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## Economics of Wildland Fire Risk Management

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Increased wildland fire activity and associated suppression costs over the last decade have significantly challenged federal agencies' ability to manage the nation's lands and meet public expectations. Three common factors have typically been identified to explain this increasing cost trend: 1) increased development within the wildland urban interface increasing the complexity, and therefore the cost of suppression activities (WUI), 2) climatic factors-- both natural shifts and global climate change that increase wildland fire season length and intensity, and 3) increased fuels associated with successful fire suppression policies over the last 50 to 100 years increasing the likelihood of fire escape, more severe fire intensity, and larger fires. The recent Station Fire in Southern California provides a concrete example. Extensive development adjacent to wildland fuels, long term drought and heat, and the fact that the fire was burning in a very large area of continuous chaparral greater than 50 years old (likely, due at least in part to past successful fire suppression) created the conditions for an extremely challenging and expensive fire management environment.

Rising suppression costs cause substantial budgetary transfers from other programs to wildfire management in years where suppression costs exceed budgeted funds. This leads to disruption in other programs and challenges ongoing partnerships. These effects are particularly felt by the Forest Service (FS), which is responsible for approximately 70 percent of all federal wildland fire suppression expenditures. More pervasive than the disruption of a given year's budget, however, is the fact that the FS has historically budgeted fire suppression at a 10 year moving average. Over the last 10 years, the 10-year moving average has increased from around \$350 million to more than \$1 billion. This ongoing budget transfer has resulted in significant reductions to non-fire related programs and has challenged the Agency's ability to meet its stated mission "to sustain the health, diversity, and productivity of the Nation's forest and grasslands to meet the needs of present and future generations".

As the FLAME Act moves through Congress, there is increased optimism that the impact of fire expenditures on the annual FS budget may be reduced. The intent of the FLAME Act is to eliminate the threat of within-year transfers from other programs, with expenditures on "emergency" fire suppression (those fires over 300 acres) coming from the Flame Fund. Additionally, the FLAME Act, as currently written, would also reduce the amount of the money appropriated within the FS budget for fire suppression, potentially increasing the amount of money available for other agency programs. Instead of budgeting fire suppression at the 10-year average of the overall suppression program, the amount appropriated for suppression would be based upon a 10-year average of non-emergency fire expenditures (total fire expenditures minus expenditures on fires over 300 acres). However, to ensure that the funds in the FLAME Act are being used responsibly, it is likely that the agencies will be subject to increased requirements to demonstrate the effectiveness of FS fire management activities. Oversight reviews of federal wildfire suppression costs have proliferated in recent years, since 2003 the GAO alone has published 10 reports on federal wildland fire management. A common theme among many reviews is the inability of the agencies to demonstrate the value of suppression activities in terms of reduced loss to valued resources and developments.

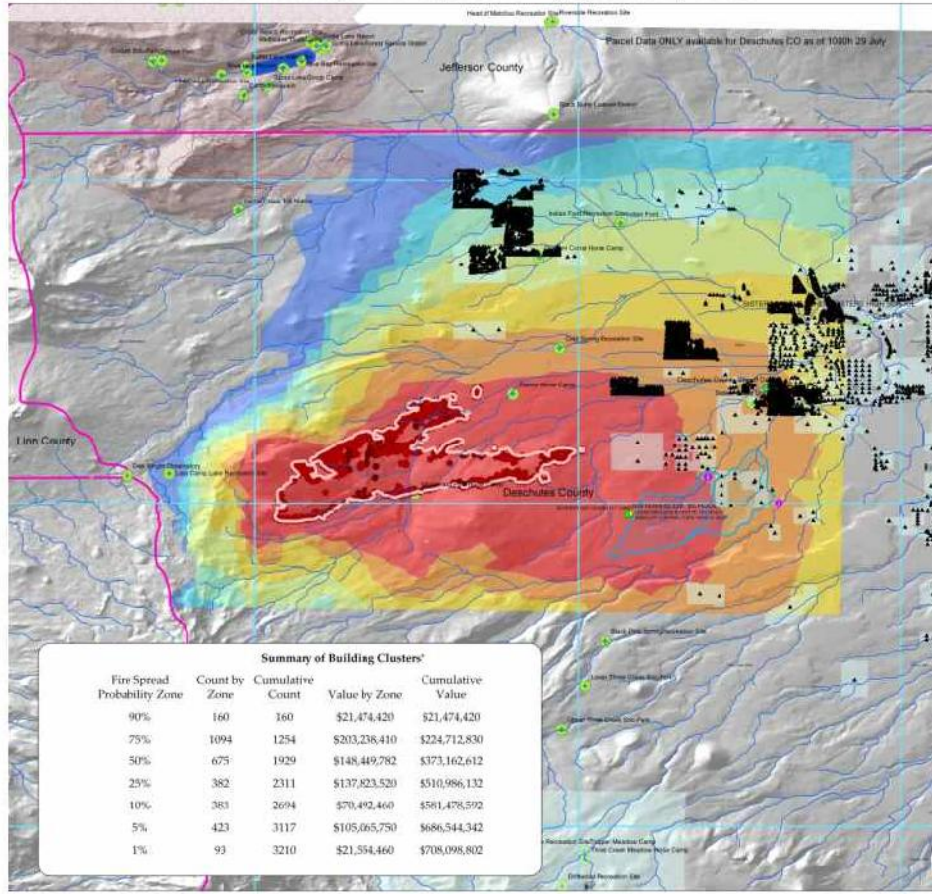
Recent fire management investments in programs such as the Wildland Fire Decision Support System (WFDSS), Fire Program Analysis project (FPA), and LANDFIRE, as well as recent interpretations of federal fire policy, have improved the ability of fire managers to apply a more risk-informed approach to fire management and increased our ability to address these criticisms. A recent review by GAO (2009) recognized that the agencies with wildland fire programs, “have taken important steps toward enhancing their ability to cost-effectively protect communities and resources. Despite the agencies’ efforts, much work remains.” Including the need to, “Develop a cohesive strategy laying out various potential approaches for addressing the growing wildland fire threat, including estimating costs associated with each approach and the trade-offs involved.”

RAVAR: Rapid Assessment of Values-at-Risk Black Crater Fire - Deschutes CO, OR - 29 July 2006 (A\_060729 kh) - DEMO

Analysis of Building Clusters at Risk in Deschutes CO, OR per FSPRO Fire Probability Spread Analysis; 7 days starting 28 July

**Legend**

- ◻ e\_060728\_2322\_perm
  - 060728\_0030\_BlackCrater\_HotSpots
  - 060728\_0022\_BlackCrater\_HotSpots
  - ▲ desco\_bldg\_clusters
- FSPRO Fire Spread Probability Zone**
- 90 %
  - 75 %
  - 50 %
  - 25 %
  - 10 %
  - 5 %
  - 1 %
  - < 1 %
- DesCO\_inpr\_Parcel
  - Waste Water Treatment Plant
  - HAZMAT: Mines
  - HAZMAT: Hazardous Waste Sites
  - Dams
  - Unhabited Landmarks
  - Critical Public Facilities
  - Roads\_2nd
  - Rivers\_2nd
  - County Lines
  - Previous 2003 Perimeters
  - Previous 2002 Perimeters
  - Water Bodies\_2nd
  - 24k\_idea
  - Water\_Supply\_Intakes 10x27
  - modis\_fire\_last7\_2006\_219
  - synthetic streams 1000 cells
  - Watershed Bound



Building Clusters are proxy for structure location. Data source: Deschutes County Parcel Layer. Building Clusters represent the center of parcels where county assessor records indicate taxable improvements are present. One or more structures and other improvements may exist proximate to these point locations.

NOTICE: FSPRO and RAVAR are experimental products of JSDA Forest Service, Rocky Mountain Research Station, Fire Sciences and Forestry Sciences Labs in Missoula, MT.

Fire spread probability contours and Values at Risk produced by a combined FSPRO and RAVAR model run for the Black Crater Fire.

**Risk Quantification**

A recent Advances in Fire Practice article argued for a more thorough accounting of losses associated with wildland fires (“U.S. Wildfire Cost-Plus-Loss Economics Project: The “One-Pager” Checklist”, Zybach et al). Although we agree that improved accounting of loss would be very beneficial to help understand appropriate risk-informed management, we recognize several limitations in the article:

1. Quantification of beneficial fire effects such as restoration of currently overstocked forest stands to a more historic condition and reduction of future fire intensity through reduced fuel loadings was not discussed.
2. The ability to quantify resource losses due to wildland fire for most resource values is quite limited. The authors suggest the use of a spreadsheet accounting tool by “local citizens, media, fire managers, and elected officials”. However a recent research article by Venn and Calkin (2009) identified significant scientific limitations in estimation of resource value change due to fire. The research community would be

challenged to fully account for resource value change due to wildland fire; estimation by recommended spreadsheet users would likely result in resource loss estimates that lack repeatability and credibility.

3. The authors argue that losses justify a more active fire management response. However, increasing investment in preventing wildland fire escapes beyond the current 98% success rate may be prohibitively expensive and perhaps impossible. Even with considerable increased investment in active fire suppression, it is uncertain if we have the ability to control the largest and most costly wildland fires that were primarily referenced in the study.
4. Certainly a contributing factor to the current level of wildland fire is due to successful fire suppression efforts over the last 50 to 100 years. Continued/ increased aggressive fire management response may transfer increased fire risk to the future, perpetuating the trend of increased intensity and severity (and associated losses) when escapes do occur.
- 5.

The above points of rebuttal highlight the need for a more comprehensive framework for wildland fire risk management than simply improved quantification of wildfire losses. Finney (2005) identified a framework that defined wildfire risk as the summation, over fire intensity and value type, of the probability of a burn of a given intensity multiplied by the associated change in value at that intensity. Implementation of this framework requires estimating the likelihood of a fire event, intensity, and change in value to resources impacted by the fire (including both losses and benefits to the resources). Several new tools and programs have adopted this framework including WFDS, FPA and the forthcoming National Wildland Fire Hazard and Risk Assessment. Expansion of this framework to estimate future risk reduction potential from fuel treatments, suppressed wildland fires, and wildland fires managed for beneficial fire effects could promote a more informed risk management paradigm that recognizes the ecological role of fire in the fire adapted ecosystems of the western US, and insures that investments in fire management are commensurate with the values at risk throughout the US.

Finney (2006) demonstrated, through simulation modeling, that a threshold exists below which fuel treatments are ineffective in modifying fire behavior outside of the directly treated area. A full understanding of these thresholds based on treatment type, geography, and vegetative recovery has yet to be fully demonstrated. However, given current fuel treatment funding and conflicting resource objectives that reduce the area appropriate for fuel reduction considerations, it is reasonable to believe that in many areas federal wildland fire management agencies are not approaching this threshold. In the absence of a dramatic increase in the area treated for fuel reduction, risk informed management of existing wildfires may have the highest chance of successfully reducing future risk due to wildland fire. That is, allowing some fires to burn under moderating fire conditions, in the absence of significant values at risk, could reduce fuel loading thus decreasing the intensity and size of future fires and increasing the efficacy of future fire management. This does not discount the importance of managing those fires that create conditions for significant losses to infrastructure, built structures, and natural resources; it emphasizes that these risks need to be carefully managed and not simply transferred to the future.

### **Towards a common wildland fire risk model**

Wildfire simulation models are being widely used by fire and fuels specialists in the U.S. to support tactical and strategic decisions related to mitigation of wildfire risk. Many applications have resulted from the development of a minimum travel time (MTT) fire spread algorithm (developed by Mark Finney) that makes it computationally feasible to simulate thousands of fires and generate burn probability and intensity maps over large areas (10,000 – 2,000,000 ha). The MTT algorithm is imbedded in a number of research and applied fire modeling applications including FlamMap, FSIM, Randig, and FSPRO. Extensive testing has shown that this algorithm can replicate large fire boundaries in the heterogeneous landscapes that typify much of the wildlands in the U.S.

Outputs from wildfire models are now being coupled with human and ecological values and loss-benefit functions to build risk-based decision support systems. The result has been a rapid advance in the application of risk analysis across the full range of wildfire management activities, from the individual fuel treatment project to national interagency budgeting. The development of a wide range of models to address the range of wildfire risk problems, however, has created considerable confusion among the management community.

Fortunately, it appears that a common unifying framework to wildfire risk quantification may be emerging. This common approach is based on the expected value change in wildfire risk definition identified in Finney (2005) and has three common elements: estimation of the probability of fire and intensity through landscape scale fire

simulation modeling; spatial identification of highly valued resources, and response functions that translate fire intensity to resource value change. Examples of this framework include ArcFuels for project level planning, Rapid Assessment of Values At Risk (RAVAR) for fire incident level planning, and the forthcoming National Wildfire Hazard and Risk Assessment.

### **Fire economics program of work within the NFDSC**

In May of 2009 the Chief of the FS established the National Fire Decision Support Center (NFDSC). The NFDSC is a collaborative effort between Fire and Aviation Management and Research and Development providing a key link between wildland fire science development and the appropriate application of that science. The NFDSC will deliver: (1) corporate decision support and monitoring; (2) improvement in supporting fire science so risk models can be enhanced; (3) development of fire economic models to inform agency administrator decisions; (4) “state of the art” risk management protocols; and (5) social science that helps inform decisions.

The fire economics team has been heavily engaged in the development of several spatial wildfire risk assessments including development of the RAVAR model of WFDSS and collaboration in the National Wildfire Hazard and Risk Assessment. Along with these projects the team has initiated several new studies to help inform agency decisions on large wildland fires. Statistical models and tools are being designed to provide information on the likely cost of emerging incidents. Currently, the Stratified Cost Index (Gebert et al. 2007) is used within the WFDSS system to estimate costs of an incident given its ignition characteristics and potential acreage. These cost estimates can also be combined with acreage estimates (either from FSPro or other estimates of potential fire acreage) to provide a graphical representation of potential fire costs for a range of fire sizes. These estimates can be used to help managers compare the current cost of a fire with historical costs and to see what trajectory costs are following. It is reasonable to expect that fires with few values at risk (tools such as WFDSS–RAVAR may be used to quantify certain values at risk) should fall into the lower percentiles of cost while fires with high values at risk may justify costs higher than the average. Steps are underway to improve the SCI models by using more spatially-explicit data related to the area within and adjacent to the fire perimeter.

Another project is developing models to inform managers, early in the life of an incident, whether the incident has a high potential to reach a final cost of more than \$5 million or \$10 million. This “warning” would allow closer monitoring and oversight of the fire early in the incident when decision space is greater. As part of the NFDSC, a group of wildland fire specialists has been hired to help monitor these types of emerging incidents and to provide decision support and information to managers and Incident Management Teams in charge of these potential high cost fires.

Always of paramount importance in any fire situation is firefighter safety. Performance measures are being developed to evaluate the exposure of firefighters and the effectiveness of suppression resources in bringing a wildfire to a conclusion. The “exposure index” compares the amount of resources being used on the fire to the amount of resources that it would take to build line around the entire perimeter of the fire (using standard resource production rates developed by the San Dimas Technology Development Center). An extremely high exposure could indicate unnecessary risk to firefighters. Additionally, by tracking the amount of line built on a fire and its relationship to the fire’s perimeter (both ongoing and final), the effectiveness of resources in building and holding line can be evaluated. This information could be useful in determining the mix of resources that may be most successful in building effective line as well as provide further information regarding firefighter safety and effectiveness.

Finally, the team has initiated a number of studies to explore the tradeoffs and priorities that the public and wildland fire managers have when determining preferred wildland fire management policies and strategies. By exploring both public and managerial preferences for alternative fire outcomes, the team hopes to identify areas where preferences diverge between the groups and explore the implications of these differences for wildland fire management. Additionally, these efforts will help inform models that provide decision support for wildland fire and fuels management.

## Conclusion

Recent advances in fire behavior modeling and the improved ability to spatially describe potential values at risk to wildland fire provide an exciting opportunity to develop a more comprehensive risk-based cohesive strategy for fire and fuel management. In fact, the version of the FLAME Act passed by the Senate calls for the agencies to submit a cohesive strategy within 1 year of the passage of the Act, including: (1) the identification of the most cost-effective means for allocating fire management budget resources; (2) the reinvestment in non-fire programs; and (3) employing the appropriate management response to wildfires. This strategy could include evaluation of alternative science-based scenarios for investments in different fire management programs and the impact to current and future wildland fire risk. These alternatives could then be used in dialog with key stakeholders to demonstrate and evaluate tradeoffs of pursuing alternative fire management strategies in order to promote a more sustainable future wildland fire management program and its appropriate role in public land management.

## Literature Cited

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