

MAPPING THE POTENTIAL FOR HIGH SEVERITY WILDFIRE IN THE WESTERN UNITED STATES

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Each year, large areas are burned in wildfires across the Western United States. Assessing the ecological effects of these fires is crucial to effective postfire management. This requires accurate, efficient, and economical methods to assess the severity of fires at broad landscape scales (Brennan and Hardwick 1999; Parsons and others 2010). While postfire assessment tools exist (such as the burned area reflectance classification (BARC) maps produced in the burned area emergency response (BAER) process), land managers need new tools that easily and quickly *forecast* the potential severity of future fires. We are currently working on one such tool aimed at helping managers to make decisions about whether and where future wildfire events may restore fire-adapted ecosystems or degrade the landscape. This tool is a 98-foot (30-m) resolution, wall-to-wall map of the potential for high severity fire in the Western United States, excluding Alaska and Hawaii.

Understanding Where Fires Are Likely To Burn Severely

Measures of burn severity are a reflection of fire intensity and aim to capture the effects of fire on veg-

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etation and soils. In the field, burn severity can be thought of most simply as the loss of biomass as a result of fire (Keeley 2009). When assessing burn severity across large geographic areas from satellite imagery, the definition of burn severity can be thought of more

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broadly as the degree of change from a prefire image to a postfire image (Lentile and others 2006). Such broad-scale assessments of burn severity have proven useful to managers in evaluating the potential for erosion, extent of tree mortality, and pathways for vegetation recovery after a fire. These assessments are valuable largely because they provide a framework for scientists and managers alike to consider the ecological effects of fire spatially. Moving beyond the application of such information to postfire rehabilitation, we believe that analyzing burn severity in a spatial context and over a long period of time can provide insight to aid management decisions at multiple planning stages, including prefire fuels treatments and

strategic management of active fire incidents.

In our research, we are analyzing where and when fires burned severely between 1984 and 2007. While we understand much about how climate, fuels, and topography influence fire extent, their effects on burn severity are little understood. We are, therefore, capitalizing on the vast database of satellite-derived burn severity data recently made available by the national Monitoring Trends in Burn Severity (MTBS) project (<http://www.mtbs.gov>) to ask the following basic questions: (1) Are there underlying properties of a landscape that drive where fires burn hotter and, therefore, result in higher severity fires? and (2) Do the influences of the physical landscape change under different climate and weather scenarios? To answer these questions, we combine burn severity observations from more than 7,000 past fires with spatial data on topography, climate, and vegetation to build predictive statistical models.

As scientists, one of our primary goals in doing this research is to further our collective understanding of where, why, and when fires burn severely. Just as important, however, is transferring this increased understanding into a set of applied products that will truly be useful to managers. By taking our statistical models built on observed relationships from past fires, we can extrapolate out across

entire landscapes to predict the potential for high severity fires in the future.

How We Map Probability of High Severity Fire

Our approach for mapping the probability of high severity fire builds on preliminary work by Holden and others (2009). Using data from the Gila National Forest, they developed methods to map the probability of severe fire occurrence based on topography and vegetation. We are now expanding on their general approach to produce a west-wide map of the landscape potential for severe fire. As an improvement on their methods, we are including weather and climate information into our predictions, even adding the capability to include current season climate and fire weather data, resulting in dynamic predictive maps of the potential for severe fire. Over the next year, we will produce maps and 98-foot (30-m) raster spatial data covering all lands across the Western United States. Both the maps and the data will be available for download online by March 2012.

Our predictive modeling and mapping work will be based on more than 7,000 fires that have been mapped by MTBS within our study area (fig. 1). Most of these are more than 1,000 acres (405 ha) in size, and all vary greatly as they encompass unburned islands and areas with low, moderate, and high severity (fig. 2). As observations of burn severity, we will use an index known as the relative differenced normalized burn ratio (RdNBR) that is produced by comparing pre-fire and postfire Landsat satellite images. Because our objective is to

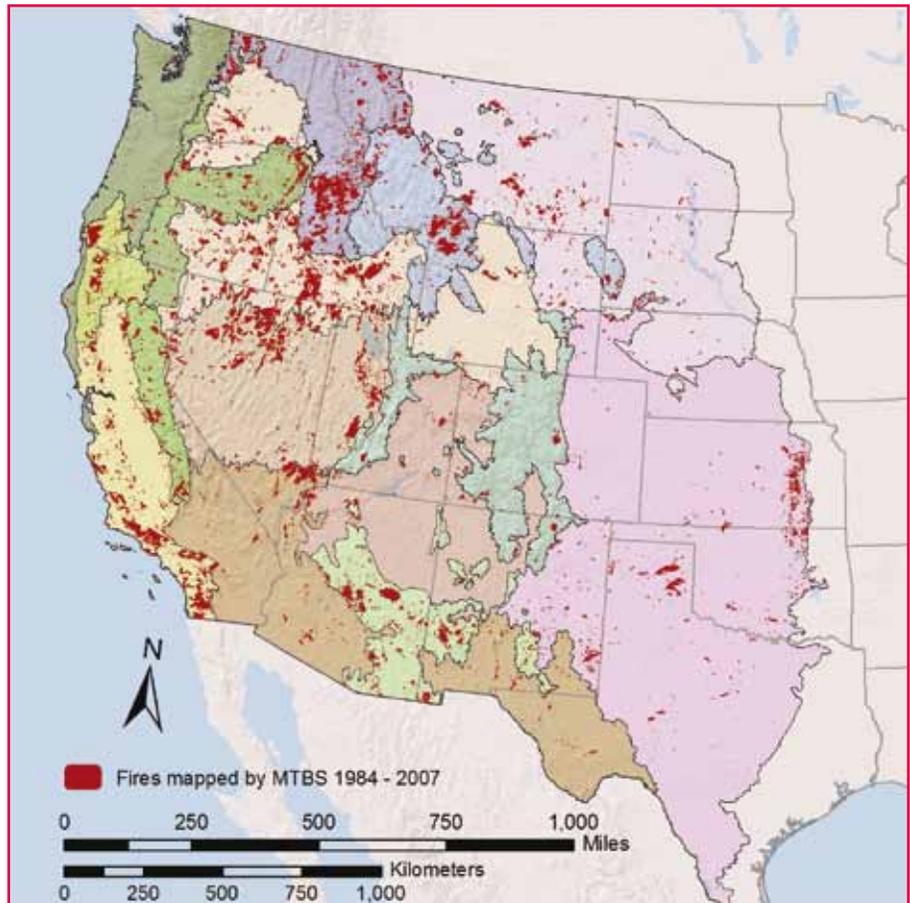


Figure 1—The geographic extent of our west-wide effort to map the potential for high severity fire. The colored areas are the 15 mapping regions we plan to use in building predictive models and producing maps.

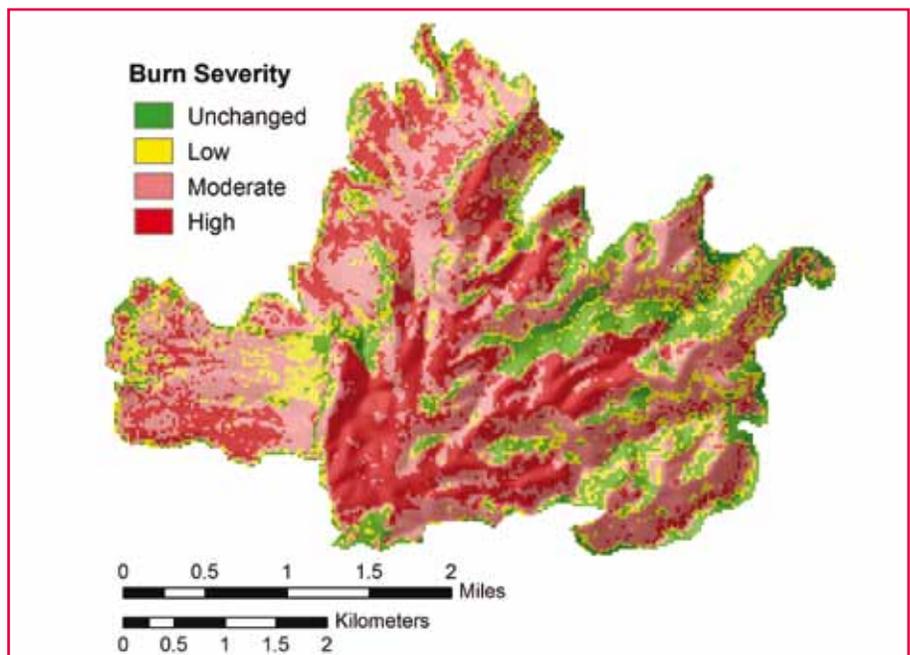


Figure 2—Example of the spatial variability in burn severity within a single fire. This map shows the relative differenced normalized burn ratio (RdNBR), classified into four categories of burn severity. We focus specifically on areas of high severity fire, where a high proportion of overstory trees are killed (in forests) or aboveground biomass has been removed (nonforest). These areas also usually experience a high degree of surface fuel consumption and exposure of bare mineral soil.

predict high severity fire, we reclassify the RdNBR into simple categories of high severity versus not high severity, using thresholds that we calibrate from field data that we and others have collected across the study area.

In each of 15 broad mapping regions based upon Omernik Ecoregions (fig. 1), we will construct separate predictive models for forested and nonforested areas. As predictors of severity, we have multiple spatial layers of topographic variables, such as elevation and incoming solar radiation, at 98-foot (30-meter) spatial resolution. Weather and climate are represented at coarser spatial scales, but at fine enough temporal scale to get values specific to the time of each fire event.

Given the size of our study area and the huge number of 98- by 98-foot (30- by 30-m) pixels in it, we begin our modeling process by selecting a very large random sample of pixels from within the MTBS burned areas. For each sampled pixel, we extract values for all predictors and use a computationally intensive algorithm called Random Forest (Breiman 2001; Prasad and others 2006; Cutler and others 2007) to develop predictive models. We then apply these models across the entire landscape to produce maps showing the potential for high severity fire for all locations.

Lastly, we will perform accuracy assessments on our map products. Already, we have collected fire severity information from 204 plots on 16 fires that burned in 2008 and 2009, and we will sample plots on fires that burned in 2010 during the summer of 2011. Our goal is to have at least 500 plots from a variety of geographic regions and

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vegetation types; we can use these data to tell managers where the maps are more, or less, accurate. Going back to the work of Holden and others (2009), they achieved over 70 percent classification accuracy for forested areas in the Gila National Forest (fig. 3), which we think lends promise to our applica-

tion of this process to other areas across the West.

What Are the Expected Benefits?

Weather and climate affect fire behavior, and fires burn differently at different elevations and

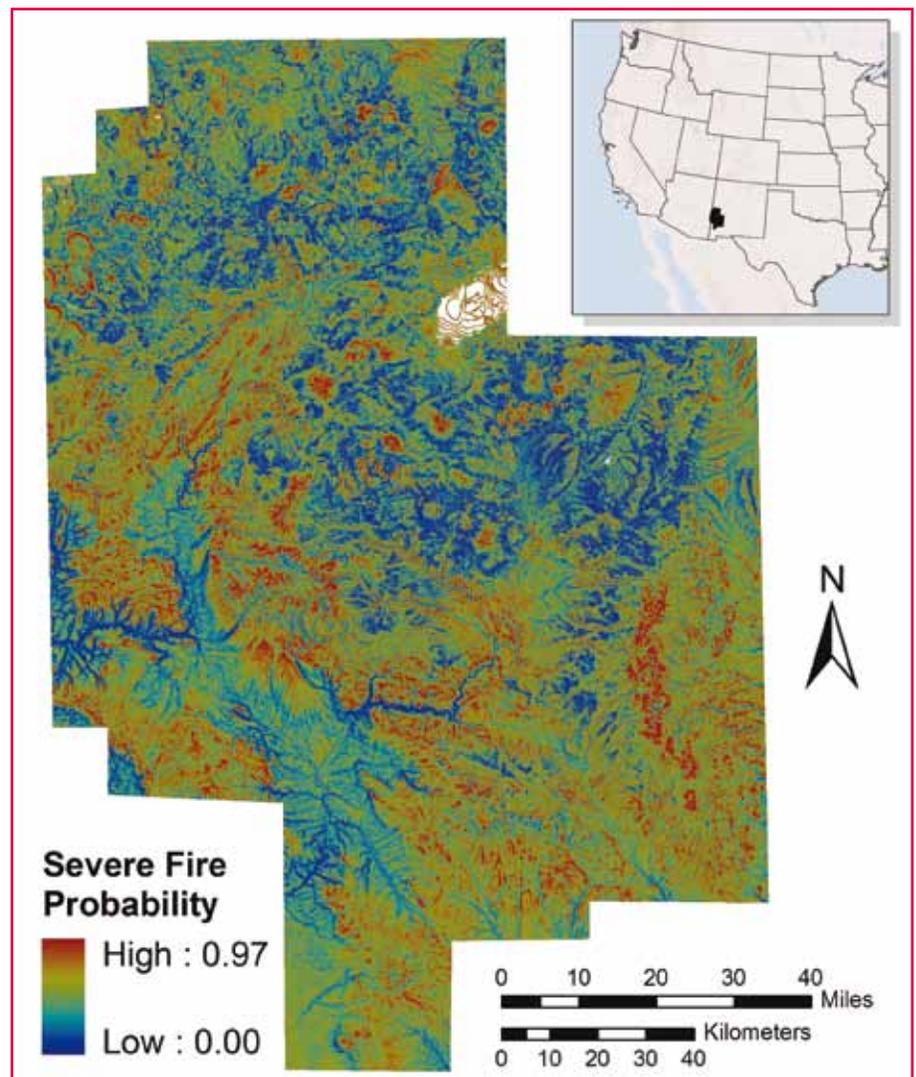


Figure 3—Map of the potential for high severity fire for part of the Gila National Forest, produced by Holden and others (2009). We will build on their methods to produce similar maps for the Western United States.

topographic settings. Yet, we don't fully understand why fires burn more severely in some places than in others. We think of climate and weather as "top-down" influences on wildland fire (e.g., through fuel moisture, temperature, or wind) that affect where and how fires burn at a broad scale. In contrast, topography and fuels are "bottom-up" controls that interact with climate and weather to alter fire behavior and effects locally. Topography is often a strong driver of general vegetation distribution, which in turn influences the distribution of fuels and patterns of severity. Based upon our preliminary analyses, we think that, while area burned is greatly affected by climate (Littell and others 2009), local topography and fuels are relatively more important to the ecological effects of those fires, though this varies across vegetation types and ecoregions. We also expect that topography and fuels may be less important when it is especially hot, dry, and windy, and so we will have multiple maps reflecting this.

Managers tell us that they will find many uses for our maps depicting the potential for severe fire. As an "off-the-Web" resource, our maps will be immediately available when new fires start, and managers expect to use them in evaluating the potential risks and effects associated with new fire events. They are also eager to see these map layers and related tools incorporated into existing decision support frameworks, such as the Wildland Fire Decision Support System (WFDSS) and the Rapid Assessment of Values at Risk (RAVAR).

Our work is part of a much larger research project, FIRESEV (<<http://www.firelab.org/research-projects/fire-ecology/128-firesev>>), funded by the Joint Fire Science Program, designed to create a Fire Severity Mapping System (FSMS) for the Western United States. With this system, managers can access fire severity map products when and where they need them. By integrating LANDFIRE data layers, fire effects models, and new techniques for analyzing satellite-derived burn

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severity data into one comprehensive computer modeling package, we hope to make it easier for managers to acquire fire hazard and fire severity maps at real-time or short-term timeframes and over a wide range of spatial scales. This FSMS will be composed of a suite of digital maps, simulation models, and analysis tools that can be used to create fire severity maps for: (1) real-time forecasts and assessments in wildfire situations, (2) wildfire rehabilitation efforts, and (3) long-term planning. This FSMS will NOT replace the suite of fire severity products currently used by fire management (e.g., BARC severity maps); rather, it would complement

them to provide a more comprehensive suite of fire severity mapping products. The blend of many fire severity mapping approaches that are incorporated into this system should help meet fire management demands for rapid but accurate assessment of spatial fire severity given their time, funding, and resource constraints.

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