Northwest Fire Science Consortium
A JFSP FIRE SCIENCE EXCHANGE NETWORK

BIOLOGICAL DISTURBANCE AGENTS, FUELS, AND FIRE IN WESTERN CONIFER FORESTS

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Biological disturbance agents (BDAs) can affect forest composition and structure in multiple ways, including by changing fuels in ways that affect fire risk and behavior. While some research has shown that BDAs can increase the likelihood and severity of wildfires, other research has shown the opposite. These opposing findings have led to confusion around the influence of BDAs on fuels and fire behavior, and uncertainty about the best ways to manage for their impacts in western fire-adapted forests.

To better understand the complex relationships at play in how BDAs impact fuels and fire, authors of this article identified the major BDA groups in western coniferous U.S. forests and reviewed existing literature on these groups to conceptualize how BDA-affected fuels will influence fire risk and outcomes. The resulting conceptual framework provides a generalized approach for characterizing BDA outcomes on fuels over time and space, including expected impacts on fuels heterogeneity throughout a BDA groups' life history. These expected fuels outcomes in turn help develop hypotheses for BDA effects on fire risk and severity.

Biological Disturbance Agents (BDAs):

Insects, pathogens, and parasitic plants, including both native and nonnative biota, that affect tree decline, mortality, and forest ecosystem processes. BDAs interact with abiotic factors such as fire and drought to determine forest composition and structure at stand and landscape scales. BDAs are a natural part of forest ecosystems and are essential to many forest functions; healthy forests are able to resist or recover from biological disturbance.

A young, healthy stand of lodgepole pine grows in the foreground with a backdrop of trees affected by a mountain pine beetle outbreak. Photo: US Forest Service Northern Region.

KEY FINDINGS

- BDA impacts on fuels and fire need to be considered in the context of ecosystem dynamics along with the afflicting BDA life history in a given location, including:
  - Whether the BDA manifests as an episode or as a chronic agent of tree defoliation and mortality;
  - The spatial scale that the BDA acts at.
- The review found little evidence to support the common belief that BDAs predominantly increase the likelihood and severity of wildfires.
- BDA impacts on fuels must be considered alongside interactions with existing forest structure, forest management legacies, future climate change and drought, and each other (e.g., overlapping BDA outbreaks).
- Because of their complex roles and influences on fuels that change over time, the consequences of BDAs on fire-related metrics and outcomes cannot be categorized as simply positive or negative.

RESULTS

Spatiotemporal aspects of BDA life histories determine fuels outcomes

BDAs in the western U.S. play many roles in shaping forest structure, composition, and fuel profiles. These impacts occur at a range of temporal and spatial scales. Spatial impacts can range from an individual tree to stand, landscape, or regional scales; and temporal impacts can range from short-lived, episodic outbreaks to chronic outbreaks that last for decades. These spatiotemporal aspects of tree damage drive the interactions among BDAs, fuels, and fire; thus each class of BDA must be considered by these aspects (see Figure 1).

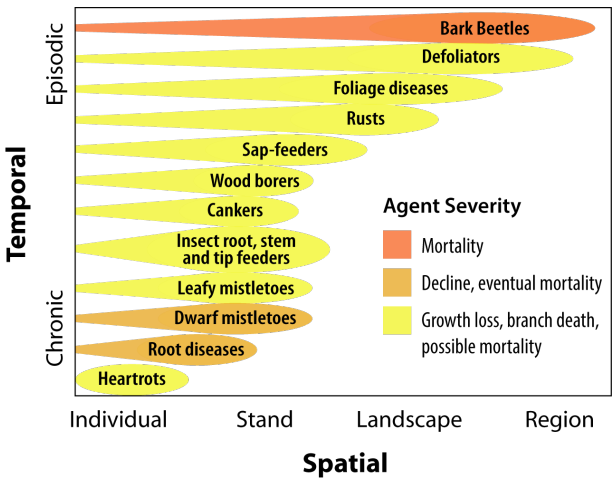

Figure 1. *Proposed relationships of major BDA groups in the western US, representing the temporal and spatial scales that they predominantly influence tree mortality and fuels.*

Principles of BDA-fuels-fire interactions

BDAs and fire interact with existing forest conditions, which emerge from legacies of forest management and land use outcomes. The way BDAs influence fire depends primarily on how significantly they influence canopy, surface, and litter/duff fuels. BDA influence on fuel structure depends on the magnitude of mortality and the effects of "time-since-event" as dead canopy biomass eventually moves downward, increasing surface and ground fuels. These changes occur at different rates for episodic versus chronic disturbance agents. BDAs also influence fuel bulk density, packing ratios, abundance, and moisture content, which collectively influence fire spread rate and severity. Ultimately, the impact of BDAs on fire must fully consider the fuels changes caused by BDAs that increase or decrease these fire behavior attributes. The authors suggest that in the absence of frequent fire, BDAs have emerged as dominant agents creating forest heterogeneity. Thus, BDAs may increase fire severity in some stands and time periods, but the heterogeneity of BDA-created fuels can increase diversity in fire severity compared to more homogeneous forest conditions that would support larger areas of high-severity fire.

Overlapping influences

Climate change and drought are affecting both wildfire and BDAs across the western US. These influences may exacerbate the effects of BDAs on tree productivity and survival, and severe fire weather may also overwhelm any influence of BDAs on fuels during a fire. In areas with more than one BDA, impacts from multiple BDAs events must also be considered. Ultimately, the complexity of overlapping interactions with these factors along with considerations for regional variation in fuels and fire, historic fire regimes, land management, and other abiotic disturbances leads to significant differences in how BDAs may influence fuels and fire, making it impossible to categorized BDA influences on fire as simply positive or negative.

MANAGEMENT IMPLICATIONS

This review offers a conceptual framework that organizes the major western BDA groups alongside their spatial and temporal patterns, offering land managers a synthesized resource of findings and hypotheses to date on how different classes of BDAs in western forests influence fuels and fire measures. For many groups of BDAs, research focused on how they affect fuels in ways that alter fire risk and behaviors is scarce or even nonexistent. This review and framework helps to categorize impacts on fuels and draws potential linkages to fire impacts while highlighting the groups of BDAs where research on fuels and fire is lacking. For BDA groups that have been the focus of much research related to impacts of fuels and fire behavior (e.g. bark beetles), the framework gathers, summarizes, and distills findings according to key considerations in overlapping influences. For both well-studied and less-studied groups of BDAs, this framework extrapolates across studies to also identify key associations with climate that also must be considered when assessing impacts on fuels and fire.

MORE INFORMATION

This brief is based on the following article:

Shaw, D.C., P.A. Beedlow, E.H. Lee, D. R. Woodruff, G. W. Meigs, S. J. Calkins, M. J. Reilly, A. G. Merschel, S. P. Cline, and R. L. Comeleo. 2023. The complexity of biological disturbance agents, fuels heterogeneity, and fire in coniferous forests of the western United States. *Forest Ecology and Management,* 525, 120572. https://doi.org/10.1016/j.foreco.2022.120572

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