Despite less ozone pollution, not all plants benefit

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From left, Christopher Holmes, the Werner A. and Shirley B. Baum assistant professor of meteorology in the Department of Earth, Ocean, and Atmospheric Science at Florida State University, and Jason Ducker, a postdoctoral researcher. Their research compared levels of atmospheric ozone to the amount of ozone plants took in through pores on their leaves at more than 30 sites over 10 years. They found that environmental factors have more impact on the ozone dose the plants received than the amount of ozone in the atmosphere. Credit: Bruce Palmer / FSU

Breathe easy: Concentrations of ozone in the air have decreased over large parts of the country in the past several decades.

But not too easy.

Policies and new technologies have reduced emissions of precursor gases that lead to ozone air pollution, but despite those improvements, the amount of ozone that plants are taking in has not followed the same trend, according to Florida State University researchers. Their findings are published in the journal *Elementa: Science of the Anthropocene*.

"Past studies of plant damage from ozone have been overly optimistic about what the improving ozone air quality means for vegetation health," said Christopher Holmes, the Werner A. and Shirley B. Baum assistant professor of meteorology in the Department of Earth, Ocean, and Atmospheric Science.

Ozone is a gas made of three oxygen molecules. In the upper levels of the atmosphere, it is helpful for life on Earth because it keeps too much ultraviolet radiation from reaching the planet's surface. But when it's found at ground level, ozone is a pollutant that can damage the lungs. It's also toxic for plants, and present-day levels of the pollutant have cut global grain yields by up to 15 percent, resulting in global losses of soybean, wheat, rice and maize valued at $10 billion to $25 billion annually.

The falling levels of ozone pollution are good news for human health, but FSU researchers wanted to know if plants were seeing benefits too. To answer this question, Allison Ronan, a former graduate student, and Jason Ducker, a postdoctoral researcher at FSU, worked with Holmes and another researcher to track the amount of ozone plants sucked up

through pores on their leaves over 10 years at more than 30 test sites. They compared those trends to measurements of atmospheric ozone.

As they expected, the ozone concentrations in the air decreased at most of their study sites, but, surprisingly, the ozone uptake into plants at the sites didn't necessarily go down at the same time. In fact, at many sites, atmospheric ozone concentrations fell while the ozone uptake into plants rose.

The different trends happen because plants can open and close the stomata pores on their leaves in response to weather, especially light, temperature, moisture, drought and other environmental conditions. If the stomata close, the plants cease taking up ozone, regardless of the concentration in the surrounding air. That means the ozone uptake into leaves doesn't exactly track the amount of ozone in the air. The FSU scientists found that these environmental factors have more impact on the ozone dose the plants receive than the amount of ozone in the atmosphere.

"We know that weather and growing conditions vary a lot from year to year, and that variability in weather turns out to be more important for driving the trends and variability in ozone uptake into plants than the concentrations in the surrounding air," Holmes said. "With decreasing ozone concentrations, we're moving in the right direction, but the benefits for crops and vegetation may not be apparent until the air quality improvements have persisted longer."

The FSU team identified the differing trends by using a dataset developed by Holmes' research group. The dataset, called SynFlux, fuses measurements from air quality networks with data from field sites that monitor energy flows between vegetation and the atmosphere. It enabled the team to study ozone uptake trends at many more sites than has previously been possible.

Future studies of plant damage and accompanying economic losses need to avoid relying primarily on measures of ozone concentration in the atmosphere and look at ozone uptake instead, researchers said.

"With the SynFlux dataset that we have developed, we've now got the information to do that on a large scale at many sites across multiple continents," Holmes said. "We're just scratching the surface of what we can learn about air pollution impacts on vegetation using this tool."

More information: Allison C. Ronan et al, Have improvements in ozone air quality reduced ozone uptake into plants?, *Elem Sci Anth* (2020). DOI: 10.1525/elementa.399

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