# Context Document: USFS During-Fire Response ESCM

http://bit.ly/NI-ESCM

Ecosystem Service Conceptual Models (ESCMs) summarize the effects of an intervention on ecological and social systems. Each model links changes in biophysical systems caused by an intervention to measurable socioeconomic, human well-being, and ecological outcomes. This is a general ESCM that assumes the intervention is successful and includes all potentially significant outcomes for the intervention. In practice, not all outcomes will be relevant to each individual project, depending on location and environmental conditions.

The direction of an outcome (whether the intervention will have a positive or negative influence) often depends on the specific situation. Multiple links (arrows) leading into an outcome may have opposite effects. In the during-fire response model, some arrows are color-coded by whether the relationship between the starting and ending nodes (boxes) are likely be positive or negative. This is intended to help clarify differences between the two interventions in the model (full fire suppression and less than full fire suppression). See the "Color-coded links" section under "Model notes and clarifications" below for more information.

This document provides information about the intervention—**During-Fire Response on U.S. Forest Service (USFS) Land**—and details about some of the relationships in the ESCM. It also includes a list of the references used to develop the ESCM and names of experts with whom we spoke to refine the model.

## USFS During-Fire Response Interventions

Two interventions are included in the ESCM and represent different approaches to wildfire response:

- **Full fire suppression** deploys firefighters to control and extinguish a wildfire as quickly as possible, including containing the fire using control lines and the use of fire retardants applied from aircraft to reduce fire intensity.
- **Other than full fire suppression** includes a range of strategies to manage a fire for resource benefit while maintaining an acceptable level of risk for nearby human communities and sensitive natural areas. Wildfire management strategies include actions to confine the fire to a defined area (e.g., line construction, bucket drops, back burns) and to protect specific areas (communities, homes, sensitive natural resources) from the fire (National Interagency Fire Center 2011). Effects of managed wildfires are similar to those of prescribed burns, but can cover larger areas than is feasible through a prescribed burn program.

## External Factors

Social factors, both outside and within the USFS, are the primary determinant of wildfire response. The general public expects fires to be suppressed, and that is historically how USFS has approached wildfires. As understanding of forest ecology improves, the U.S. Forest Service has recognized the important role of fire in forest ecosystems for maintaining populations, promoting

germination of certain species, and managing fuel loads (North et al. 2015). Despite this, as recently as 2015, the U.S. Forest Service spent more than half of its budget on fire suppression, which leads to a positive feedback loop where fire suppression maintains high levels of fuel load that exacerbates the risk of catastrophic fires in the future (Stephens et al. 2016). As climate change progresses, fires are expected to become more frequent and more severe (Schoennagel et al. 2017). During the past decade, a growing body of researchers have advocated for the use of wildfire management as a safe and cost-effective approach for reducing the fuel load in U.S. forests (Thompson et al. 2018). One successful example of wildfire management on USFS land is the 2017 Pinal Fire in Arizona, which used control lines and back burns to manage a 7,500-acre fire started by lightning (O'Connor and Calkin 2019). Management of the Pinal Fire was guided by a community-developed strategic wildfire response strategy that was prepared before the fire season; this type of pre-fire planning is key for implementing fire management to increase ecological and social resilience (Thompson et al. 2016).

## Model Notes and Clarifications

**Economic activity from fire response:** There are links from both of the interventions (wildfire management and fire suppression) to the economic activity outcome because both interventions require resources (including staff) to implement. However, fire suppression is much more expensive and supports more jobs than wildfire management. In 2015, the USFS spent more than 50% of its budget on fire suppression (up from 16% in 1995) (Stephens et al. 2016).

**Fire suppression and fire-related injury or death:** Wildland firefighting is a high-risk occupation; a review of five surveillance systems that capture wildland firefighter fatalities identified 247 unique deaths that took place during wildland firefighting between 2001 and 2012. The most common causes of death were aviation-related (Butler et al. 2017). A review of studies of wildland firefighting and mental or physical health outcomes found some evidence for hypertension, post-traumatic stress disorder, and decreased lung function, but results were inconsistent, and many studies were lower quality (Groot et al. 2019). A recent survey of wildland firefighters highlighted lower-body injuries (including back, knee, and ankle injuries) as the most common (Moody et al. 2019). The safety of responders, and decisions around when to deploy them for fire suppression, has been a topic of discussion within USFS (Thompson et al. 2018).

**Current burn characteristics (area burned and burn intensity), forest characteristics, and future catastrophic fire risk:** Many of the intermediate effects shown in the ESCM (the boxes in the middle of the ESCM) occur because of opposing effects of the two management interventions on characteristics of the current fire (area burned and burn intensity), and therefore on forest characteristics that influence future catastrophic fire risk. Fire suppression tends to decrease the area burned by the current fire and its burn intensity, while wildfire management's hands-off approach allows a larger area to burn. When a managed wildfire burns out, it leaves behind a forest with decreased fuel load and heterogeneous structure, potentially including patches of higher burn intensity with few trees. This tends to decrease the risk of future catastrophic fires because the landscape is not a homogenous bed of fuel (North et al. 2015; Schoennagel et al. 2017; Stephens et al. 2016). In contrast, areas that are prevented from burning due to fire suppression

have the same high fuel loads they had before the fire, leaving them at risk of burning in the next fire.

**Carbon flux:** The carbon flux node represents changes in carbon emissions or sequestration. This can occur through short-term events, such as carbon emissions from fires, or over a longer time period, like changes in carbon sequestration rates after shifts in forest structure or tree species composition. Both types of changes are included in the ESCM, represented by the links leading to the carbon flux node.

**Color-coded links:** The color-coded links (arrows) in the ESCM indicate the likely direction of the relationship between the two nodes (boxes) and can help to identify differences between the interventions. For example, wildfire management increases area burned, while fire suppression decreases it. Because area burned decreases fuel load, and fuel load increases future catastrophic fire risk, wildfire management is expected to decrease future catastrophic fire risk through that pathway (increase * decrease * increase = decrease), while fire suppression is expected to increase future catastrophic fire risk (decrease * decrease * increase = increase). Not all links are color-coded to indicate direction; gray links reflect relationships for which the direction is uncertain, or where the increase/decrease terminology isn't applicable (e.g., effects on plant species composition).

**Other relevant ESCMs:** The green oval in the ESCM indicates that another ESCM, for post-fire emergency response, may be relevant if you are considering the potential outcomes of fire-related management on a landscape.

## Experts Consulted

Matthew Thompson, Research Forester, USFS

## References


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