Foul fumes found to pose pollinator problems

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This photo illustration depicts a tobacco hawkmoth navigating to a flower amid air fouled by vehicle exhaust emissions. Credit: Floris Van Breugel/University of Washington

A team led by researchers at the University of Washington has discovered a major cause for a drop in nighttime pollinator activity—and people are largely to blame.

The researchers found that nitrate radicals (NO_3) in the air degrade the scent chemicals released by a common wildflower, drastically reducing the scent-based cues that nighttime pollinators rely on to locate the flower. In the atmosphere, NO_3 is produced by chemical reactions among other nitrogen oxides, which are themselves released by the combustion of gas and coal from cars, power plants, and other sources.

The findings, published in the journal *Science*, are the first to show how nighttime pollution creates a chain of chemical reactions that degrades scent cues, leaving flowers undetectable by smell. The researchers also determined that pollution likely has worldwide impacts on pollination.

The team—co-led by Jeff Riffell, a UW professor of biology, and Joel Thornton, a UW professor of atmospheric sciences—studied the pale evening primrose (Oenothera pallida). This wildflower grows in arid environments across the western U.S. They chose this species because its white flowers emit a scent that attracts a diverse group of pollinators, including nocturnal moths, which are one of its most important pollinators.

At field sites in eastern Washington, the researchers collected scent samples from pale evening primrose flowers. Back in the laboratory, they used chemical analysis techniques to identify the dozens of individual chemicals that make up the wildflower's scent.

"When you smell a rose, you're smelling a diverse bouquet composed of different types of chemicals," said Riffell. "The same is true for almost any flower. Each has its own scent made up of a specific chemical recipe."

Once they had identified the individual chemicals that make up the wildflower's scent, the team used a more advanced technique called mass spectrometry to observe how each chemical within the scent reacted to

NO_3. They found that reacting with NO_3 nearly eliminated certain scent chemicals. In particular, the pollutant decimated levels of monoterpene scent compounds, which, in separate experiments, moths found most attractive.

Moths, which smell through their antennae, have a scent-detection ability that is roughly equivalent to dogs—and several thousand times more sensitive than the human sense of smell. Research suggests that several moth species can detect scents from miles away, according to Riffell.

Using a wind tunnel and computer-controlled odor-stimulus system, the team investigated how well two moth species—the white-lined sphinx (Hyles lineata) and the tobacco hawkmoth (Manduca sexta)—could locate and fly toward scents. When the researchers introduced the pale evening primrose's normal scent, both species would readily fly toward the scent source.

But when the researchers introduced the scent and NO_3 at levels typical for a nighttime urban setting, Manduca's accuracy dropped by 50%, and Hyles—one of the chief nocturnal pollinators of this flower—could not locate the source at all.

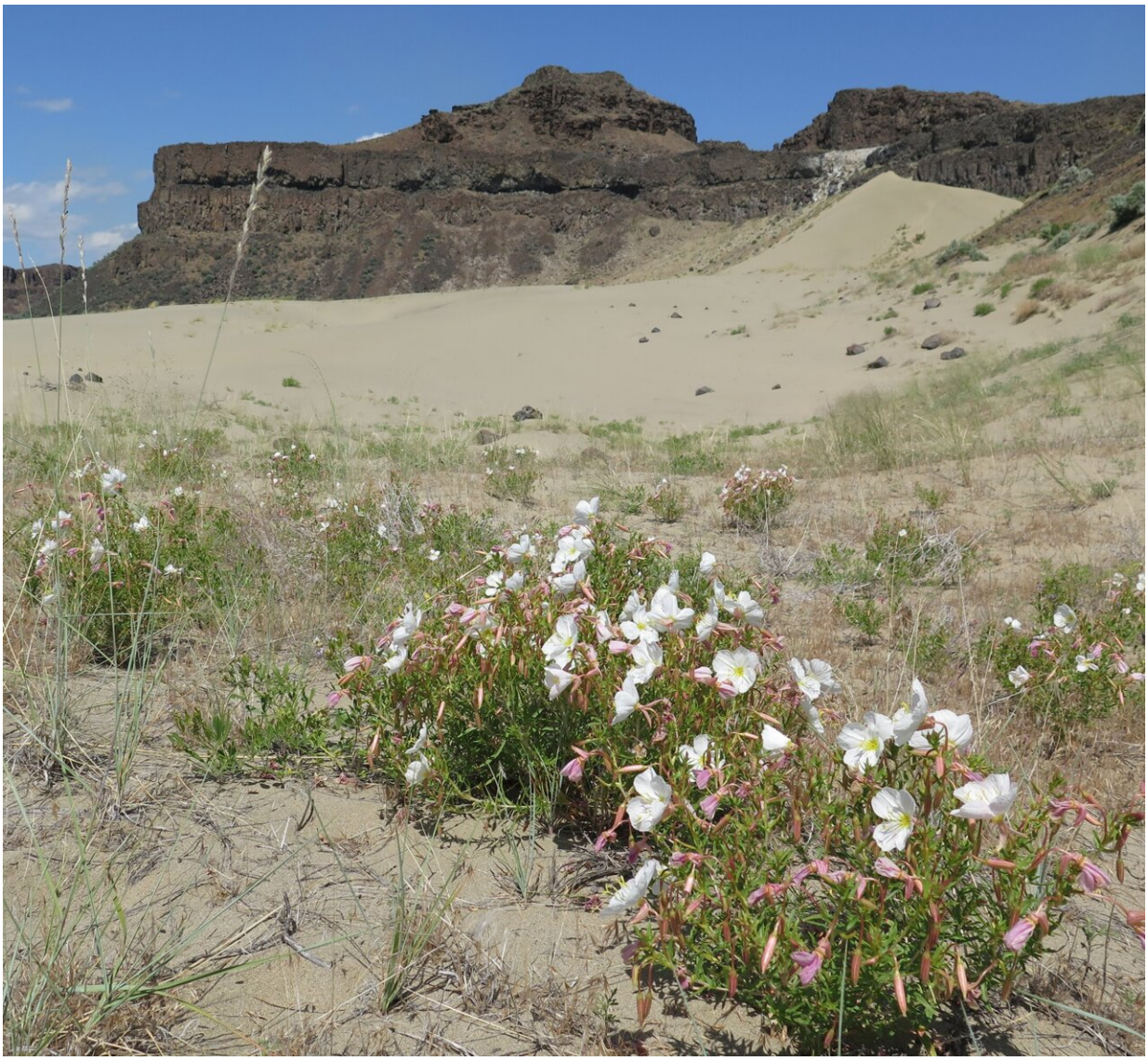

Image of a field site in eastern Washington showing pale evening primrose flowers. Credit: Jeremy Chan/University of Washington

Experiments in a natural setting backed up these findings. In field experiments, the team showed that moths visited a fake flower emitting an unaltered scent as often as they visited a real one. But, if they treated the scent first with NO_3, moth visitation levels dropped by as much as 70%.

"The NO_3 is really reducing a flower's 'reach'—how far its scent can travel and attract a pollinator before it gets broken down and is undetectable," said Riffell.

The team also compared how daytime and nighttime pollution conditions impacted the wildflower's scent chemicals. Nighttime pollution had a much more destructive effect on the scent's chemical makeup than daytime pollution. The researchers believe this is largely due to sunlight degrading NO_3.

The team used a computer model that simulated both global weather patterns and atmospheric chemistry to locate areas most likely to have significant problems with plant-pollinator communication. The areas identified include western North America, much of Europe, the Middle East, Central and South Asia, and southern Africa.

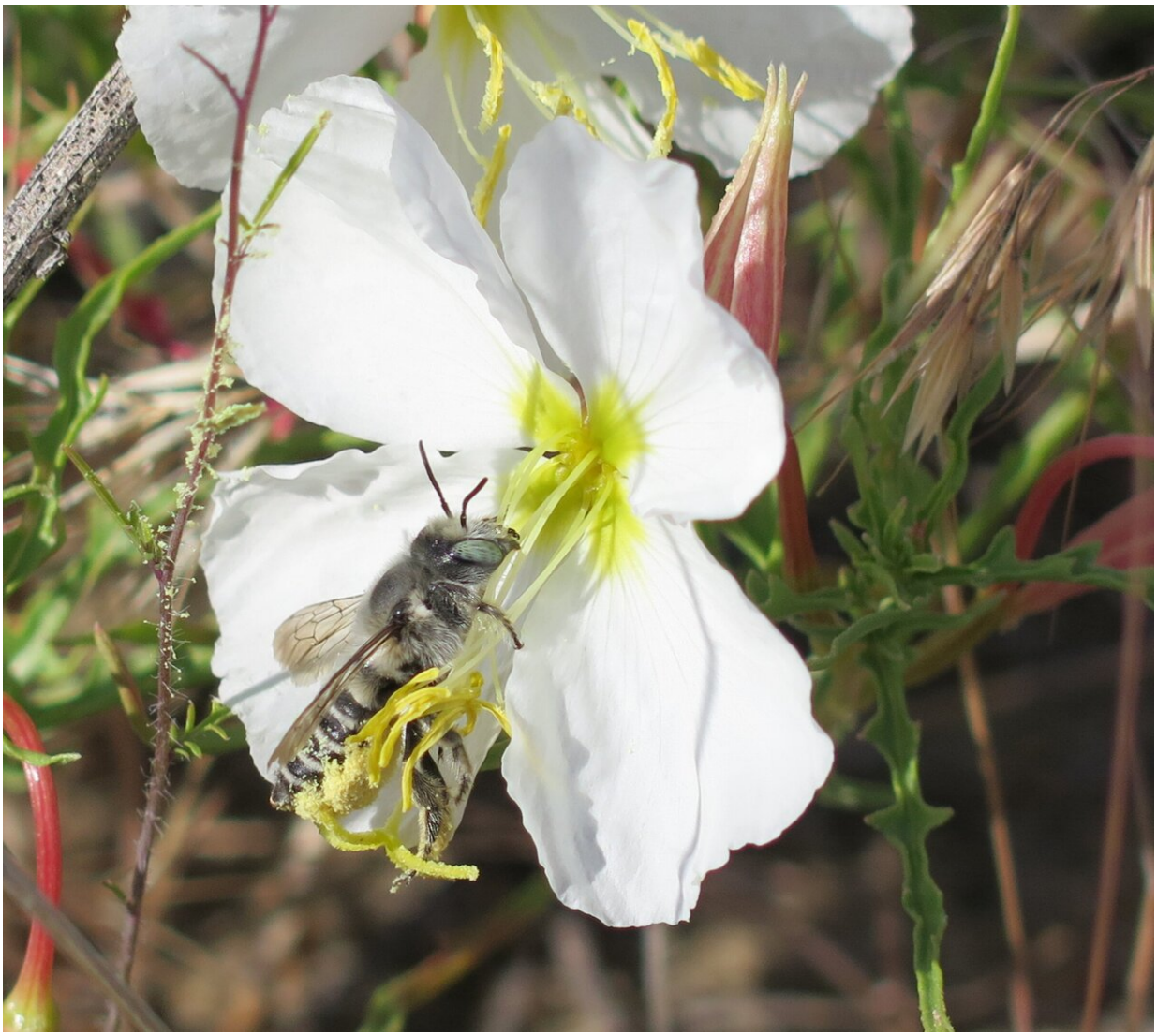

Image showing a bee (genus Megachile) pollinating a pale evening primrose flower in eastern Washington. Credit: Jeremy Chan/University of Washington

"Outside of human activity, some regions accumulate more NO_3 because of natural sources, geography, and atmospheric circulation," said Thornton, who added that natural sources of NO_3 include wildfires and lightning. "But human activity is producing more NO_3 everywhere. We wanted to understand how those two sources—natural and

human—combine and where levels could be so high that they could interfere with the ability of pollinators to find flowers."

The researchers hope their study is just the first of many to help uncover the full scope of pollinator failure.

"Our approach could serve as a roadmap for others to investigate how pollutants impact plant-pollinator interactions and to really get at the underlying mechanisms," said Thornton. "You need this kind of holistic approach, especially if you want to understand how widespread the breakdown in plant-pollinator interactions is and what the consequences will be."

Image showing a tobacco hawkmoth visiting a paper flower that is emitting a pale evening primrose scent. Credit: Charles Hedgcock/University of Washington

Image showing a white-lined sphinx pollinating a pale evening primrose flower. Credit: Ron Wolf/University of Washington

The study highlights the dangers of human-fueled pollution and its implications for all pollinators and the future of agriculture.

"Pollution from human activity is altering the chemical composition of critical scent cues, and altering it to such an extent that the pollinators

can no longer recognize it and respond to it," said Riffell.

Approximately three-quarters of the more than 240,000 species of flowering plants rely on pollinators, Riffell said. And more than 70 species of pollinators are endangered or threatened.

More information: J. K. Chan et al, Olfaction in the Anthropocene: NO3 negatively affects floral scent and nocturnal pollination, *Science* (2024). DOI: 10.1126/science.adi0858.
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