ECOLOGY

Nitrogen Oxide Pollution May Spark Seeds' Growth

Could a common air pollutant be fooling the seeds of some wild plants into germinating when conditions are deadly to the seedlings? That's the provocative question raised by a finding reported in this issue. Two ecologists have learned that the seeds of a common California wildflower can be prompted to germinate by exposure to nitrogen oxides, gases produced by both natural wildfires and motor vehicles and power plants.

Botanists have long recognized that many plants inhabiting fire-prone areas, such as the arid forests of the Southwest and the shrub-choked hillsides of southern California, grow best on freshly burned-over land. Scorched soils are often rich in nutrients, such as nitrogen and phosphorus released from burned vegetation, and they are free of shrubs that can otherwise shade sun-loving seedlings. For many of these phoenixlike plants, a fire's searing heat is what prompts them to rise from the ashes. Heat cracks the hard, outer coat of seeds that can lie dormant in the soil for decades. This allows water to seep in, spurring growth.

In the late 1970s, however, scientists began realizing that heat was not the only trigger. Exposing the seeds of some of these plants to charred wood was enough to prompt germination, and in the last few years, smoke has been recognized as a potent trigger. Researchers have identified dozens of smoke-germinated species around the world and isolated more than 70 compounds in smoke thought to be potential germination triggers. But they never identified exactly which compound induced germination in a particular plant.

Now, on page 1248, plant ecologists Jon Keeley and C. J. Fotheringham of Occidental College in Los Angeles report that nitrogen dioxide, one of the several nitrogen oxides found in wood smoke, spurs the germination of seeds from Yellow Whispering Bells, an annual herb that springs up after fires in California's chaparral and sage scrub plant communities. "This work documents a fascinating and novel mechanism for cueing seed germination to a fire event," says William Schlesinger, a biogeochemist at Duke University in Durham, North Carolina, who has studied fire-related germination.

In their study, Keeley and Fotheringham, who are interested in how burned sites are recolonized by plants, collected dormant seeds from Whispering Bells growing in the Los Angeles Basin. The researchers then placed the seeds in small chambers and exposed them to either straight nitrogen dioxide or wood smoke made by burning a few sprigs of chamise, a common chaparral shrub, on an electric hot plate. Exposure to either smoke or nitrogen dioxide for as little as 1 minute triggered germination in every seed. The researchers saw similarly high germination rates after they exposed seeds to nitrogen dioxide vapors from sand, paper, and water that had been allowed to absorb smoke as long as 2 months before the tests. In contrast, seeds not exposed to smoke or nitrogen dioxide did not sprout. "The germination response of these seeds to even small quantities of nitrogen dioxide was remarkable," says Keeley.

He cautions that nitrogen dioxide may not be a universal trigger: Although other smoke-triggered species he has tested do respond to the gas, a few appear to be responding to something else. Schlesinger adds that not even all populations of Yellow Whispering Bells rely on fire to germinate. In the early 1980s, he and a colleague demonstrated that germination in seeds from Whispering Bells collected in the Mojave Desert appears to be sparked by sand abrasion. The fact that fires are relatively rare in the desert would explain this different adaptation, he says.

A nitrogen oxide trigger "makes sense" for plants growing in fire-prone regions, Schlesinger says, because the germination signal would reach even seeds not directly exposed to smoke. He notes that rates of soil nitrification, in which soil bacteria convert ammonium, a common fire byproduct, into nitrogen compounds, can "absolutely skyrocket in the months after a fire." Buried seeds may be responding to these changes in soil chemistry, which can elevate nitrogen oxide levels, rather than directly to the smoke, researchers say.

The seeds' sensitivity to nitrogen oxides raises what Schlesinger calls a "provocative but reasonable question": Could nitrogen oxide from air pollution trick seeds from some smoke-sensitive plants into germinating before a wildfire has cleared the way for their growth? If so, hapless seedlings might sprout and quickly die in the shade of bushes, and the soil's natural bank of stored seed might become depleted, threatening future plant populations. "The concern is that after a fire you wouldn't see regeneration, because the seed reserves wouldn't be there," says Keeley.

The question has particular relevance in the Los Angeles area, which is home to dozens of smoke-germinated species—and has the nation's highest levels of nitrogen oxide pollution. U.S. Forest Service researchers estimate that as much as 45 kilograms of airborne nitrogen are deposited per hectare in the Los Angeles Basin annually, mostly in the form of nitric acid. This potentially represents at least five times the amount of nitrogen oxides needed to trigger germination in Yellow Whispering Bells.

"The effect of air pollution on germination could be real but very hard to document," says Schlesinger. One problem is that the soil and atmospheric chemistry of nitrogen compounds are complex and poorly understood, as is the exact process by which nitrogen oxides trigger seed germination. In addition, ecologists say that finding small plants that mistakenly sprout amid thick shrubs could be a daunting task—a task further complicated by hungry rodents that might eat the appetizing shoots long before any scientist finds them.

–David A. Malakoff

TOM STORY

Smoke signals. Nitrogen oxides, gases produced by wildfires and motor vehicles, prompt some plants in fire-prone areas to germinate.

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