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Assessing the Impacts of Fire on Forests

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Fire severity vs. fire intensity

Fire can have positive or negative effects on forest ecosystems, depending on the characteristics of the forest and of the fire. The results of the interaction between fire, weather, and forests are often described using the terms fire severity and fire intensity. These terms are often used together but have different meanings. The impact of fire on forest ecosystems, or fire severity, is most often quantified as tree mortality, decrease in above-ground biomass, compositional changes to vegetation, or changes to soil properties including water holding capacity and erosion (Table 1). These impacts can be sampled in the field or estimated using images captured by aircraft or satellites.

Table 1. Measures of fire severity

Component	Measure
Trees and other vegetation	Basal area mortality, canopy cover loss, bole or crown scorch, change in tree growth rates, post-fire regeneration, shifts in species composition, forest structure changes
Soil	Reduction in litter and duff, amount of oxidized soil, amount of volatized nutrients, changes in respiration, depth of heat penetration, amount of erosion, potential for mass movement.

Fire intensity quantifies energy release from fire. Energy release from fire can be measured in several ways (Table 2).

Table 2. Definitions of common measures of fire intensity.

Term	Technical Definition - https://www.nwcg.gov/glossary/a-z
Fireline intensity	The product of the available heat of combustion per unit of ground and the rate of spread of the fire, interpreted as the heat released per unit of time for each unit length of fire edge. The primary unit is Btu per second per foot (Btu/sec/ft) of fire front. The rate of heat release per unit time per unit length of fire front. Numerically, it is the product of the heat yield, the quantity of fuel consumed in the fire front, and the rate of spread.
Heat per unit area	Total amount of heat released per unit area as the flaming front of the fire passes, expressed as Btu/square foot; a measure of the total amount of heat released in flames.
Reaction intensity	The rate of heat release, per unit area of the flaming fire front, expressed as heat energy/ area/time, such as Btu/square foot/minute, or Kcal/square meter/second.
Flame length (common surrogate)	Flame length is the distance measured from the average flame tip to the middle of the flaming zone at the base of the fire. It is measured on a slant when the flames are tilted due to effects of wind and slope. Flame length is an indicator of fireline intensity.

Why does it matter?

Fire severity and fire intensity are often correlated within the same types of vegetation. For instance, a fire that kills all trees (high severity) in a stand of mature Douglas-fir would likely release more heat energy than a fire that kills half of the trees (moderate severity) in an adjacent stand with similar tree cover and stand age. Severity is often imperfectly correlated with intensity across different vegetation types. For instance, fire burning across a forest stand that has just been planted may kill all the planted seedlings (high severity) but likely releases less heat energy than a fire that kills half of the trees (moderate severity) in a stand of mature Douglas-fir.

In addition to evaluating severity in the immediate aftermath of fire, it is important to consider the effects of severity in the context of vegetation traits and management objectives.

There may be important lagged effects of fire, that is, impacts that occur many years after fire that are not accounted for by measurements taken immediately after fires burn. Lagged effects may include the spread of invasive species, insect outbreaks, landslides, and associated impacts to vegetation or infrastructure critical to forest management. For example, high severity fire in older stands will often result in a long-lasting snags and down-wood, a structural legacy that may not remain after younger stands burn at similar severity (see figure). A variety of fire effects may not be apparent until many years after fires burn. For instance, fire may release fire resistant species from competition, create biological diversity as different species regenerate, and may help create important forest structures, such as large standing snags with cavities.

High severity fire in structurally complex older forest in a U.S. Forest Service late successional reserve (left) and in a young managed forest stand (right). Intensity of these fires is unknown but was likely greater in the structurally complex forest.

Information about past or predicted future wildfire intensity and wildfire severity can be used to model fire risk or fire hazard. For instance, variability in the distribution of different types of fuel across a landscape can be used to predict fire intensity, while predictions about fire behavior (i.e., crown fire potential) can be used to estimate severity.

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