
Supporting the Burned Area Emergency Response (BAER) Program with Remotely Sensed Imagery

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Introduction

In the immediate aftermath of a wildfire, a Forest Service Burned Area Emergency Response (BAER) team is dispatched to the site to do an initial assessment of burn severity and to estimate the likely future downstream impacts due to flooding, landslides, and soil erosion. One of the first tasks for this team is the creation of a burn severity map that highlights the areas of high, moderate, and low burn severity. This map then serves as a key component in the subsequent flood modeling and Geographic Information System (GIS) analysis.

Traditionally, the BAER burn severity map was created by sketch mapping on a topographic map—or even a forest visitor map—from a helicopter or road-accessible overlook. With this method, location accuracy and wall-to-wall coverage were often difficult to come by. As a result, BAER burn severity mappers began researching ways to obtain a single image of the burned area at or near the time of the fire’s containment.

In 1996, the Remote Sensing Applications Center (RSAC), in conjunction with several experienced Forest Service hydrologists and soil scientists, tested an airborne color infrared digital camera for its ability to quickly record postfire condition (Lachowski et al 1996). The resulting image mosaic proved useful and led to further refinement of the technique—eventually culminating in the commercialization of the product. Today, BAER team leaders can hire approved contractors to quickly fly and build a digital image of a burned area.

However, inherent limitations to these airborne digital image mosaics caused BAER mappers to seek further improvements. In 2001, RSAC agreed to evaluate a variety of other platforms and sensors for use in BAER burn severity mapping. The project team collected data from moderate- and high-resolution satellites, as well as from fixed-wing hyperspectral and multispectral sensors. Eventually, the difficulties with scheduling rapid acquisition and delivery of fixed-wing data prompted further research into the capabilities of satellite data as a more likely alternative.

Discussions began on the possibility of rapid acquisition and delivery of satellite data with various vendors and satellite operators. (Prior to the start of this project, data delivery times varied from 2 weeks to 2 months.) After explaining the limitations of airborne digital image mosaics to the data

providers, we discovered that same-day or next-day delivery of satellite data was possible. We tested that possibility over the course of the 2001 fire season by ordering rapid acquisition and delivery of satellite images for about 15 National Forest burned areas. We obtained imagery from six different moderate- to high-resolution sensors during that fire season including Landsat 7, Landsat 5, SPOT 1, SPOT 2, SPOT 4, and IKONOS.

While the results were mixed and delivery was not always as smooth as planned, we succeeded in providing very timely and useful data to a number of BAER teams during 2001. As a result, we received funding from the National Fire Plan to reprise our service for the 2002 fire season. That funding allowed us to upgrade our hardware and software capabilities to better meet the demand for operational support. For 2002 we provided daily satellite tracking, ordering, and processing services to dozens of Forest Service BAER teams as well as onsite support in a number of cases. The almost universally positive response from the field has encouraged us to continue to offer these services during 2003 and beyond.

What We Provide

Despite the frequent media portrayals of complete devastation, the typical wildland fire burns at varying levels of intensity depending on weather and fuel conditions. As a result, the postfire burned area will be a mosaic of unburned islands, light understory burns, and high- and moderate- severity patches. It is the job of the BAER burn severity mapping team to locate these areas and produce a full coverage four-class burn severity map. The classes are high severity, moderate severity, low severity, and unburned. RSAC assists in this process by delivering a number of satellite-derived products to BAER teams in the field.

Preliminary Burn Severity

Our preliminary burn-severity product is developed using any of a number of band ratios depending on the type of imagery we've acquired for a particular fire. The most common and well known of these are the NDVI and the NDBR. These ratios have been proven effective for highlighting burned area conditions. We classify the resulting ratios using an ISODATA clustering routine and visual interpretation. The final product is a georeferenced four-class burn severity map in raster and vector formats that is delivered via File Transfer Protocol (FTP), Compact Disk, or hard copy poster. The product is "preliminary" and requires field verification by experienced soil scientists and/or hydrologists.

Imagery

In addition to our preliminary burn-severity product, we also supply BAER teams with a georeferenced copy of the satellite image itself in both digital and poster formats. This allows the BAER team to do its own digital image processing if there are team members with the necessary skills. It also serves to provide a synoptic view of the entire burned area for team and public meetings. Finally, it can be used as a basemap for traditional sketch mapping if the BAER team mappers are uncertain of the accuracy of our initial burn severity product.

Three-Dimensional Visualization

For very large fires or special requests, we have the tools to build three-dimensional (3d) visualization products for the BAER teams. These include 3d .jpegs and posters as well as short “fly by” movies. While not necessarily useful for GIS analysis, these products are effective public relations tools.

Technical Support

Once our products are available to field users, we work to help them understand the products and how they can best be utilized. This is frequently done over the phone or via e-mail, but we also provide onsite support by request. During 2002, we worked on location with BAER teams at the East Fork and McNally Fires, among others. These collaborations provide an opportunity for us to learn about the BAER process and to develop more useful products.

Image Archive

Finally, as a byproduct of our image-acquisition program we have developed an extensive image archive that is available for future projects such as burned area monitoring. Depending on data licensing restrictions, these data may be shared with other agencies and organizations. All of the images that we collected during 2002 can be viewed on our Web site at <http://firemapper.fs.fed.us/baerfire/baer.html>.

2002 Case Studies

The RSAC BAER support team provided Landsat 7, SPOT 4, IKONOS, and Quickbird data to over 70 incidents during the 2002 fire season. Since many fires required several images for full coverage, we processed and posted more than 120 separate image files to our Web page and ftp site. These files included data for burned areas as small as 500 acres. Our most successful images, however, were obtained for several of the very large wildland fires that burned during 2002. A couple of those are described below.

Missionary Ridge, CO

On June 9, 2002, the Missionary Ridge Fire ignited on the San Juan National Forest about 10 miles north of Durango, CO. By the time it was contained on July 17, it had grown to more than 70,000 acres—much of it in steep terrain. The BAER team had assembled by the end of June. To assist the team, RSAC obtained several images, two of which were used extensively for burn severity mapping and for public information.

On June 23, Space Imaging collected an image of the fire with its IKONOS satellite. We purchased both the 4-meter multispectral and the 1-meter panchromatic data from them. After merging these two data sets, we delivered a 1-meter multispectral image to the BAER team. These were huge digital files with very fine detail. This sort of imagery is not very useful for automating ratios and classifications, but it was used effectively to demonstrate to the public the values at risk from postfire landslides and flooding—both of which occurred after the first big rain event. (On 1-meter data homes and individual tree crowns are clearly visible.)

On June 30, a Landsat 7 image was acquired by the EROS data center. We purchased it on July 1 and produced a preliminary burn severity map for delivery on July 2. This was a 30-meter data product on which individual homes were not visible, but broad areas of high, moderate,

and low severity were delineated. On July 3, two RSAC BAER support staff members went to Durango to work directly with the BAER team. While there, we worked to modify the burn severity map, collected ground verification data points, and developed 3d visualizations using the IKONOS data.

The results of our work on Missionary Ridge were very positive. From the ground control data points we collected, we estimated that our preliminary severity map was about 70 percent accurate. Some BAER team members have estimated that this level of accuracy can save them up to 10 days work on a large fire because they can focus their efforts on the areas of confusion between, for example, high and moderate severity. In addition, the onsite work gave us the opportunity to collaborate with the BAER team on changes to the burn severity map and to learn more about their needs.

Biscuit, OR

In the middle of July 2002, several small fires ignited on the Siskiyou National Forest in southwestern Oregon. Originally called the Biscuit Complex, these small fires eventually merged and became the huge—half million acre—Biscuit Fire that was finally contained on September 5. The BAER team began assembling in late August, but it wasn't until the first week of September that their work began in earnest. By that time, RSAC had collected three Landsat images of the fire, two of which were eventually used by the team.

On August 14, the EROS data center obtained a smoky image of the Biscuit Fire that we purchased on August 15. The fire was estimated at about 400,000 acres. While there was still a lot of active burning and a fair amount of haze due to smoke, we produced our first preliminary severity map for use by the initial BAER team members late on August 15. This first image and severity product gained importance the following week when southwestern Oregon was visited by several high level delegations from Washington, DC. While we were uncertain of the validity of our map because of the poor conditions under which it was created, it was the best available map at the time. Fortunately, a couple days of reconnaissance by a few staff members around this time confirmed that our initial product was reasonably accurate and useful.

Then, on August 30, EROS data center obtained another Landsat image. This one was almost 100 percent smoke free, and the fire was estimated at about 499,000 acres—very close to its final size. We repeated our severity mapping processing and issued a new “preliminary” severity map by August 31st. Fortunately, this map was similar to our original product. After several helicopter reconnaissance flights by the primary BAER team mapper and a few days of editing, the burn severity map was finalized.

Once again, the feedback was positive. For a fire of this size, the traditional methods of mapping via helicopter or road overlook were unlikely to be practical. Other options, including high-resolution fixed wing mosaics or IKONOS images were likely to be very expensive, large, and time consuming. A 30-meter, landsat-derived, burn-severity map was probably the best possible solution in this case and, with it, the BAER team was able to complete its work in record time.

How to Obtain Assistance

It is important for BAER teams to contact us early in the process so that we can negotiate acquisition and delivery with our data providers prior to the team's deadline. We are always tracking fires and satellites, but imagery will not be purchased until it has been requested by the BAER team. On the other hand, it is reasonable to wait until the fire's progress has slowed and there is some expectation of containment. During 2002, we purchased several images that were probably too early and too smoky to be useful. Also, some requests—no matter how well timed—will go unfilled due to clouds obscuring the view. If it is cloudy over our area of interest on the day of acquisition, we will be unable to help the BAER team.

The BAER team leader can help us provide appropriate satellite image support by providing the following information:

- Designate a contact person equipped with good computer and GIS skills, if possible, to help us coordinate effective digital delivery and troubleshooting.
- Advise us of any special products the team may need. For example, we can provide just the classification or we can provide a number of other products including hard copy plots and 3d visualizations.
- Alert us to special circumstances such as remote locations inaccessible to FedEx or GIS teams working outside the Forest Service firewall.

With these things in mind, it is easy to start the ball rolling: Simply give us a call or send us an e-mail.

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More Information on BAER

Additional information on the BAER program can be found at: fsweb.gsc.wo.fs.fed.us/baer/.