Red cedar tree study shows that Clean Air Act is reducing pollution, improving forests

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A collaborative project involving a Kansas State University ecologist has shown that the Clean Air Act has helped forest systems recover from decades of sulfur pollution and acid rain.

The research team—which included Jesse Nippert, associate professor of biology—spent four years studying centuries-old eastern red cedar trees, or *Juniperus virginiana*, in the Central Appalachian Mountains of West Virginia. The region is downwind of the Ohio River Valley coal power plants and experienced high amounts of acidic pollution—caused by sulfur dioxide emissions—in the 20th century.

By studying more than 100 years of eastern red cedar tree rings, the scientists found that the trees have improved in growth and physiology in the decades since the Clean Air Act was passed in 1970.

"There is a clear shift in the growth, reflecting the impact of key environmental legislation," Nippert said. "There are two levels of significance in this research. One is in terms of how we interpret data from tree rings and how we interpret the physiology of trees. The other level of significance is that environmental legislation can have a tremendous impact on an entire ecosystem."

The findings appear in the scientific journal *Proceedings of the National Academy of Sciences*, or *PNAS*, in the article "Evidence of recovery of Juniperus virginiana trees from sulfur pollution after the Clean Air Act."

The principal investigator on the project was Richard Thomas, professor of biology at West Virginia University. Other researchers include Scott Spal, master's graduate from West Virginia University, and Kenneth Smith, undergraduate student at West Virginia University.

For the study, the scientists collected and analyzed data from eastern red cedar trees ranging from 100 to 500 years old. The researchers wanted to better understand the trees' physiological response and the growth response to long-term acid deposition, or acid rain.

The team focused on red cedar trees because they are abundant, long-lived and a good recorder of environmental variability. Red cedar trees grow slowly and rely on surface soil moisture, which makes them sensitive to environmental change. Their abilities to live for centuries meant that researchers could analyze hundreds of years of tree rings, Nippert said.

The researchers analyzed the stable carbon isotopes within each tree ring as a recorder of physiological changes through time. Nippert's Stable Isotope Mass Spectrometry Laboratory at Kansas State University analyzed the samples. Researchers analyzed tree rings back to the early 1900s, when sulfur dioxide deposition throughout the Ohio River Valley began to increase.

By studying the stable isotopic signature in each tree ring, the researchers were able to compare the trees' growth patterns and changes in physiology to changes in atmospheric chemistry during the 20th century. Results showed that despite increased carbon dioxide—which tends to increase plant growth—tree growth and physiology declined for the majority of the 20th century when acidic pollution was high.

But scientists noticed a dramatic change around 1980, 10 years after the Clean Air Act was enacted.

"Our data clearly shows a break point in 1982, where the entire growth patterns of the trees in this forest started on a different trajectory," Nippert said. "It took 10 years for that landmark environmental legislation to reduce sulfur dioxide emissions, but it eventually did. When it did, we saw an entire ecosystem recover from years of acidic pollution."

Another interesting finding from the tree ring analysis: Results from the Great Depression era in the 1930s were very similar to the results from post-1980. Because of the suppressed economy during the Great Depression, coal power plants were less productive and the Ohio River Valley had reduced fossil fuel emissions. Similar to the post-1980 data, data from the 1930s showed improved tree growth and physiology.

"It's kind of interesting that those two very important periods in our history match up perfectly in terms of the responses seen throughout this whole forest ecosystem," Nippert said.

More information: Evidence of recovery of Juniperus virginiana trees from sulfur pollution after the Clean Air Act , www.pnas.org/cgi/doi/10.1073/pnas.1308115110

Provided by Kansas State University