University of Idaho

Rangeland Center

Promoting Collaborative Solutions for Rangelands

Research Summary: The Hidden Passengers in Wildfire Smoke, Fungi and Bacteria Emissions in Wildland Fire Smoke

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Smoke from wildland fire has long been associated with health risks, but it's impact on the surrounding ecosystem is largely unknown. Emissions from wildfire contain airborne particles from organisms consumed by the fire, also known as bioaerosols, including microbes such as bacteria and fungi. Wildland fire smoke contains elevated levels of these microbes, but the concentration and dispersal of these bioaerosols has never been quantified. Understanding bioaerosol emissions from wildfire is critical for assessing risk to wildland fire fighters, communities, and understanding the ecological implications of the dispersal of these microbes. Research from the University of Idaho's Kobziar Fire Ecology Lab and collaborators are working to fill this gap. Their work demonstrates that wildfire smoke carries living microorganisms that can travel long distances and remain viable upon landing. These findings show wildland fire can be a mechanism of biological transport, and smoke emissions contain significantly elevated concentrations of microbes.

A drone samples smoke emissions above a wildfire.

KEY TAKEAWAYS

- **Wildland fire smoke is biologically rich.** Smoke contains significantly elevated concentrations of bacteria and fungi compared to background air, with near-fire fungal spore concentrations reaching 4-5 times higher than background air.
- **Smoke-borne microbes can travel far.** Computer modeling suggests over 99% of fire-emitted bacteria travel beyond the immediate burn area, with potential for cross-continental transport.
- **Smoke can carry beneficial microbes.** Fire-emitted microorganisms successfully colonized sterilized soil in laboratory experiments, increasing biological activity and contributing to microbial diversity, suggesting smoke could aid ecosystem recovery after fire.
- **Questions remain for rangelands.** Whether pathogens present in livestock or bison dung can become airborne during prescribed burns or wildfire has not yet been studied but should be a future area of study given the prevalence of grazing and fire on rangelands.

The Rangeland Center is bridging the gap between science and land management by engaging stakeholders to develop solution-based research that has valuable and real world implications for Idaho rangelands.

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METHODS

When a fire burns vegetation and heats the soil surface, it disrupts the microorganisms living in plants, organic matter, and topsoil. A combination of intense heat and powerful updrafts from the fire pushes these microorganisms into the atmosphere, where they are transported in smoke plumes.

To measure this, researchers flew drones equipped with specialized sampling equipment to collect air samples before and during wildland fire in contrasting ecosystems, including the frequently burned Kansas tallgrass prairie and infrequently burned Utah subalpine forest. They followed up with laboratory experiments to analyze the viability and behavior of smoke-transported microbes.

RESULTS

Results show the concentration of fungal spores to be significantly elevated in smoke, compared to background air. Concentrations were 5x higher in prairie smoke and 4x higher in forest fire smoke. Additionally, bacterial cells were 2x higher in forest fire smoke compared to background air. Further analysis through computer modeling showed that over 99% of bacteria emitted by a fire traveled beyond the 17km modeled area. Lab experiments showed that these smoke-transported microbes can successfully colonize in new environments. When researchers exposed sterilized soil to smoke from burning rangeland vegetation, the microorganisms established themselves in the soil, increasing biological activity and contributing nearly 30% of the microbial diversity in the sample.

IMPLICATIONS

These findings suggest wildfire smoke may play a natural role in ecosystem recovery and connectivity. By delivering beneficial soil microorganisms back to the area, smoke emissions may contribute to burned areas recovery, influencing nutrient cycling and soil health restoration. Furthermore, smoke transport may create connections between distant ecosystems that would otherwise be isolated, potentially helping explain patterns of microbial diversity across fire-adapted landscapes.
Beyond the ecological implications, this research

Researchers work with drones to collect data from smoke emsissions.

also holds ramifications for human health. Among the microorganisms detected in smoke, researchers identified 37 species of fungi associated with human or animal disease, and laboratory studies confirmed that several of these caused infection, inflammation, or immune responses in mice. For rangelands, it has yet to be determined whether fires could also transport pathogens present in livestock or bison dung. While this has not been directly studied, it is an important question, given the number of grazing animals across managed rangelands and the regular use of fire as a land management tool.

FURTHER READING

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