fire earth

# Fire Intensity Impacts on Net Primary Productivity

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## Key Findings

- The greatest post-fire productivity loss occurred one year after the fire (Figure 1).
- Forests dominated by fire-resistant species experienced the smallest relative productivity reductions compared to forests with less resistant species (Figure 1).
- Reductions in productivity were greater when fire intensity was greater in forests that were dominated by fire-resistant species. Meanwhile, in forests dominated by susceptible species productivity was reduced to similar levels regardless of fire intensity (Figure 1).
- In some cases, this reduction in productivity persisted for more than a decade post-fire, highlighting a legacy effect of fire intensity on post-fire carbon dynamics in these forests (Figure 1).

**Keywords.** Wildfire: net primary productivity, carbon cycle, coniferous forests, wildfire: anthropogenic climate change, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Larix occidentalis*, *Abies grandis*

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Forested ecosystems cover nearly one-third of Earth's land surface and can perform an essential function as one of the globe's largest **terrestrial carbon sinks**, absorbing more carbon than they release, lowering the concentration of carbon dioxide in the atmosphere. **Wildfire affects the carbon cycle** through direct carbon emissions during combustion and tree mortality, potentially impairing the ability of surviving trees to sequester carbon and limiting the photosynthesis of surviving saplings. While **studies have demonstrated** that increases in fire intensity can lead to reductions in post-fire net primary productivity (hereafter: productivity), wildfires have largely been assumed to either cause tree mortality, or conversely, cause no physiological impact. With increasing fire activity, lower fuel moisture **projected as a result of climate change** and limited resources for post-fire rehabilitation, it has never been more important to understand the longer-term effects of wildfire on the surviving vegetation.

**Researchers at the University of Idaho** set out to understand how fire intensity affects post-fire net primary productivity in conifer-dominated forested ecosystems in the western United States on the scale of large wildfires. Fires were chosen to represent forest stands ranging from those dominated by fire-resistant species (that typically survive low-intensity fires) to those dominated by fire-susceptible species (that do not). Forests dominated by fire-resistant species were typically composed of ***Pseudotsuga menziesii***, ***Pinus ponderosa***, ***Larix occidentalis***, and lesser quantities of ***Abies grandis***. Forests dominated by fire-susceptible species were typically composed of ***Picea engelmannii***, ***Abies lasiocarpa***, ***Pinus contorta***, and lesser quantities of ***Pinus albicaulis***.

There was considerable variability in the productivity-fire intensity relationships within each fire resistance grouping. Despite an average post-fire observational period of 8.4 years across all fires, only the lowest fire intensity class in one fire had recovered to pre-fire productivity levels about nine years post-fire. These results are consistent with observations showing large differences in productivity between burned and unburned forest stands at time periods greater than 10 years post-fire. The convergence of some of the productivity trajectories could be

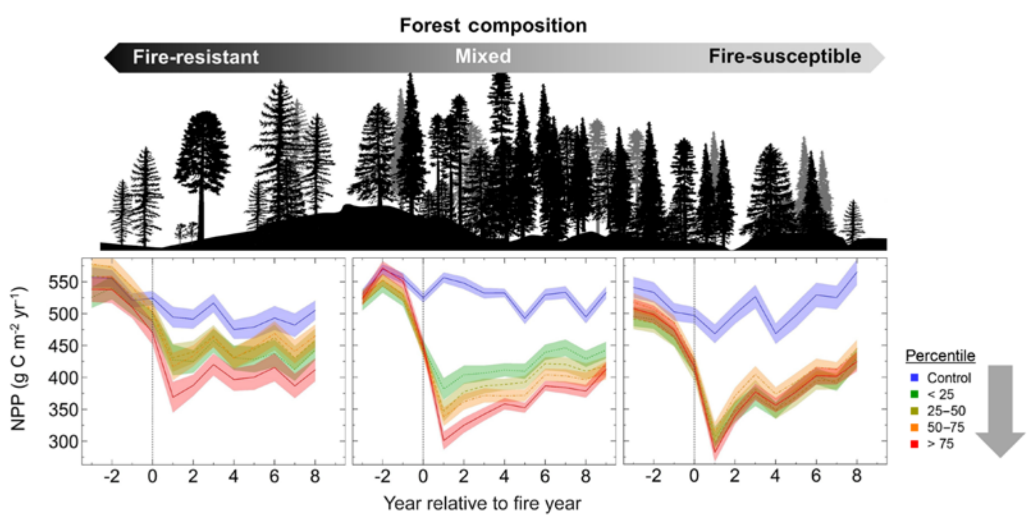


*Figure 1. Fire intensity impacts on net primary productivity (NPP) in forests dominated by fire-resistant (left) to fire-susceptible (right) species. Each colored line represents a percentile group of fire intensities, ranging from the control (not burned; blue), to the top 25% of fire intensities (red). The shaded areas around each line represent 95% confidence intervals. The gray arrow by the figure legend represents the direction of increasing fire intensity. Figure reproduced from Sparks et al. (2018) under Creative Commons Attribution 4.0 License.*

*Fire intensity can vary across a landscape, leading to varying impacts on the forest's net primary productivity, even though wildfires have largely been assumed to either cause tree mortality, or conversely, cause no physiological impact. Photo: Oregon Department of Transportation under CC BY 2.0.*

attributed to rapid recovery and colonization of fire-affected areas by understory species. For example, forests in the current study occur in areas where rapid post-fire colonization by shrub and herbaceous species is common, which could make **productivity recover more rapidly in areas where the forest overstory has been removed**. Additionally, variability in climate can significantly **alter vegetation establishment and growth post-fire**. Drier post-fire conditions can **significantly reduce tree regeneration** and potentially lead to conversion to non-forest vegetation. **Higher temperatures can also reduce tree growth and recovery**, while increased precipitation can lead to greater growth.

## Management Implications

Researchers have demonstrated that fires have a long-lasting effect on forest productivity in these forests, and we can measure these changes using satellite observations. Fire intensity is one of the main drivers of post-fire forest productivity, but species composition matters. Species composition influenced the magnitude of the post-fire productivity loss, highlighting the importance of the relative fire resistance of forest species in accounting for post-fire carbon dynamics. Increasing fire intensity can result in greater loss of post-fire net primary productivity in coniferous forests, especially those dominated by fire-resistant tree species. This relationship appears to have a legacy effect on carbon dynamics, in some cases lasting beyond a decade post-fire. Regardless of the fire intensity, most forests did not fully recover in the 12-year post-fire observation period; that is, forests remain a carbon source for a long time after the fire.

These results might be employed when planning post-fire management. For example, given a map of fire intensity, land managers can use these maps to decide where actions should be taken, such as thinning damaged-but-alive forest stands, salvaging logs or replanting killed forest stands. Such data could also be utilized in improving growth and yield models that managers rely on when planning forest management. For example, given a certain forest species composition and fire intensity, what is the expected forest productivity 'X' years after the fire?

## Foundational Publication

Sparks, A. M., Kolden, C. A., Smith, A., Boschetti, L., Johnson, D. M., & Cochrane, M. A. (2018). *Fire intensity impacts on post-fire temperate coniferous forest net primary productivity.* Biogeosciences, 15(4), 1173-1183. **https//doi.org/10.5194/bg-15-1173-2018**