fire earth

Assessing Landscape Vulnerability to Wildfire

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Predictive assessments can help managers implement proactive, pre-fire activities designed to mitigate the impacts of future fires. Treatments before the 2003 Davis Lake Fire, Oregon may have contributed to tree survival. Photo: Oregon State University under CC BY-SA.

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Wildfire is a **dynamic natural process** that continually shapes the structure and composition of landscapes. However, due to a combination of factors including climate change, management decisions and population growth, this natural process is having negative impacts on **important ecosystem goods and services** (EGS). It is critical to accurately measure and predict wildfire occurrence, its impacts to EGS and their post-fire response if effective adaptive management of landscapes is to take place. **Vulnerability assessments** have informed such adaptive management in response to other stressors. Yet our understanding of what makes landscapes and communities more or less vulnerable to wildfire specifically remains incomplete, which can undermine our ability to ensure that landscapes and communities are fire adapted.

Researchers conceptualized a framework for guiding landscape vulnerability assessments in the context of wildfire that include both retrospective and predictive components, as the combination of both is most powerful for informing adaptive management of landscapes. **Retrospective assessments** are done after a fire, with observational and other data to assess impacts. These assessments are critical for better understanding where and how a landscape was vulnerable to various impacts of wildfire, yet their timing limits managers' options to only responding to those impacts. On the other hand, **predictive assessments** are carried out before a fire and analyze factors that can predict various impacts in order to evaluate future wildfire vulnerabilities. There is a natural degree of uncertainty in predicting future events, and this uncertainty increases in tandem with temporal distance to the future event. However, these projections allow managers to broaden their options to include proactive, pre-fire activities designed to mitigate the likely negative impacts to EGS.

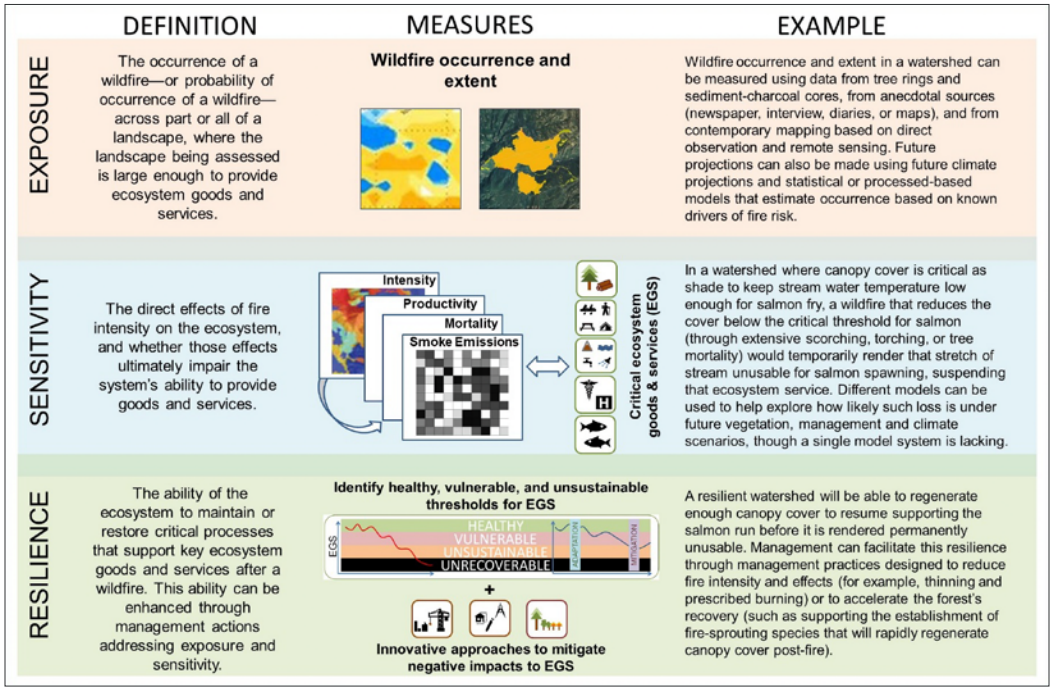


Figure 1. *The researchers conceptualized a framework for guiding landscape vulnerability assessments specifically in the context of wildfire. Characterizing fire vulnerability of a landscape requires assessment of exposure, sensitivity and resilience factors within a defined area. (A live text version of this figure is included as an appendix, so screen readers and other assistive technologies can read its content.)*

Characterize Exposure	Focus Sensitivity	Explore Resilience Options	Integrate Adaptive Actions
i. Define the area of interest, and consider how to use the existing and modeling data to quantify occurrence and extent.	ii. Identify the critical ecosystem goods and services, and consider what existing and modeling data can be used to estimate fire effects on those goods and services.	iii. Use exposure and sensitivity information, along with understanding of system recovery thresholds, to explore actions that could mitigate impacts and enhance recovery of critical goods and services.	iv. Integrate actions likely to mitigate impacts and enhance recovery into dynamic adaptive management plans.

Figure 2. *Steps needed to create and use a vulnerability assessment in addressing wildfire risk and impacts.*

The Landscape Vulnerability Assessment Framework Explored

This landscape vulnerability assessment framework draws on our current understanding of ecological vulnerability which is defined in climate change studies as the extent to which a natural or social system (in this case a landscape) is susceptible to sustaining damage from a stressor (in this case, wildfire). **Vulnerability has three primary components**: exposure to the stressor, sensitivity to a range of stressor variability, and resilience following exposure, which is also referred to as **adaptive capacity**. Each of these components are defined in the context of wildfire and applicable measures are identified, both for retrospective and predictive assessments (Figure 1).

Exposure. *The occurrence of a wildfire across part or all of a landscape.* The area for which exposure is quantified should be relevant to the management decisions on the landscape of interest, and large enough to provide EGS. Wildfire exposure is quantified on the basis of fire occurrence and its extent, often called **area burned**. In a retrospective assessment, an area either has burned or it has not. Meanwhile, a predictive assessment employs data from previous fires and their drivers to estimate the probabilities of different areas burning.

Sensitivity. *The direct effects of fire intensity on the ecosystem, and whether those effects ultimately impair the system's ability to provide EGS.* The effects considered in the assessment should include not only the immediate effects of the fire, but also the cascading consequences after fire (for example, **erosion and increased runoff from burned slopes**). Wildfire sensitivity can be quantified in different ways, including how much biomass was consumed or how different functions (e.g., photosynthesis, primary productivity, plant mortality, smoke emissions) have been affected. How sensitivity is defined and quantified will depend on what EGS are of interest in each particular management context.

Resilience. *The ability of the ecosystem to maintain or restore critical processes that support key EGS after a wildfire.* This ability can be enhanced through actions in a managed landscape that mitigate the system's exposure to wildfire and help adapt to a broader sensitivity range. To determine what actions are required, managers need to understand what impacts wildfire has (immediately and over a longer term) on the EGS the landscape provides, and what the threshold limits are that could impair the system's ability to provide these in the future. **Enhancing resilience is not a straightforward thing to do**: it requires identifying and understanding a multitude of dynamic factors that interact with fire, including climate variability and change, land cover change, invasive species, and human activities. Planning scenarios that consider these factors and their contribution to pushing the system past recovery thresholds can be used to explore options and their effectiveness.

Resilience determines the system's ability to continue to provide ecosystem goods and services, such as clean water and plant productivity, after a wildfire. Photo: Jessica Halofsky under CC BY-SA 2.0.

Management Implications

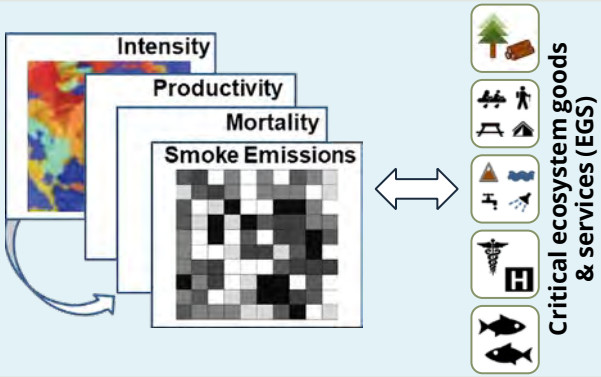
A vulnerability assessment will support fire managers' adaptive management capacity, as they work towards achieving fire-adapted communities and fire-resilient landscapes. To complete a vulnerability assessment based on this framework, managers need to (i) define what aspects of exposure to wildfire are most important in their particular context; (ii) determine what EGS are most important in that landscape and for that community, and how they might be impacted by wildfire (sensitivity); (iii) utilize existing data on past wildfires, models and tools to project future wildfires and estimate potential impacts to important EGS; and (iv) identify management actions that can mitigate exposure to wildfire and enhance adaptation of that landscape to a broader sensitivity range, thereby enhancing its resilience to wildfire (Figure 2).

These management actions can then be integrated into adaptive management plans that guide action on the landscape. Since climate and other impacts are still in some ways unpredictable, the management plans must be adaptive and dynamic to create the best likelihood of success.

Foundational Publication

Vaillant, N. M., Kolden, C. A., & Smith, A. M. (2016). *Assessing landscape vulnerability to wildfire in the USA.* Current Forestry Reports, 2(3), 201-213. https://doi.org/10.1007/s40725-016-0040-1

Appendix: Figure 1

	DEFINITION	MEASURES	EXAMPLE
EXPOSURE	The occurence of a wildfire—or probability of occurence of a wildfire—across part or all of a landscape, where the landscape being assessed is large enough to provide ecosystem goods and services.	**Wildfire occurence and extent** 	Wildfire occurence and extent in a watershed can be measured using data from tree rings and sediment-charcoal cores, from anecdotal sources (newspaper, interview, diaries, or maps), and from contemporary mapping based on direct observation and remote sensing. Future projections can also be made using future climate projections and statistical or processed-based models that estimate occurence based on known drivers of fire risk.
SENSITIVITY	The direct effects of fire intensity on the ecosystem, and whether those effects ultimately impair the system's ability to provide goods and services.		In a watershed where canopy cover is critical as shade to keep stream water temperature low enough for salmon fry, a wildfire that reduces the cover below the critical threshold for salmon (through extensive scorching, torching, or tree mortality) would temporarily render that stretch of stream unusable for salmon spawning, suspending that ecosystem service. Different models can be used to help explore how likely such loss is under future vegetation, management and climate scenarios, though a single model system is lacking.
RESILIENCE	The ability of the ecosystem to maintain or restore critical processes that support key ecosystem goods and services after a wildfire. This ability can be enhanced through management actions addressing exposure and sensitivity.	**Identify healthy, vulnerable, and unsustainable thresholds for EGS**  +  **Innovative approaches to mitigate negative impacts to EGS**	A resilient watershed will be able to regenerate enough canopy cover to resume supporting the salmon run before it is rendered permanently unusable. Management can facilitate this resillience through management practices designed to reduce fire intensity and effects (for example, thinning and prescribed burning) or to accelerate the forest's recovery (such as supporting the establishment of fire-sprouting species that will rapidly regenerate canopy cover post-fire).