

BREAK-EVEN POINT

Suppression-cost analyses in Montana weigh resource values as determined by tax records and available GIS data.

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Over the past decade, an increase in larger wildland fires has converged with rapid growth in the wildland-urban interface. Suppression resources, including firefighters, equipment and money, are pressed to their limits. Attacking every fire with equal priority is not an option, as some play an essential role in keeping forests healthy.

The questions then: Which wildland fires do we attack first, and how hard do we hit them? Where can we employ wildland fire use? We currently have no methods to systematically and rapidly identify, quantify and compare resources we want to protect that are in areas of expected fire spread. Such a comparison needs to account for how many, how much and the location of resources relative to the advancing fireline.

Less-aggressive suppression efforts for selected fires will contain suppression costs and may be appropriate

where resource values are low and wildland fire use may provide ecological benefits. However, given the limited information available on the types and location of resources at risk, fire managers are likely to err on the side of caution. When in doubt, suppress.

UNDERSTANDING COSTS

Seeking solutions for cost containment and resource identification, researchers at the U.S. Forest Service Rocky Mountain Research Station located at the Forestry Sciences Lab in Missoula, Mont., have developed new procedures using Geographic Information Systems, commonly known as GIS, to rapidly assess resource values at risk from wildland fire.

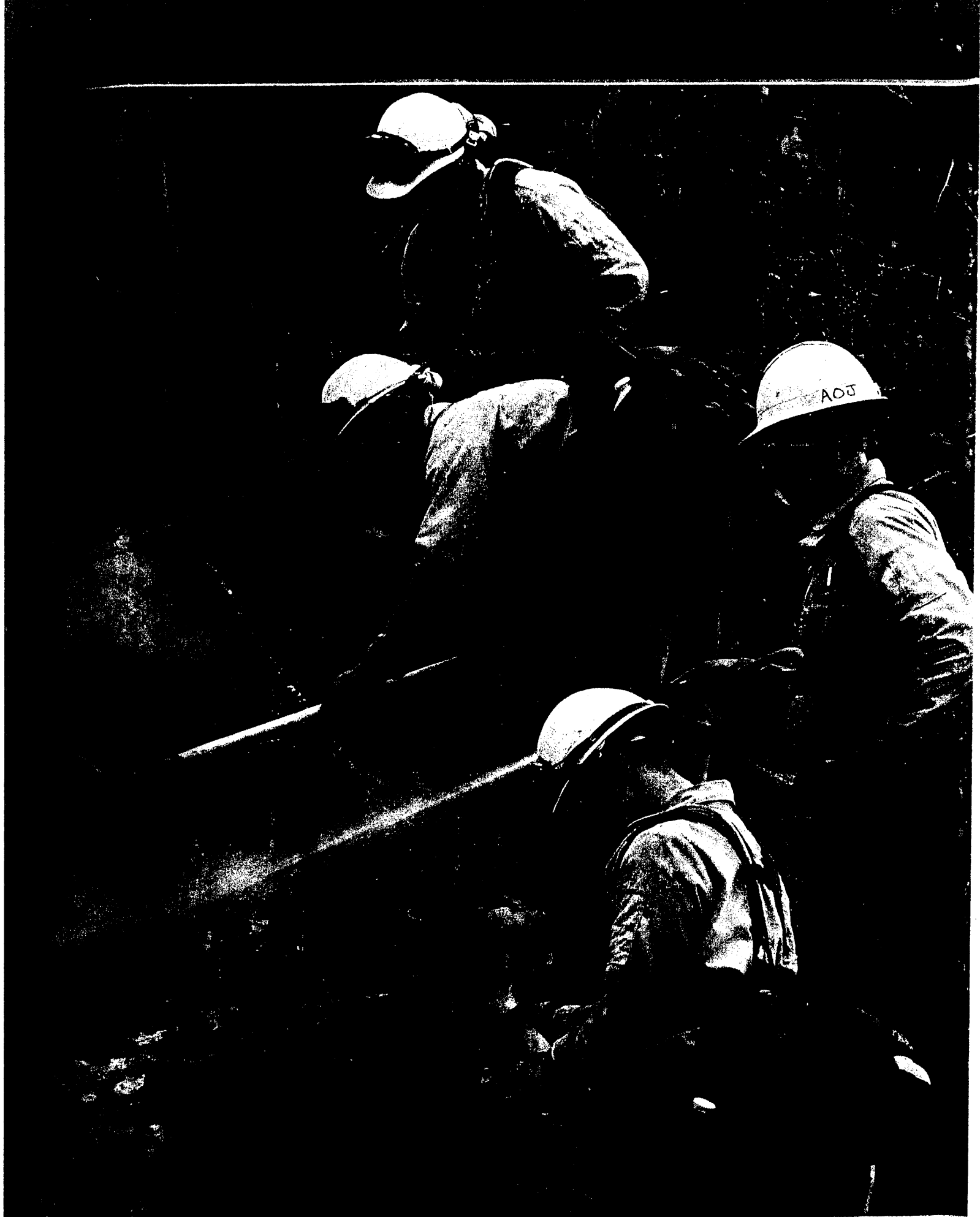
The idea is to improve strategic suppression planning by decreasing the time it takes to identify threatened resources. This information can streamline resource allocation and help determine just how aggressive suppression

should be and where techniques from wildland fire use may be appropriate.

The project began as a retrospective analysis of suppression costs, instigated by federal fire suppression expenditures exceeding \$1 billion during three of the last four years. Dave Cleaves, director of resource valuation and use research, asked researchers at the Forestry Sciences Lab for analytic procedures to evaluate how fire money has been spent relative to resources protected.

The approach chosen for the study was break-even analysis, or the point where project costs equal benefits. Working with wildfire costs, this translates to determining how big a fire would have had to grow before the value of resources protected equaled actual suppression costs.

Under this logic, if a fire likely would have grown beyond the break-even point without suppression, then suppression costs are considered economically justified. Note that even if such fire



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Safety Officer Tom Nash from Virginia lined up a freighter crew bus through an area where fires had burned in Grand Staircase-Escalante National Monument.

growth was unlikely, any unquantified non-market resource values at risk, such as critical habitat or cultural landmarks, may still justify an aggressive, high-cost suppression attack. However, if suppression costs substantially exceed the value of resources protected, it would indicate that a more critical examination of suppression expenses is merited.

RETROSPECTIVE CASE STUDY

The retrospective analysis began as a case study applying break-even analysis to the 2003 Black Mountain and Crazy Horse fires in western Montana.

The Black Mountain Fire in the Lolo National Forest burned 7,062 acres in August 2003. The Forest Service spent \$19.7 million on suppression, or \$2,788 per acre. The fire burned in the urban interface southwest of Missoula and threatened a number of densely populated neighborhoods. Three homes were burned. About 83% of the area within

the final burn perimeter was Forest Service non-wilderness, 16% was private non-industrial land and less than 1% was commercial timberland.

The Crazy Horse Fire on the Flathead National Forest, with a final burned area of 11,132 acres, occurred in a more rural setting. The fire began in a Forest Service wilderness area and burned into Forest Service non-wilderness and private timberland. No structures were burned. The fire put substantial acreage of industrial timberland at risk, and the Forest Service spent \$10 million on suppression.

To establish resource values, we dug into existing GIS libraries, mining databases representing both market and non-market resources. Using the comprehensive Montana Natural Resources Information System at <http://nris.state.mt.us/gis> and Forest Service holdings, we identified multiple resources inventories, including land parcels with tax-

able building and land values, utility infrastructure, water resources, vegetation data, and aquatic habitat.

CERTAINTY OF GIS AND TAXES

In a situation that's unique to Montana, the full property tax record is available online in GIS format. The parcel polygon layer is attributed taxable land and building values. Given that the values are derived as the tax base, they represent conservative assessments of the full market value. From this we created a proxy structures layer, a parcel-based point feature that defined locations of building clusters. Parcels with buildings were identified by selecting all polygons where the taxable building value was greater than zero. Then centroids were generated for the selected polygons. The result was a point layer interpreted as the approximate locations of building cluster throughout Montana. These point locations retain the associated taxable values.

Of course, caution is in order when using this data set. The building cluster points are approximate and should be used strategically, not tactically. If the exact location of a structure is needed, current air photos, the local authorities or an area recon is necessary. There also may be errors, omissions or new structures, so some parcels with structures will not be identified. With these caveats accepted, this derivative of the Montana cadastre provides managers with vital GIS-based structures information never previously available.

Given the significance of this cadastral data set, the pilot analysis focused first on building locations, counts and cumulative values. Structures, specifically homes at the wildland-urban interface, are among the most obvious values at risk from wildland fire. Threatened structures significantly influence suppression decisions. Also, structures are potentially the most difficult, dangerous

and expensive resources to protect.

Taxable land values also were available for private industrial timberlands. The timberland values are assumed to combine the land value with the marketable timber value. For the analysis, we assume the fire negatively affects the timber value and set that amount at 25% of the total assessed value. Summary of these values within threatened areas provides useful value comparisons between fires and within areas downwind of individual fires.

Given that public lands are tax-exempt, no taxable values were assigned to federal or state jurisdictions. However, Montana state lands are managed to support schools, so the acreage threatened by fire should be accounted for.

In addition to structures and land values, we evaluated dominant vegetation types, fire regime condition classes and bull trout habitat. Resource distribution was considered relative to dis-

tance from the fire perimeter and dominant land jurisdiction. Vegetation assessment allowed interpretation of fuel types and potential departure from historic fire regimes. Assessment of bull trout habitat provided opportunity to demonstrate the procedure applied to non-market resources.

Summary by dominant land jurisdiction was most relevant for the Crazy Horse Fire and served two purposes:

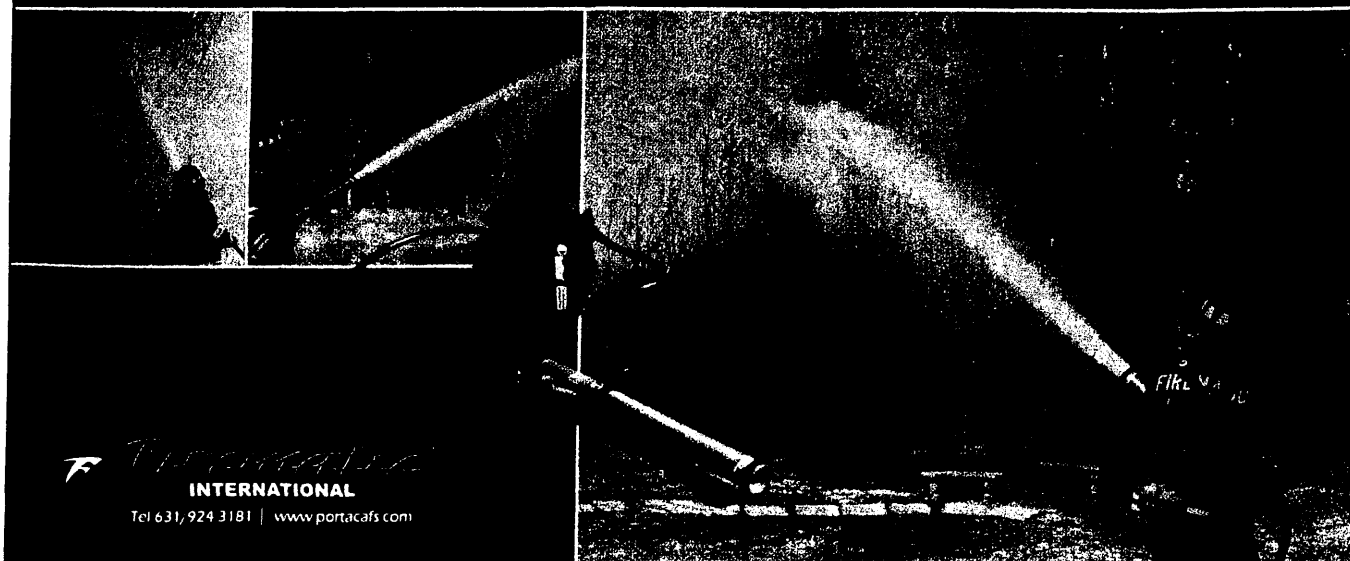
1) Threatened resources could be compared among stakeholders, information that may prove important as we sort through questions about the influence of jurisdictions on suppression costs.

2) The fire originated within a designated wilderness and spread downslope into section grid mosaic of managed federal, state, and private commercial jurisdictions. This information applies to the question of how to improve support for "let-burn" decisions with wilderness ignitions.



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REAL-TIME ASSESSMENT

While developing the GIS method for the retrospective analysis, we realized these techniques could be used proactively. Discussions with fire managers followed, and it became clear that this method could be adapted for real-time use during large fire events.

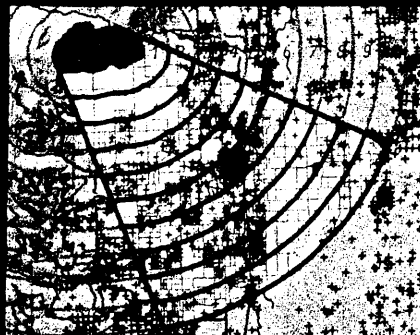
This fire incident application is called RAVAR, for Rapid Assessment of Values at Risk. Multiple benefits are expected from this approach. When faced with multiple large fires, RAVAR may provide valuable information to guide resource allocations. This information also may help managers identify areas where less-aggressive suppression techniques may be appropriate.

The value of this project goes beyond resource allocation and response strategies. Currently, there's no systematic approach to evaluate resource values at risk to wildfire. In fact, the use of GIS tech-

niques to improve strategic decision-making varies across agencies, regions and incident management teams. A new tool, the Fire Information Management Tool, developed by the USFS Rocky Mountain Region GIS shop as led by John Varner, was released for nationwide testing during the 2004 season.

Available at <http://gis.nwcg.gov>, FIMT functions within the ESRI Arc 8.x platform and provides a uniform framework and standardized tools with which to build, organize, annotate and display fire incident data. RAVAR may compliment the firt extension by providing standardized analytic procedures.

The RAVAR application also may contribute to development of the Wildland Fire Situation Analysis strategic planning documents. GIS outputs contribute to report detail, clarity and overall organization. The RAVAR approach may constructively influence the development of future



AOC analysis zones with intersected building clusters and land parcels.

officials appreciated the very specific inventory of structures threatened by wildfire. The map images sent to FEMA led to expedited

strategic decision support tools.

Finally, the RAVAR approach applied specifically with structure location and value databases may streamline requests by states for assistance from the Federal Emergency Management Administration. Montana state fire officials used the Montana parcel database in a manner similar to the RAVAR method during the state's very active 2003 fire season. John Pilsworth of the Montana Department of Natural Resources and Conservation reported that FEMA

approval and response.

Researchers with the Forest Service Rocky Mountain Research Station are working closely with Region 1 Fire and Aviation Management team and the interagency Northern Rockies Coordination Group to test the RAVAR procedures. Kevin Hyde and Dave Calkin of the RMRS in Missoula are coordinating with Deputy Director Greg Greenhoe, R1 F&AM, and Region 1 GIS specialists to provide real-time maps of values at risk during the 2004 fire season in Montana.

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PILOT STUDY RESULTS

With a base GIS built and resource layers in place, we began the analysis. The objective was to locate, identify and quantify the resources that were threatened by the two fires relative to the distance of the threatened resources from the final fire perimeter.

Again, we started with the taxable value of private residences within perimeters, expanding in a possible direction of fire spread. The area represented by probable fire spread was defined as the area of concern, or AOC. We also identified the area of an expanded fire perimeter where the market values of private property equaled the amount of money spent suppressing the fire — the break-even point.

Buffers and areas of concern. Buffers were generated around each fire perimeter at 0.5km increments out to 10 km. The AOC for both fires was defined due east from the northernmost to the southernmost perimeter limits. During

the Montana fire season, prevailing winds from the west create the highest fire risk. The Black Mountain AOC extended immediately across the Missoula Valley and into the city of Missoula. The Crazy Horse AOC extended downslope across the mixed-jurisdiction mosaic into private holdings along the valley floor.

Structures. The Black Mountain Fire literally burned to the edge of Missoula. Residential development extends to the base of the mountain, and a stream valley that drains the area is lined with homes right up to the National Forest boundary. Scores of structures in high-density developments were directly threatened by the fire. More than 117 structures with a taxable building value exceeding \$19 million lay inside the AOC, less than a kilometer from the final perimeter. Over 1,400 structures with a value exceeding \$197 million lay within 5km.

In contrast, housing density within the Crazy Horse AOC was very low. Building clusters were generally isolated, with a few cluster clumps within the AOC. Four building clusters valued at more than \$320,000 were within a kilometer from the final fire perimeter. Within the 5km AOC zone, there were 80 clusters valued at over \$7.7 million.

Timber values. There was one 40-acre parcel of private industrial timberland located within the final Black Mountain Fire perimeter. It had an estimated timber value of \$3,500. There were no state forests associated with the Black Mountain Fire.

However, private industrial timberland, valued at \$450,000, accounted for nearly a quarter of the acreage of the Crazy Horse burn. There were 1,740 acres of commercial timberland within a kilometer of the Crazy Horse perimeter valued at \$325,000. Within 5km, the amount exceeded 4,300 acres and \$627,000. Nom-



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inal acreage of state lands fell within the Crazy Horse Fire perimeter; 264 acres were within 1km and a total of 920 acres were within 5km.

Vegetation. The vegetation within the Black Mountain burned area was mixed-mesic forest dominated by western larch and Douglas fir. It rapidly transitions to open grasslands and urban areas. Half the burned area was classed Fire Regime Condition Class 1, low departure from historic fire regime; 14% was classed at FRCC 2, moderate departure; with high departure, FRCC 3, assigned to 17% of the area with the residual area non-forested.

Mixed-subalpine fir forests with large acreages of lodgepole pine dominated the burned area of the Crazy Horse Fire. Moving downslope to the east, lodgepole dominance increases before the vegetation transitions through Douglas fir dominance into mixed-mesic forests. The FRCC classifications within the

burned areas and the AOC were well within the conditions expected for these vegetation types. FRCC 1 classification was assigned to over two-thirds of all zones.

Bull trout habitat. Sensitive trout habitat existed only within the areas affected by the Crazy Horse Fire. The majority of the burned area contained strong populations and was identified as important spawning and rearing habitat. Much of the AOC was identified as important migratory corridors with small but stable populations.

INTERPRETATION OF RESULTS

Considering the value of structures alone, this analysis shows that suppression expenditures on the Black Mountain Fire were economically justified if these efforts reduced the potential fire perimeter a modest amount. Even modest growth of the fire threatened significantly more structures. Recall the Black

Mountain suppression costs, \$19.7 million. The fire would have had to grow less than 6,100 acres, a 55% increase of final fire size, before the value of threatened structures exceeded suppression costs. Fire growth somewhat less than 87% represents the break-even point of the Black Mountain Fire.

However, again considering only the threatened structures, the Crazy Horse Fire would have had to grow considerably larger to economically justify the suppression costs. A more than 200% increase in fire size, representing about 24,000 acres, would have had to occur before structure values exceeded the \$10 million suppression costs. If estimated timber values are included, the burn would have had to expand 180%, over 20,000 acres, before costs equaled the measured values protected. Again, these value estimates are conservative; the actual break-even protection area is probably somewhat smaller.

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The most direct lessons regarding vegetation and FRCC rating come from the Crazy Horse Fire and the proximity to designated wilderness area. If structures were not at risk, then the vegetation types and condition classes suggest that this area was a candidate for wildland fire use or at least less-aggressive suppression. The majority of the area had minimal departure from historic fire regimes. However, the intermix of private and state timberlands adjacent to federal lands may have triggered an aggressive suppression response.

WHAT'S NEXT

The successful pilot study led to an expanded retrospective analysis. Montana's major fires during 2000, 2001 and 2003 were mapped relative to multiple resource inventories, starting with structure locations and taxable values. The analysis is in progress.

Focusing on market-value assess-

ment of structures for the pilot study provided robust and clear demonstration of the values-at-risk analysis but underemphasized many other very important resource values, such as timber values. The challenge will be to assemble spatially continuous timber value databases with which to conduct the at-risk analysis. Also, methods to account for changes to timber values if burned must account for salvage harvest recovery and how fire interrupts optimal yield cycles.

Refining approaches to analysis of non-market values poses greater challenges. The questions of just how to value non-market resources are neither new nor trivial. We hope that efforts to incorporate analysis of these resources in at-risk assessments will constructively contribute to sustainable ecosystem management and protection.

Similarly, the relationship between wildfires and bull trout habitats isn't clear.

The effects of wildfire on trout habitat are poorly understood and depend on many factors such as burn severity, pre-fire population size, and stability in burned areas and nearby unburned habitats, as well as the timing and intensity of rainfall following the fires.

Which effects are potentially detrimental: the risk of catastrophic post-fire erosion and short-term loss of stream-side canopy? Which might be beneficial: woody debris recruitment leading to increased habitat complexity? These and other important ecological questions about non-market resources remain to be determined. **W**

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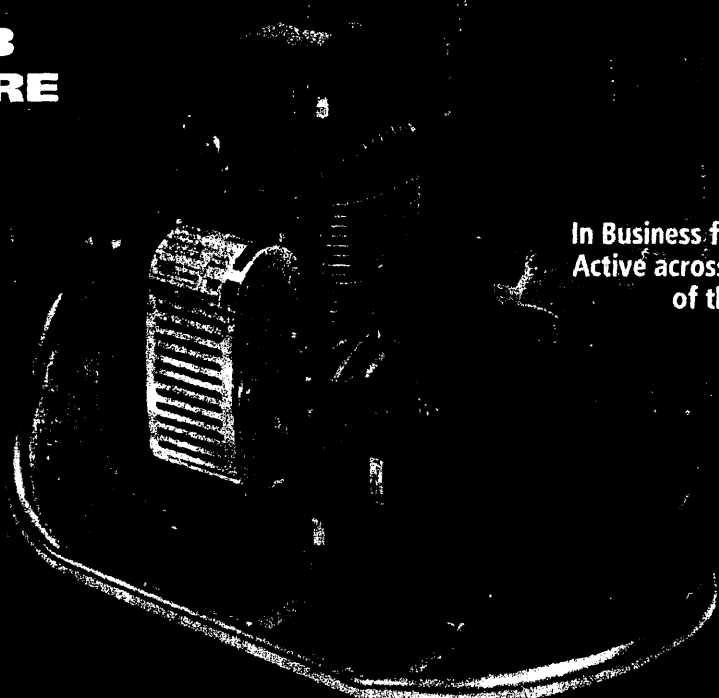
Kevin Hyde is landscape modeling hydrologist employed by METI Inc. of El Paso, Texas, and currently is under contract with the Rocky Mountain Research Station in Missoula, Mont.

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