ASSESSING POST-FIRE BURN SEVERITY ON THE GROUND AND FROM SATELLITES: A REVIEW OF TECHNOLOGICAL ADVANCES

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ABSTRACT

Question: Burn severity mapping and post-fire assessment has changed dramatically over the past two decades—what changes do the future hold?

Background: For >30 years, USDA Forest Service and USDOI Burned Area Emergency Response (BAER) teams have been among the first specialists on-site after a wildfire to assess and map fire effects. Their primary task is to determine the burn severity, with an emphasis on the fire's effect on the soil, which is used in turn to help identify areas at increased risk for post-fire soil erosion, flooding, or debris flows. Large fires near the wildland–urban interface in recent years have been the target of increased public scrutiny of federal land management practices. This has prompted a renewed focus on developing objective, repeatable methodologies for creating accurate post-fire maps.

Immediately after the 1988 Yellowstone wildfires, fire perimeter and tree mortality mapping was completed using aerial photography and sketch mapping from fixed-wing aircraft and helicopters. These preliminary maps were deemed adequate for emergency use, but more detailed data were necessary for long-term scientific evaluation. Satellite images were used to create post-fire burn-severity maps in the early years following the 1988 Yellowstone Fires. These maps emphasized spatial patterns of burn severity, patch sizes, and tree mortality, and were used to estimate potential vegetation recovery.

Currently, high-resolution burn-severity maps (30-m pixels) are rapidly produced from satellite imagery within days of fire containment. These maps are verified in the field and adjusted to reflect the effects of the fire on the soil, which impact post-fire soil hydrological functions. The field-validated maps highlight areas where increased runoff and peakflows, flooding, erosion, and sediment delivery to streams threaten values-at-risk. The maps are so quickly produced and highly utilized because of years of fine-tuning and standardizing the process by the USFS Remote Sensing Applications Center and the USDOI Earth Resources Observation and Science groups.

Location: Large wildfires in the western United States, especially those near the wildland–urban interface and other downstream values-at-risk.

Methods: Traditionally, BAER burn-severity maps were created by sketch mapping from a helicopter or road-accessible overlook. Accuracy and complete fire coverage were difficult to obtain with these early methods. In 1996, color infrared digital imagery was first tested for creating post-fire maps, which segued into the first use of remotely sensed satellite imagery in 2000. Since 2001, primarily Landsat satellite imagery has been used to create post-fire burn-severity maps used in post-fire assessments.

Results: Advances in GIS and remote sensing have provided tools that greatly improve the speed, precision, and accuracy of fire mapping efforts, particularly on large and inaccessible fires. The post-fire burn-severity map is also used by other resource specialists to identify potential impacts to road, structures, aquatic and terrestrial habitat, cultural resources, and resources downstream from the burned area. Examples of using GIS to derive fire effects information include overlaying the burn-severity map with steep slopes, soils, or ownership, for use in modeling post-fire slope stability or measuring acres of burn severity by ownership or by watershed. New remote sensing tools are increasingly being used to identify direct wildfire effects that predict potential secondary effects, such as increased runoff and erosion. Higher-resolution airborne hyperspectral images (4-m pixels) have been used to create post-fire maps of green and charred vegetation, exposed mineral soil, and ash. A map of these erosion-related ground-cover components provides information relevant to potential watershed response. Quickbird and IKONOS satellites provide the highest spatial resolution multispectral imagery (2-m pixels) that has been successfully used to create burn-severity maps at an even finer scale than is possible with Landsat.

Conclusions: A better understanding of fire's role in healthy ecosystems has generated great interest in the applications of burn-severity mapping, especially in relation to longer-term effects such as invasive species, vegetation recovery, and productivity. With the future of Landsat uncertain, other data sources and mapping methods are being investigated, many of which have greater spatial and spectral resolution than Landsat. These new data products hint at the future of burn-severity mapping and may allow land managers to more confidently prescribe post-fire rehabilitation only to the areas where they are most needed. Time, money, and resources will be saved if treatments are only used where they have the potential to reduce the risk to downstream values-at-risk.

keywords: burn-severity mapping, Landsat, remote sensing.

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