RESEARCH BRIEF

# Pyroaerobiology: the aerosolization and transport of viable microbial life by wildland fire

Kobziar, L. N., M. R. A. Pingree, H. Larson, T. J. Dreaden, S. Green, and J. A. Smith. 2018. Ecosphere 9(11):e02507. 10.1002/ecs2.2507

**Pyroaerobiology** (PAB), a new term introduced in this publication, seeks to understand the ecological and societal impacts of viable microbes (e.g., fungi, bacteria) transported by wildland fire smoke. In this exploratory study, authors sought to establish basic understanding of wildland fire's capacity to transport viable aerosolized microorganisms (fungi and bacteria), and how this might vary with distance, different types of combustion (flaming versus smoldering), and fuel sources. Aerosolized microbial organisms were captured and cultured on petri dishes (containing malt extract agar medium) exposed to smoke from three prescribed fires, and also from collected surface fuels and soils (organic layer) burned in a controlled combustion laboratory. For both burning treatments, smoke was sampled from smoldering and flaming combustion, as well as ambient air from each site to serve as controls. For the prescribed fires only, smoke was sampled at successively further distances from the flaming front (starting at 0.5 m). Cultured samples were microscopically examined, microbes were grouped by morphological characteristics (morphotypes), and colony-forming units (CFUs) were counted. A subset of morphotypes were selected for DNA analysis to further identify and to determine pathogenicity.

Prescribed fires were conducted from late spring to late summer at three sites near Gainesville, Florida, USA, each having a different management history and forest type. One was in a mature longleaf pine sandhill ecosystem that had been burned every two years for the previous 12 years (**Sandhill Biennial**); another was conducted in a longleaf pine flatwoods forest type that had been burned annually for 25 years (**Flatwoods Annual**); and the third took place in a hydric longleaf and loblolly pine flatwoods with only one incomplete burn in the past 75 years (**Flatwoods Long-Unburned**).

Surface fuels and soils (organic layer) burned in the laboratory were sampled from a semi-arid steppe mixed-conifer forest with a shrubby understory in the Palouse Range near Moscow, Idaho, USA. Soil samples were collected from three different stands, half from units in which surface fuels and small trees were shredded and left onsite (mastication), and half from no-treatment (control) units.

For all three prescribed burn sites in Florida, CFU abundance for all organism types (fungi, bacteria, yeast) was negatively related to distance during flaming combustion, though only statistically significant for bacteria. Interestingly, in the

### MANAGEMENT IMPLICATIONS

- Viable microbes (pathogens and non-pathogens) are transported in wildland fire smoke.
- Recovered microbe abundance decreased with distance.
- Microbe abundance and diversity is influenced by past management.

*The abundance of microbes (pathogens and nonpathogens) recovered from smoke decreased with distance from a prescribed fire in Florida. (Photo: Leda Kobziar)*

# Pyroaerobiology

Flatwoods Long-Unburned site CFU abundance was lowest at very small or great distances from the flames, but highest at intermediate distances (3- and 6 -m), suggestive that convective wind vortices associated with the dense/tall vegetation in the understory (unique to this treatment) aerosolized the microbes. Regardless of combustion type, CFU abundance was highest on the burned sites (Sandhill Biennial, Flatwoods Annual). DNA analyses identified a diverse group of fungi from several orders, including pathogens and non-pathogens. Flaming combustion had significantly higher CFUs than ambient air samples, but not compared to smoldering samples, and resulted in the highest and most variable CFU abundance levels at the Sandhill Biennial.

Unique morphotypes were found in smoke from Idaho soils (masticated fuels and no treatment) and surface fuels. CFU abundance in surface fuels smoke did not differ significantly among combustion type, nor compared to the ambient air samples, however, the composition of morphotypes did. Also, smoke from masticated fuels yielded more CFUs compared to non-treated fuels, but neither differed statistically from the ambient air samples. Soil samples from the masticated fuel sites yielded the highest number of unique morphotypes.

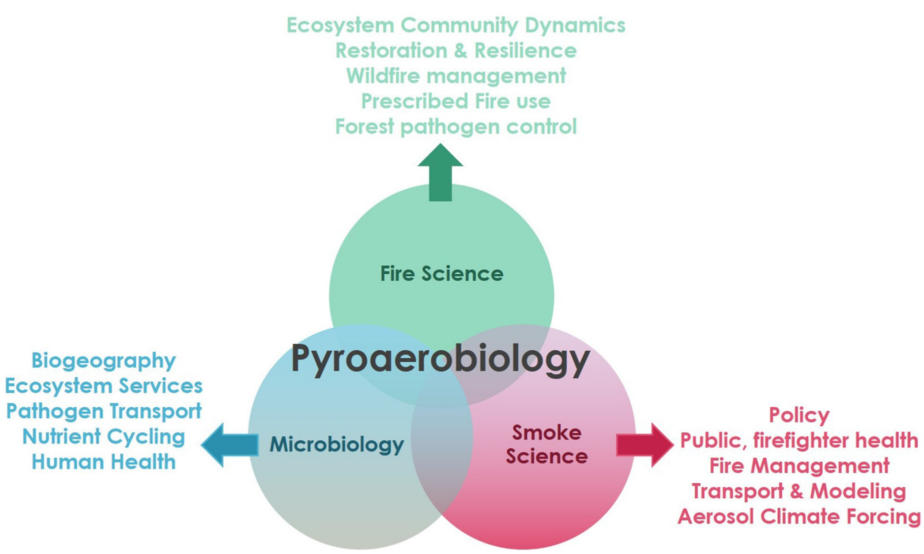
Combustion phase (flaming vs. smoldering) led to different microbe species abundance only in the Florida prescribed sites. Flames burned fuels of a different size and type (e.g., grasses, twigs) than smoldering (large woody debris), making it not possible to identify if the cause of the difference was combustion type or fuel source. However, since combustion phase did not lead to significant differences in species abundance in the laboratory burning of organic soils from the mixed-conifer forest, it may be that energy outputs between combustion phases did not affect the microbes cultured.

The results of this study show that fire and smoke aerosolize and transport multiple types of viable microbes, in assemblages that are different than those occurring without fire. While viable microbes were captured and cultured, because medium type affects what microbes respond, and that most microbes are unculturable, it is likely that only a small component of microbes present in the smoke were recovered.

This study provides foundational understanding to an entirely new science, with much room for understanding to advance. The authors identify a list of considerations for future research, including: researchers should sample smoke plumes of different fire types at increasing heights and distances from source; include a broad range of microbial diversity assessments such as community sequencing, different media, and baiting; employ a variety of sampling techniques to maximize the spectrum of viable organisms captured; and link findings with predictive models already used (i.e., smoke, fire behavior) so to best understand their relevance to human and ecosystem health.

Future smoke-transport research on microbes known to affect human health is warranted as well, according to the authors. Increased knowledge regarding the composition and viability of microorganisms in smoke plumes, and their post-transport fates, may impact ecosystem restoration efforts, and may also have societal health impacts (see Kobziar and Thompson 2020 for more on this).

With such knowledge, land managers could better determine when and where to apply prescribed fire to minimize undesired effects, and also when wildfires may facilitate the spread of infectious disease.




*Pyroaerobiology integrates theory and methods from microbiology, smoke and atmospheric sciences, and fire ecology, with a range of broader impacts and value added to each discipline.*

## FOR FURTHER READING

Kobziar, L.N, Thompson, G.R. (2020) Wildfire smoke, a potential infectious agent. Science 370(6523):1408-1410.

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