The Emergence and Potential of New Wildfire Risk Assessment Tools

By Josh McDaniel
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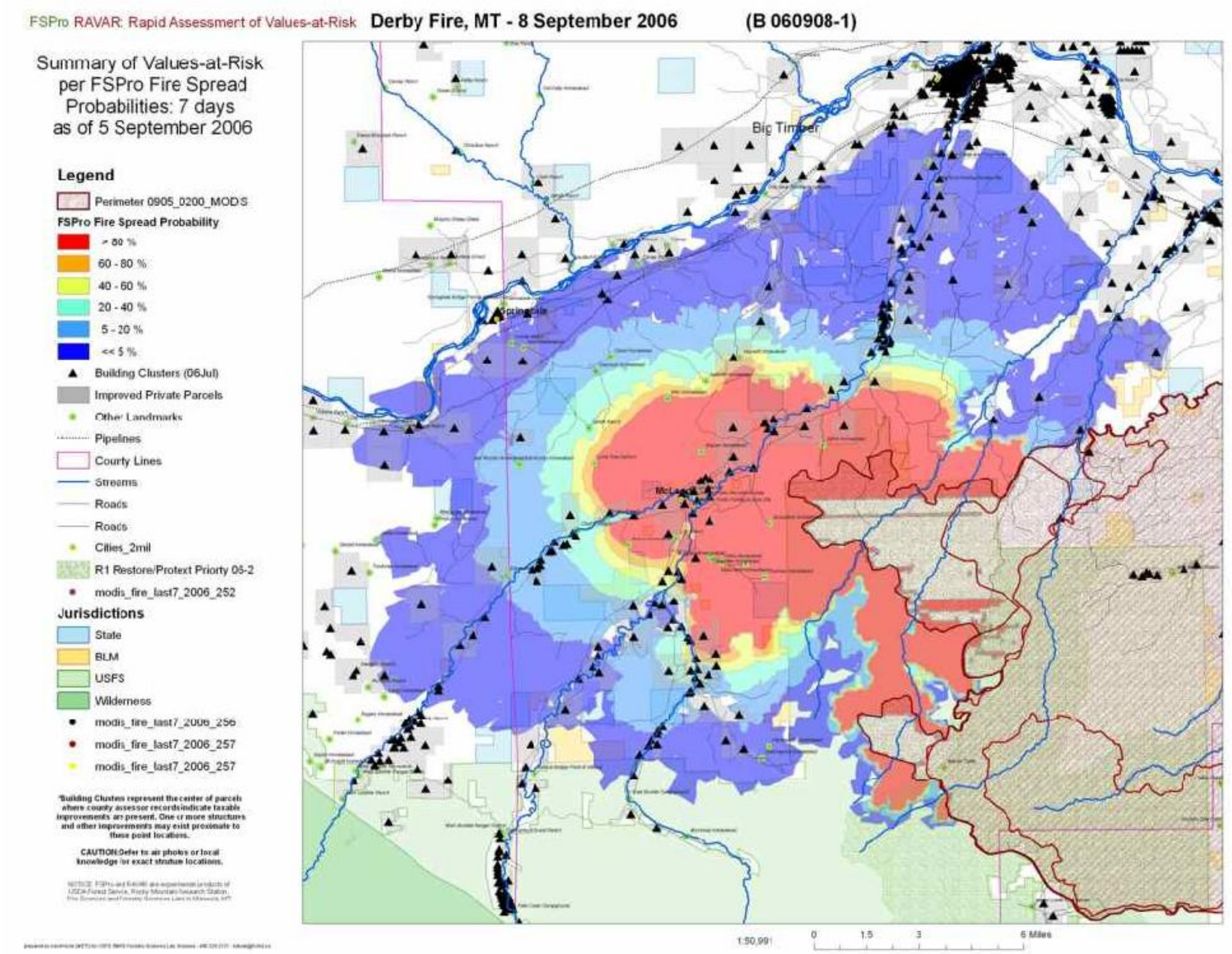
How do we measure the effects of proposed fuel treatments and other restoration activities on a potential fire? How do we deal with the fact that wildfire risk has little to do with local stand conditions, which is the focus of fuel treatment analyses, when the real risk needs to be measured at the larger landscape scale? How do we treat fuels to reduce fire risk to "values" on a forest, while adhering to the varying and often conflicting management restrictions layered across a forest?

These are questions that have plagued land managers for decades, making it difficult to predict the effectiveness of proposed investments. Until recently the tools just didn't exist to answer these types of questions.

New, powerful wildfire simulation models can now show where fires are most likely to burn, and when linked with economic models that incorporate human and ecological values, they can show the probable effects of these fires on the things we care about on a forest. These new risk assessment tools are already firmly integrated into incident management, and are now transforming fuels management planning at the project and forest level. Researchers are even working on a national level risk framework that should help with and budgeting and project prioritization.

Mark Finney, a researcher with the Missoula Fire Lab, has been instrumental in developing much of the fire behavior models that underlie these systems, but a growing number of researchers have also begun to shape the new risk framework. Dave Calkins, an economist with the Rocky Mountain Research Station, developed the Rapid Assessment of Values At Risk (RAVAR) program to integrate with Finney's burn probability mapping within the Wildland Fire Decision Support System (WFDSS). RAVAR is an economic model that provides dollar estimates of values (structures, infrastructure, etc.) threatened by a fire, as well as assessments of non-monetary values such as critical habitat. Alan Ager, an operations research analyst at the Western Wildland Environmental Threat Assessment Center (WWETAC), has been working on the ArcFuels program for integrating the proliferation of vegetation and fire behavior models into one GIS framework for fuels project planning purposes. Ager has also begun to use the risk frameworks to identify areas that are sources and sinks of fire.

Other researchers are using risk analysis to examine how wildfire might impact forest restoration goals and to create guides for fire resilient forest composition and structure. The new tools are also being used to look at potential negative wildfire effects such as smoke emissions, soil heating, duff consumption and hydrologic effects. Economics impacts are also a major component with consideration of financial values like treatment costs, potential timber revenues and projected changes to future wildfire suppression cost from fuels projects.



Fire spread probability contours and Values at Risk produced by a combined FSPro and RAVAR model run for the Derby Fire.

The Emergence of Risk in Wildfire Research

"Wildfire risk has two parts: the likelihood an area will burn and the resulting change in ecological or financial value if it does," explains Alan Ager. "Our definition of wildfire risk is the product of the probability of a fire at a specific location by the change in financial or ecological value."

The probability of a wildfire at any particular location is dependent on a chain of events that include ignition, weather, fire spread, suppression actions taken, and many interactions among these factors. However, the vast majority of acres burned in the western US are from a very few large fires that aren't really suppressed until weather conditions moderate for suppression actions to be effective. So, the main determinant of wildfire risk for any given location is whether or not that spot is in a path that a nearby large fire is likely to follow.

In the past, the probability of a fire occurring in any one place could not be estimated real well. We might know that a high intensity fire in a ponderosa pine forest would be bad, but we had no idea of the chance that it would occur. Maybe it was so rare there was no reason to worry. "We didn't know how much investment was needed to reduce the probability of occurrence or to change the susceptibility part of the equation," says Mark Finney. "If the chances of a fire affecting something are low, why spend millions of dollars in mitigating a level of risk that doesn't justify the investment."

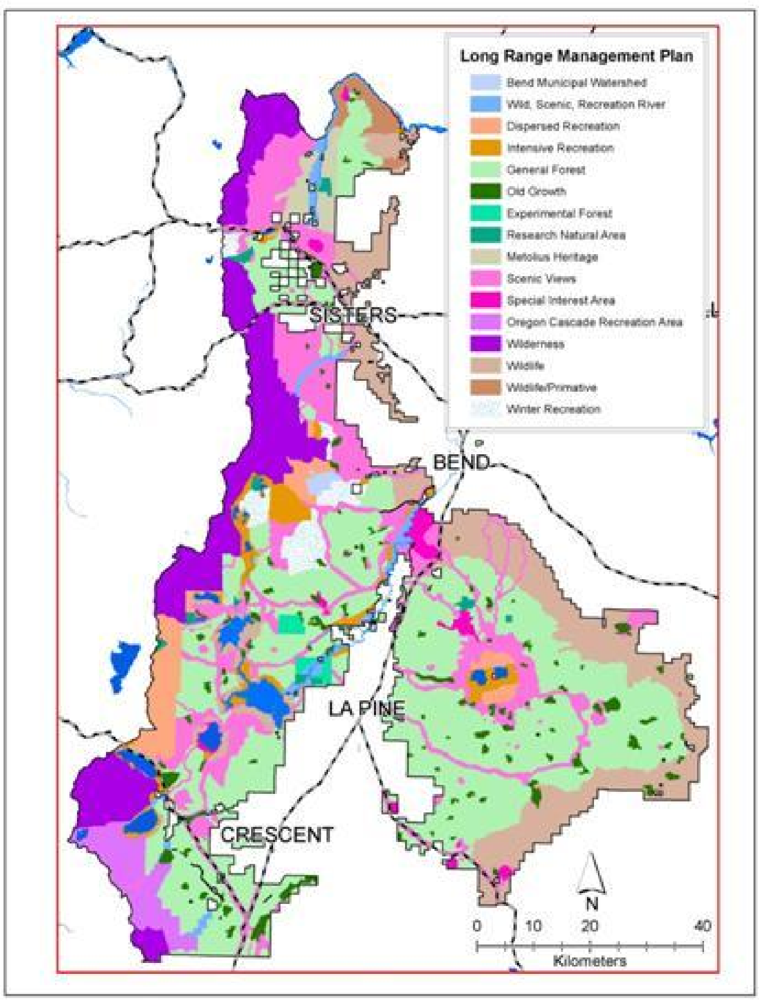
The real breakthrough in the application of risk analysis to wildfire came with Finney's development of the minimum travel time (MTT) fire spread algorithm. The MTT calculation represented an important simplification of the complexity of a fire that makes it feasible to simulate thousands of fires and generate burn probability maps over large areas (10,000–2,000,000 hectares). The new models create robust fire spread probabilities weeks out from a given ignition or fire location using weather data from RAWS stations and recent problem fires. Finney had the insight of modeling fires based on the big blow up events which account for almost all of fire growth.

"It is bloody practical," says Finney. "You can look at a fire as something very complex–winds blow and then stop, weather fronts move in, etc., but we have known for over a hundred years that most of the fire growth occurs on just a few days. So, MTT uses data from old fires in the areas to see which conditions really push it."

This is the basis of the new, more powerful, fire modeling systems such as FSPro, as well as decision support systems such as WFDSS. Dave Calkin says that these new tools allow the user to look at the likelihood that a cell will be impacted by a fire, and then assess what is in the cell of value and what the likely loss will be.

Fire and the Best Laid Plans

The northern spotted owls that inhabit the forests of the Pacific Northwest prefer dense, multi-storied, old-growth forests. Unfortunately for the owls, so does wildfire. Wildfire accounted for 75% of the loss of owl habitat between 1994 and 2003. Alan Ager has been interested in the question of whether active or passive management of owl habitat reserves (and other conservation habitat such as riparian conservation reserves for salmon) is most effective in mitigating fire risk while preserving remaining habitat. He has also been looking at forest restoration activities designed to resume natural fires and associated ecological processes affecting risk for conservation reserves in Oregon's fire prone forests. Ager says that long term sustainability of some habitat conditions may be difficult given competing demands for ecological services on national forests.



Forest plan management areas and conservation reserves for the southern portion of the Deschutes National Forest

Working with Finney, Ager has begun using burn probabilities to identify areas of the forest that are sources and sinks for fire. Every national forest is carved into different management areas with layers of varying forest and land management and conservation objectives. Threatened and endangered species habitat, research natural areas, recreation sites, and wilderness are just some of the land areas with specific conservation aims and related management restrictions. Unfortunately, wildfire doesn't recognize conservation or management area boundaries, and it can play havoc with policies such as the Northwest Forest Plan designed to create reserves and buffers around owl habitat.

Ager and Finney, working with land managers on the Deschutes National Forest, designed a relatively simple risk assessment process to examine wildfire risk among and within an array of conservation reserves and other land management designations on the forest. The process can be applied to any national forest and provides detailed risk profiles and rankings for resources of concern. In this study they were examining three questions: (1) What is the relative wildfire risk among the array of management designations and conservation reserves on the Forest? (2) Are specific conservation reserves contributing to wildfire risk and to the loss of other highly valued resources? (3) How do fuel treatments reduce wildfire risk when conservation reserves are excluded from treatment?

The researchers started by estimating burn probabilities through simulations of 50,000 wildfires on a 6 million acre area that encloses the forest. The burn conditions replicated recent severe wildfire events on the Forest. The burn probabilities represented the chance that a specific "pixel" on the forest (90 x 90 m) burns given a random ignition within the study area and a "problem fire" event. For each polygon within selected management designation and conservation reserves they calculated: (1) average burn probability, (2) expected flame length, and the (3) average size of fire generated by an ignition within the polygon.

In general, they found wide variation within and among conservation reserves and other land designations in burn probability and expected flame length.

Ager says that the concept of competing risks needs to be addressed in these highly fragmented conservation reserve networks. "If fuel treatments and restoration activities are prohibited in, for instance, owl habitat and riparian areas, we take on added risk of reserves burning each other."

He also says that the questions raise questions regarding future threatened and endangered species listings. "Before someone proposes another listing or new conservation reserve, we need to ask how this will increase fire risk to existing reserves. We may list something that contributes to the demise of existing habitat reserves."

"How do you determine the relative value of a pair of spotted owls versus a salmon? I don't know," adds Dave Calkin. "These are the type of trade-offs that we need to make explicit in these frameworks by developing loss functions. But computing those types of values is difficult."

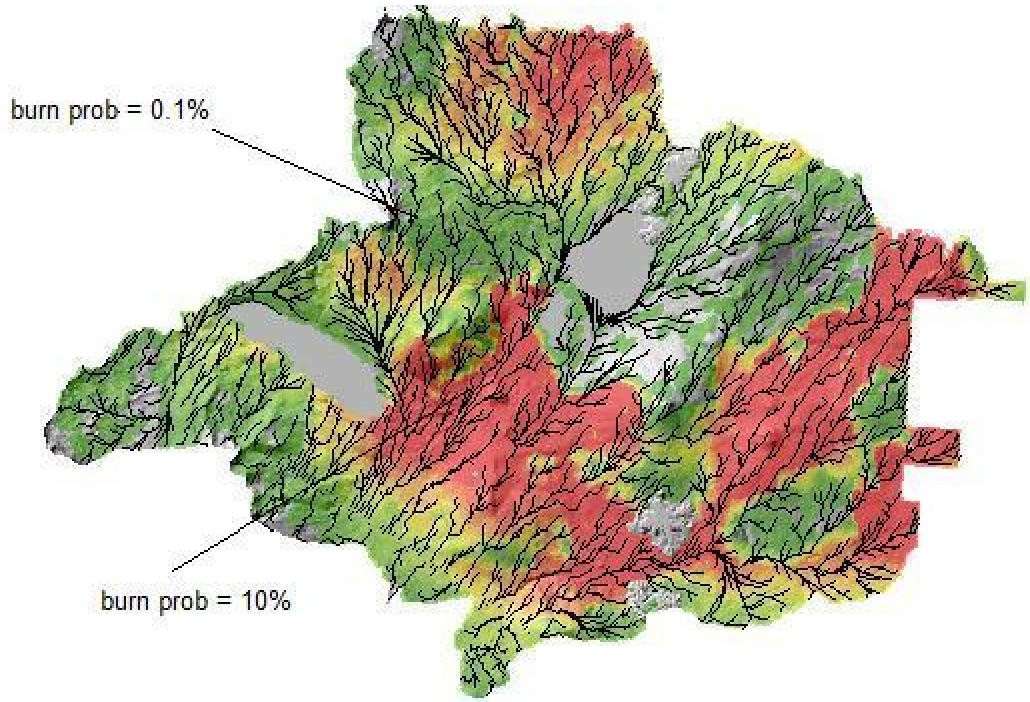
Despite the researchers' concerns, land and fire managers are starting to see the value in these analyses.

"Spatially, this is helping us a lot," says Dave Owens a fire planner with the Central Oregon Fire Management Service. "We want to lay out different land management objectives and look at the values in the area, and see where the real hazards are."

The ignition points from modeled wildfires (left image) are colored according to the size of the fire generated fire flow paths and burn probabilities (right image) determine risk to important values, and help planners design effective fuel treatment projects.

Going from Risk Assessment to Treatment

Most of the area burned each year is from a relatively few large fires, meaning that understanding large scale wildfire spread is the key to understanding risk and effective mitigation. "Fire is a landscape process, and it will take landscape change to alter spread patterns," says Ager. Effecting change on large landscapes, however, needs to be strategic.



The Five Buttes planning area, Deschutes National Forest.

Ager and Finney have examined the potential use of optimized fuel treatments to reduce fire risk in specific areas of the Deschutes National Forest. They simulated 2000 wildfires that included multiple configurations of fuel reduction treatments—all relegated to outside actual spotted owl habitat. By utilizing natural fire breaks, such as lakes and lava flows, and strategically locating fuel treatments to interrupt the flow of fire, they were able to significantly reduce wildfire risk to owl habitat without ever altering the habitat itself.

They found that fuel treatments on a relatively minor portion of the forested landscape (20%) resulted in a 44% decrease in the probability of spotted owl habitat loss averaged over all habitat stands.

“You can treat fewer acres if you can treat the right acres,” says Finney. “If a treatment changes the movement of fire, it changes burn probability and also changes its effects.”

The researchers feel that this work can help land managers explore different options for mitigating fire risk in the remaining late-successional reserves. Maps of burn probabilities, wildfire flow paths and optimized treatment locations (Finney, 2006) within and around late successional reserves can provide managers with the types of data and information they need to make decisions about treatment placement and size.

Tom Spies, a research ecologist with the Pacific Northwest Research Station and an expert on old-growth forest conservation, says that the application of fire behavior models to the problem of conserving owl habitat on a fire prone landscape is cutting edge.“Where is the best place to put treatments? How much of the landscape do you treat? This work is giving us the tools to answer those questions,” says Spies.

The Northwest Forest Plan is restrictive in what managers can do inside and outside of conservation reserves, but Spies says that these tools are starting to give some hints on how the landscape can be broken up to slow down the negative impacts of fire on the conservation areas that the NFP was designed to protect.

“We need to get to the point where we are not just blocking things into reserves, but are looking at landscape ecological goals,” says Spies.

Just as the new risk assessment tools are creating new ways of looking at old questions of fire spread, fuels management, and conservation, they are also being used to look at the big questions at the national level, addressing questions of risk in the interface, for example.

Scaling Up to the National level

"The real power of the new risk frameworks is the scalability. You can look at project level trade-offs but also apply the same analytical process to issues such as national budget prioritization," says Calkin.

A team of scientists from the Rocky Mountain Research Station and WWETAC are also trying to build a risk framework for national level analysis of effective strategies and investments that reduce fire risk. The group is working on the development of a nationwide wildfire risk map that links the probability of fire and fire intensity with specific resource benefit and loss functions and maps of highly valued resources. The National Wildfire Hazard and Risk Assessment is designed to be used by policy makers, planners and managers in prioritization of projects. The project develops, from a strategic view, a first approximation of how fire probabilities and fire intensities influence important values at the national scale.

So far, the group has developed a formal risk framework. This framework requires spatially defined estimates of the likelihood of fire entering an individual area, the expected intensity, and the effects on values (both losses and beneficial fire effects)—not necessarily an easy task at the national level.

National data sets on highly valued resource layers are being compiled from a number of sources for a range of values that include critical habitat, energy infrastructure, recreation, population density, and other. Benefit loss functions were developed by a science panel to quantify the effect of fire on each of the highly valued resources.

Tom Quigley, a science and policy analyst with the METI Corporation and an advisor to the federal land management agencies, says that this type of analysis would not have even been possible two to three years ago, but with the availability of consistent data sets across the US and the increase in modeling and computing capacity, we can begin to have meaningful discussions about prioritizing work to address risk across the entire country.

"This is the first approximation to using probability and values at risk at this scale. It isn't the final answer and as the data gets better the second approximation will be even better," says Quigley. "But, this will lead to changes in where and how the work gets done and it has the potential to make a big difference."

Challenges remain to fully incorporating wildfire risk assessment into land and fire management at all scales, but these tools are allowing us to at least look past some of the barriers that have impeded analysis and action in the past. The barriers are still formidable to implementing landscape level fuel treatments–budgeting, politics, and conflicting stakeholder and resource management goals, but these tools are showing a way forward. And, that is the first step.

Advances in Fire Practice is a sub-site of wildfirelessons.net and is focused on bringing efforts and ideas to the forefront that leaders in the fire management, practice, and research communities have identified as innovative and widely applicable. It provides access to critical and proven fire information and resources. Advances in Fire Practice section can be reached directly by going to http://www.wildfirelessons.net/AFP.aspx or through the main Wildland Fire Lessons Learned Center website at www.wildfirelessons.net.

The Wildland Fire Lessons Learned Center actively promotes a learning culture for the purpose of enhancing safe and effective work practices in the entire U.S. wildland Fire community. It is located at the National Advanced Fire & Resource Institute in Tucson, Arizona.

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