey ghosts in the Smokies

But the loss of hemlock trees can also damage fisheries. Waterways would become much warmer without the shade of the canopy, making it impossible for species like brook trout to spawn. The quality of water could also decrease significantly without hemlock roots to filter out pollutants and sediments, and without roots to stabilize soil, streambanks would become eroded. Without the ecosystem services provided by hemlock trees, many New York and Pennsylvania game fish could lose important habitat.

What Can We Do?

Consider your favorite fishing spots. What would they look like without hemlock trees? How would the loss of this tree affect the species there?



An HWA infestation does not have to be a death sentence for hemlock trees. While it may be too late to act in some areas of the Smokies, there is still hope of managing HWA in other forests, like the Allegheny National Forest and Cook Forest in Pennsylvania, as well as the Adirondacks in New York.

Insecticides and biological controls are being used by national parks and forest managers in

many states to successfully treat trees and protect those that are at risk of future infestations. However, hemlock trees must be consistently surveyed to determine where the insect has spread and to assess which trees are the highest priority.

Early detection of HWA is vital to save the tree. While you are out in the forest, please keep an eye out for HWA, and help protect hemlock forests for future generations to enjoy!

Identifying HWA

Anyone can survey for HWA! From November to April, HWA is visible as woolly masses, about $\frac{1}{4}$ the size of cotton swabs, on the underside of hemlock branches. Spider sacs, spittle bugs, and pine sap are sometimes mistaken for HWA, but while these are generally found in only one spot of a branch, HWA is spread over the entire branch, specifically at the base of needles.



HWA ovisacs (left) and lookalikes, including a spider sac (middle) and spittle bugs (right)

Reporting

If you suspect you have found HWA, report your findings! Contact the NYSDEC or the DCNR. In your report, make sure to include detailed information about the site so that it can be easily found again. GPS coordinates and photographs are also encouraged.

- NYSDEC HWA Survey Form:
https://www.dec.ny.gov/docs/lands_forests_pdf/hwasurvey.pdf
- DCNR Bureau of Forestry: <https://www.dcnr.pa.gov/about/Pages/Forestry.aspx>

Alternatively, you may use the iMapInvasives app or website to record your findings in New York or Pennsylvania.

- PA homepage: www.paimapinvasives.org
- NY homepage: www.nyimapinvasives.org

For more information about HWA and other invasive species in New York and Pennsylvania, visit:

- <https://www.dec.ny.gov/animals/265.html>
- <https://www.dcnr.pa.gov/Conservation/ForestsAndTrees/InsectsAndDiseases/Pages/default.a>