Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

The consequences of a major wildfire can be far reaching. This photo shows a culvert near Big Sur, California, which could be blocked by a landslide or debris flow, closing a major highway for several days.

New Tool Helps with the Tough Post-fire Decisions

Summary

After a wildfire is extinguished, the work is not done. In the U.S., many public natural resource agencies immediately begin considering appropriate post-fire steps. The most widely used system is the Burned Area Emergency Response (BAER) process. The purpose of BAER is to assess the effects of the fire and to make recommendations for appropriate next steps to protect health and safety, to prevent further loss of property or habitat, and to stabilize the fire area to allow revegetation and appropriate future use.

Advanced mapping and measurement tools are available and widely used to define and describe affected areas. Another important step is to assess what values are at risk and to what extent finite resources should be used to protect them. Recent work done under a grant from the Joint Fire Science Program studied practices by the Forest Service and the Department of the Interior (DOI). This work developed tools to assist with the values-at-risk (VAR) evaluation. This report explains this challenge and describes the specialized VAR assessment tool that was developed.

Key Findings

- Refinements are needed in the Burned Area Emergency Response (BAER) process to more systematically measure values-at-risk (VAR) and more accurately assess potential risks to both market and non-market resources.
- Risks to life and safety cannot be monetized, but should be included in the BAER process and subsequent actions.
- A variety of possible methods have been suggested for evaluating non-market VAR. The most generally useful tool appears to be the *Break Even Analysis or Implied Minimum Value (IMV) Method*. It is suggested for adoption in the BAER process.
- The Erosion Risk Management Tool (ERMiT) for calculation of potential erosion risk and soil loss is a valuable adjunct to other tools for VAR calculation.
- Although the Forest Service and Department of Interior (DOI) have somewhat different standards for performing BAER calculations, both will benefit from more systematic VAR procedures.
- The VAR calculation tool that came out of this research has potential to improve the VAR portion of the BAER process

Risks after the fire

Burned area emergency response (BAER) is an emergency risk management reaction to post-wildfire conditions that present risks to human life, property and the environment, or which could further destabilize or degrade burned lands. Potential risks include flooding, erosion, mud and debris flows, and related loss of man-made improvements and non-market recreational, cultural and ecological resources. These jeopardize people and properties within and downstream of burned areas as well as presenting risks to desirable watershed values.

The BAER process typically begins shortly after fire containment. A key initial step is assessment of risks resulting from the fire. Investigators evaluate effects of the wildfire against values needing protection. A team of specialists is recruited to perform the evaluation. Composition of the team varies, depending on the characteristics of the region. Specialists often include soil scientists, engineers, botanists, foresters, range managers, hydrologists and experts on cultural resources.

BAER teams, such as this one evaluating the Station Fire in 2009, use a variety of tools to evaluate fire areas and to make recommendations for investments to minimize risks to values-at-risk.

Identifying values a key step

Procedures followed by both the Forest Service and DOI agencies call for the team to submit reports and funding requests that establish justification for treatments. DOI approach is essentially a qualitative "cost-risk analysis," whereas the Forest Service requires a quantitative analysis that assigns dollar values to all resources, market and non-market alike. BAER teams use a "cost-risk analysis worksheet" which requires four basic inputs: (1) probability of the threat occuring, (2) cost of mitigation treatments, (3) probability that treatments will be successful, and (4) VAR in dollar values.

Recent Joint Fire Science Program (JFSP)-funded work has resulted in the development of the Erosion Risk Management Tool (ERMiT) which can predict many aspects of inputs 1 and 3. Costs of many common post-fire treatments for input 2 are available in the instruction guide for the worksheet. However there have been no tools to guide calculation of monetary values for the VAR as identifed by the BAER team.

A JFSP-funded project was undertaken in 2004 by a U.S. Forest Service team, with principal investigators Dr. David Calkin, Dr. J. Greg Jones, and Dr. Peter Robichaud. This project focused on accurately calculating VAR in ways that can contribute to an efficient BAER process. The team developed a calculation tool to standardize and simplify this task.

According to Calkin, part of the reason that the VAR portion of the process has lagged the other elements is because of the lack of tools for evaluating non-market resources. Calkin says, "Understanding the value of protecting, for example, a stream reach with a sensitive wildlife species and comparing it with the cost of treatment is challenging since the value of maintaining the stream reach is rarely identified in monetary terms."

This project examined current practices for post-fire assessment of VAR and looked for information and practices to simplify this task faced by every BAER team. Data was acquired by a survey of BAER personnel, direct observation of BAER operations, and review of resource valuation literature. The goal of the project was: To review current BAER resource valuation procedures and develop pilot precedures and a decision support tool to guide calculation of values-at-risk downstream of burned areas.

Evaluating current procedures

In 2005, two BAER teams in post-fire situations were observed to review the current BAER work environment and to document current VAR assessment procedures.

Observations were recorded and questions were asked of team leaders to clarify procedural logic, especially where it related to VAR assessment and valuation. A third BAER observation was performed in 2006 and was used primarily to test ideas on how procedures might be improved.

The first BAER observation was done following the Mason Gulch Fire in July 2005. This site is about 35 miles west of Pueblo, Colorado and encompassed a fire of over 11,000 acres, most of which was within the Pike-San Isabel National Forest. The second BAER observation was in August 2005, following the School Fire which burned 53,000 acres in southern Washington involving private, state and federal jurisdictions, including portions of the Umatilla National Forest. Following are the insights developed from these two observations:

- Benefit/cost (B/C) analysis would be improved if the focus of the analysis is shifted from threat analysis to risk-based analysis.
- Preparation of data and some pre-processing, especially of maps, would launch the analysis more rapidly.
- Preliminary VAR should be identified at the first BAER meeting.
- A method is needed to determine values for benefit-cost analysis that is faster, more systematic, and consistent.
- Suggestions are needed to improve the BAER report process to better justify proposed costs and provide a basis for monitoring.

Ideas from the 2005 observations were tested during the third and final field study of the BAER assessment of the Gash Creek Fire during September of 2006. This 8,200 acre fire burned almost entirely within the jurisdiction of the Bitterroot National Forest in western Montana. With the benefit of the previous year's assessments, the assessment group offered the following additional recommendations:

- Consistent and effective procedures to assess threats are being used, but there is little consistency and much uncertainty in the establishment of VAR.
- Use of maps to establish VAR, and to connect threats to VAR is inconsistent.
- Preparation of BAER assessments was inconsistent and did not take full advantage of geographic information systems (GIS) tools.
- Teams struggled with non-market valuations and in determining probability of event occurrence and treatment success.

Surveying BAER personnel

Following the three field observations, researchers developed a survey to collect the experiences of BAER personnel. Survey responses came from 214 BAER team participants, including those from the Forest Service, the Bureau of Land Management, the Bureau of Indian Affairs, the National Park Service, the Fish and Wildlife Service, and others. The survey results strongly suggested that BAER teams find it difficult to apply direct dollar values to non-market resources. Although the current DOI process does not require the cost-risk analysis required by the Forest Service, there was general agreement on the need for process improvements.

This view of a burned area perched above Goleta, California shows potential risks to a recently restored slough project, the University of California Santa Barbara, Santa Barbara Airport, and a Pacific marine habitat in the distance. BAER teams seek to minimize risks to all of these resources.

Studying the literature

Researchers reviewed literature for information on VAR assessment practices, especially for resources that are not easily monetized. They concluded that values at risk should be separated into market values for those things that are typically bought and sold (examples might be grazing allotments, timber, roads, buildings and developed recreation facilities) and non-market values (non-developed recreation opportunities, wildlife habitat, native vegetation and watershed health).

Literature reviews identified research on non-market values typically encountered by BAER teams. Researchers felt that although life-and-safety are often identified as values-at-risk, monetization is problematic and not appropriate for BAER assessments. Regarding life-and-safety values, Calkin notes, "Although the average value of a human life has been estimated within the literature and is applied in some policy settings, we recommend these issues be considered outside the VAR tool." He adds, "I believe it is particularly important to make BAER practitioners think about the likelihood of a life-and-safety issue with and without treatment. In many cases, treatments cannot reduce safety concerns to a manageable level without requiring additional investment in appropriate warning systems or administrative closures."

Valuation techniques

Literature review indicated that various valuation systems have been used for non-commodity resources. These include:

- Contingent valuation (CV)—Based on consumer willingness to pay for or receive compensation for change in resource condition.
- Travel cost (TCM)—Based on travel cost and time as the value of accessing a non-market resource.
- Hedonic pricing (HPM)—Valuation based on a comparison of property market values of properties having different degrees of a non-market attribute

and extracting the implicit value of the attribute from the variation in property values.

- Ecosystem services (ES)—Valuation based on assigning an economic value to natural systems required to support human welfare.
- Production possibility analysis (PPA)—Valuation based on the potential for the land to produced a desired resource output under various management scenarios.
- Benefit transfer (BT)—Valuation based on adaptation of economic information from a specific site to another site with similar resources and conditions.
- Break Even Analysis—Valuation based on identifying the minimum benefits required from an activity such that the activity is economically justified (benefits = costs). This can also be referred to as implied minimum value (IMV).

Researchers felt that of the valuation options, the Break Even Analysis (IMV) method to be generally the most useful for BAER assessments. Using this method, if managers determine that a treatment is justified to protect a non-market resource, then the implication has been made that the minimum value of the potential resource value change to society exceeds the cost of treatment divided by the reduced likelihood of experiencing the negative outcome.

This view is of the Chappie-Shasta area near Redding, California, which saw a wildfire and subsequent BAER assessment in 2008. A popular off-highway vehicle trail system and staging area, the Redding water supply, and vulnerable aquatic species were all at risk from post-fire erosion on steep burned slopes.

As an example, if the team recommends $10,000 to reduce the likelihood from 50 percent to 40 percent of one mile of bull trout stream spawning habitat being severely degraded for three years, they have implied a minimum value of the change. The value is not $10,000 but $100,000 because the likelihood was reduced only 10 percent. This solution supports local decision-making by providing a sound economic basis for the decision.

Developing the VAR calculation tool

A proposed assessment framework and a spreadsheet tool were developed to create a VAR valuation process that reflects observations and results developed from the survey and its analysis. The proposed framework integrates the qualitative assessments currently used by DOI with many of the quantitative procedures required by the Forest Service.

The first step in using the tool is to focus field assessments on VAR. Next, the team does a formal resource valuation. Direct market values of VAR are acquired as needed for benefit-cost ratio analysis. Monetary values for life-and-safety are not evaluated using benefit-cost analysis. Non-market values are handled separately and later.

Subsequent steps are followed to perform estimates of probabilities that identified threats will cause damage to identified VAR and to estimate the probable success of mitigation treatments. Treatment costs are calculated. The final step is to calculate the benefit-cost ratio and IMV for all non-life-and-safety VAR. These values are used to justify BAER funding requests.

Commonly encountered VAR

Some 394 BAER reports from the past 25 years were examined to determine the VAR listed, and the justification for the requested treatment projects. One of the realizations from this effort was that VAR and threats were frequently confused. For example soil erosion is not a VAR, it is a threat to the current soil condition and the values that the soil provides. Following are risks reported in the 394 reports:

Resource Value at Risk	Observations
Soil Erosion (landslides)	70
Watershed damage	55
Property and Improvements	47
Engineered (roads, fences, utilities, signs, etc.)	46
Ecology (site productivity and soil)	46
Fisheries	43
Human life	23
Endangered species and habitat	16
Wildlife range	15
Recreation (campgrounds, lakes, etc.)	9
Cultural	5
Range	4
Invasives	4
Wilderness	2

Taking advantage of ERMiT

Increases in post-wildfire runoff and erosion are the most frequently encountered threats that must be evaluated by BAER teams. Recent JFSP-funded work (JFSP #98-1-4-12 and #01-3-02-08) has resulted in the development of the ERMiT. This tool provides probabilistic estimates of single-storm post-fire hillslope erosion. This tool is a useful adjunct to the VAR calculation tool by providing realistic estimates of erosion risk.

Teams using the VAR tool

Since its development, the VAR calculation tool has been used by several of the larger Forest Service BAER teams. Dr. Keith Stockmann, Acting Regional Economist, Northern Region, from the Forest Service has supported these uses, and several Forest Service teams have also used the tool separately. Stockmann has provided training on the VAR tool each spring, and has joined BAER teams for full assessments on four large wildfires.

Stockmann says, "The tool has been welcomed by all the teams with which I have been involved. The elegance of the simple calculations leading to the ability to confidently investing or not investing seems to resonate with many of the team members and team leaders." Stockmann indicates that the use made of the tool does vary as there are many factors used in each decision, where economics is only part of the larger picture. He points out, "Some team leaders rely on the tool to help provide structure to the assessment and presentation of recommended treatments. Others test proposed treatments to ensure they appear to be wise investments." He adds, "If you consider the role of the tool to scrutinize potential BAER investments to ensure that spending is economically rational, we have been successful in using the tool in every assessment where it has been attempted."

Stockmann points out, "When an economist or another specialist is involved, the tool certainly provides great input. However the use of the tool requires some additional work. The more complicated the post-fire environment, the more work is required to track all potential values at risk and to draw a useful economic analysis for proposed treatments. It works particularly well for situations where there is a comparison of treatments to mitigate a single threat to a small list of values at risk."

He explains that more complicated assessments have required creative application of the simple tool. "Although this presents a challenge, when treatments have the capability to mitigate multiple threats to multiple values at risk, the tool needs to reflect this to produce a useful analysis."

Measuring success

Calkin explains why it is often difficult to evaluate the success of a BAER project. "Treatments are successful if they stop or reduce the negative consequence that they were designed to mitigate and if the negative consequence would have occurred in the absence of treatment. Therefore, it cannot be known with certainty whether a treatment was successful or not since we only experience one realization of the event.

Following this logic, Calkin notes that an economically justified treatment may in fact fail; similarly an economically unjustified treatment may be successful. "If a treatment is implemented and no negative ecological consequence occurs it could simply be that no consequence would have occurred even if the treatment was not conducted."

Calkin points out that in those cases where market values are the major justification for treatment, benefit-cost ratios can be estimated. However, he explains that since consistent appropriate dollar values are rarely available for non-market values, benefit-cost ratio is not easily measured. He says, "In fact, in any situation where non-market values provide the justification for a treatment, the benefit-cost ratio using this approach is 1.0. If a treatment is implemented we simply know that the resource is worth enough to make the benefit-cost ratio equal 1."

Management Implications

- In initiating a BAER process, it is important to use local information and values in establishing VAR.
- Life-and-safety concerns cannot be monetized for a VAR evaluation, but must be included in budgeting decisions. The best way is estimate the likely effectiveness of mitigation measures and warning systems, and budget for the costs of these programs.
- The IMV method is generally the most effective tool for determining non-market resource values for BAER assessments.
- The recently developed ERMiT soil erosion modeling tool is an effective adjunct to the BAER VAR estimation process.

Where BAER is headed

Calkin feels progress is being made in sharpening the BAER process. "Given the growing importance and stressors on western watersheds, the importance of managing post-fire response can only increase. Risk assessment tools are emerging that can estimate fire effects (including post-fire response) from probabilistic fire behavior." He feels that one of the primary challenges facing the BAER community is to develop tools so that the potential for severe post-fire consequences are incorporated throughout the fire management process, including pre-season fire planning, fuel treatments, and ongoing fire management. He stresses, "If the consequences of post-fire response can be better incorporated throughout the range of wildfire risk assessments, post-fire losses can be reduced. If this is accomplished the BAER process will improve since the values at risk data and potential responses in the post-fire environment will have been developed prior to the formation of the BAER team."

Give it a try!

The BAER VAR Calculation Tool is now available for your projects. We recommend trying it, along with the ERMiT Tool, for your post-fire BAER activities. The tools are both available online:

BAER VAR Calculation Tool Access:
http://forest.moscowfsl.wsu.edu/fswepp.

ERMiT Tool Access:
http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl.

Further Information: Publications and Web Resources

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Scientist Profile

Dr. David Calkin is a Research Forester with the Forest Service, Rocky Mountain Research Station in Missoula, MT. He is the Economics Team Lead for the National Fire Decision Support Center. His research focuses on the development of economic models and risk assessment tools for wildland fire management.

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