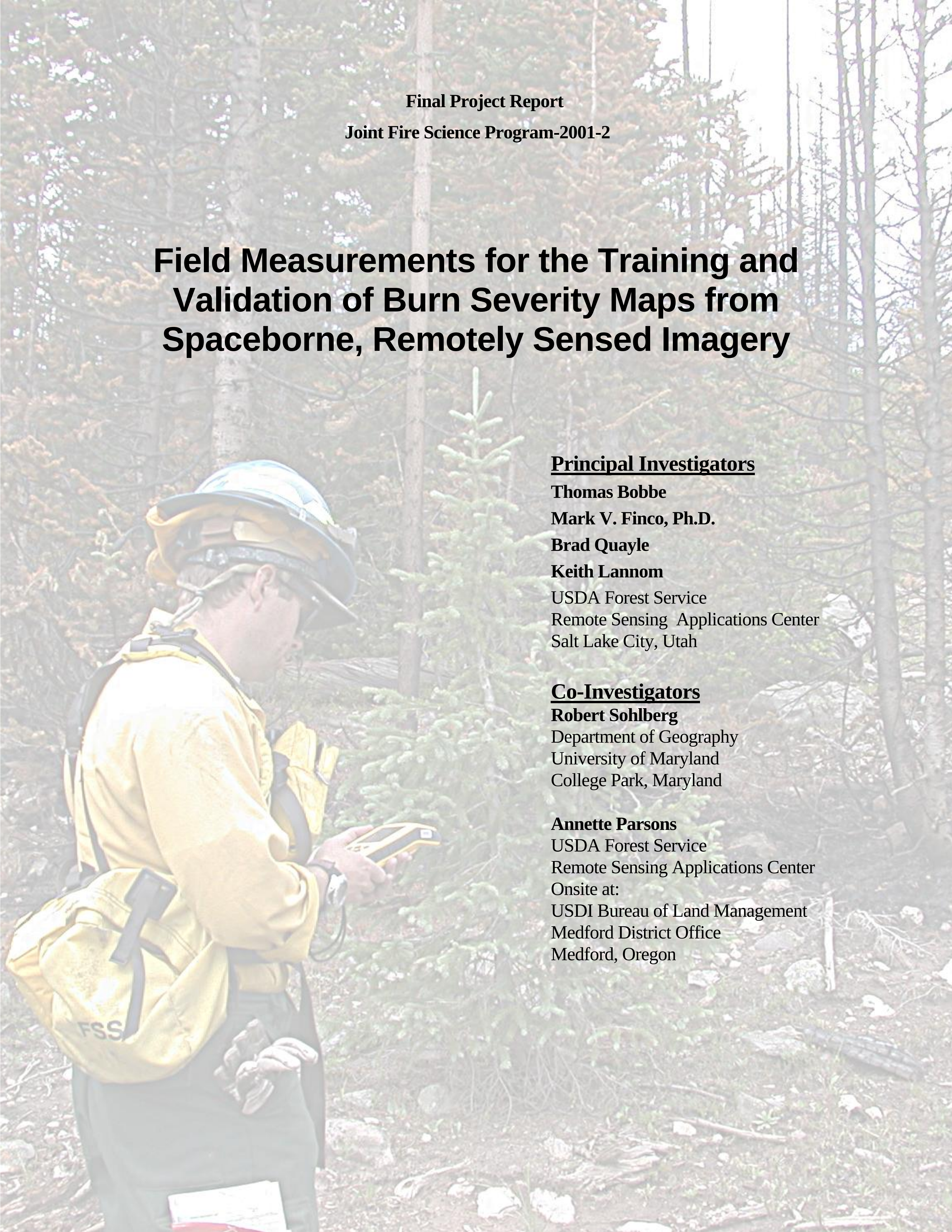

Final Project Report

Joint Fire Science Program-2001-2

Field Measurements for the Training and Validation of Burn Severity Maps from Spaceborne, Remotely Sensed Imagery

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ABSTRACT

This Joint Fire Science Program project provided support for scientists to collect geo-referenced field observations pertaining to burn severity and vegetation condition for the purpose of refining and validating satellite image-derived Burned Area Reflectance Classification (BARC) products used to create maps of burn severity used by Burn Area Emergency Response (BAER) teams. The advantages of utilizing BARC data to derive burn severity maps include rapid availability of the BARC products and an unbiased and repeatable methodology.

During the 2002 fire season, the project team collected 202 field observations for seven wildland fires in four States. In addition, the project team provided the BAER teams with BARC data for the fires that were visited. Single scene and multi-date BARC image classification methods were investigated and two methods of accuracy assessment performed. Based on these two sources of data (field observations and BARC classification) overall accuracies between 50% and 60% were achieved. Producers accuracies were typically highest for high severity and unburned areas (66% to 83%), and lowest accuracies were in the low burn severity class. Given the subtle differences in the ground characteristics of moderate and high severity burned areas and the fact that many low burn severity areas were discovered to be a mix of high/moderate burn severity areas and unburned areas, these accuracy values were higher than expected. Unexpectedly, the overall accuracy of the single-scene classification method was slightly higher than the multi-date method. Several possible reasons for this discrepancy are discussed. Regardless of the classification method, the accuracy of BARC products are sufficient for providing BAER teams with a foundation for the development of a final burn severity map, which is always derived using additional field observations and interpretation by BAER teams.

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1. INTRODUCTION

In addition to resources lost during a wildland fire, the loss of vegetation and high temperatures damage soils, thus increasing runoff and endangering structures, watersheds and soils. To mitigate the effects of wildland fire, the USDA Forest Service and other federal land management agencies conduct Burned Area Emergency Response (BAER) to stabilize soils, reduce downstream threats and protect other resources at risk. One of the first steps in the BAER process is the creation of a map that highlights the areas most in need of immediate attention by rehabilitation teams. Many of the rehabilitation treatments implemented by resource specialists on BAER teams require maps that show burn severity, soil type, slope, and aspect. Because rehabilitation treatments can be very costly, the accuracy of the burn severity maps is important. In addition, BAER teams use these mapping data to model erosion and runoff/flood flow.

1.1. Burn Severity Maps

One of the most difficult BAER products to generate in a timely manner is the assessment of how the wildland fire affects the hydraulic properties of the soil. The term burn severity can have different meanings and connotations depending on the audience and application. For BAER work and this Joint Fire Science Program (JFSP) project, burn severity is indicative of the degree of impact to soil properties and is used to prioritize treatments for protecting resources at risk. Generally classed as unburned, low, moderate, or high, burn severity directly influences resource management decisions concerning the treatments applied on the ground. Figure 1 portrays examples of high, moderate and low severity burned areas.

(a) (b) (c)

Figure 1. Burn severity classes as viewed from the ground, a) High = Winter Fire (Oregon), b) Moderate = Eyerly Fire (Oregon), c) Low = Toolbox Fire (Oregon).

Traditionally, burn severity assessment and mapping was performed by manual sketch mapping, either utilizing ground based surveys, or, ground based surveys in conjunction with aerial surveys conducted from a low flying fixed wing aircraft or a helicopter. Ground based surveys are necessary to verify the impacts of wildland fire, however, there are several shortcomings to burn severity mapping with manual sketch mapping. Methods used to map burn severity differ between agencies and even among BAER teams within the same agency. For large wildland fires, field surveys are often incomplete and only sample a small percentage of the burned area due to the compressed time requirements in which BAER teams operate. Aerial surveys and sketch mapping for large wildland fires tend to be expensive and present the risks associated with flying in light aircraft over mountainous terrain often during smoky conditions. Manual sketch mapping results are subjective, biased, and rely on the experience and skill of the person performing the mapping.

In the mid-1990s the USDA Forest Service, Remote Sensing Applications Center (RSAC) worked with Kodak to develop a color infrared digital camera that could be mounted in an aircraft to acquire imagery and map an entire fire (Hardwick et al. 1997). Figure 2 is an example of one frame from the color infrared digital camera. Typically, several hundred of these frames may be required to cover the extent of a wildland fire. This process for acquiring imagery, compositing, and interpreting the color infrared digital imagery was commercialized and made available to BAER teams. BAER teams viewed this technology as an improvement over aerial sketch mapping, but small format airborne digital camera imagery for burn severity mapping has several limitations including:

a) It is expensive to cover large geographic areas,

b) There are a limited number of vendors that provide this support, thus potentially creating an unacceptable delay between imagery order and delivery,

c) The time required to process and mosiac the numerous digital images can create unacceptable delays,

d) The imagery results in very large files that are often difficult for the BAER teams to work with on standard Forest Service or Department of Interior computers, and

e) Many BAER team members have stated that the imagery has more detail than is required to map burn severity.

Figure 2. A single digital color infrared camera image collected for burn severity assessment.

This JFSP project refined and validated the next generation of imagery-based burn severity maps. The imagery for this project comes from satellites, making large area mapping possible at a relatively low cost.

1.2. Satellite Imagery-based Maps

During the 2001 fire season, USDA Forest Service Remote Sensing Steering Committee (RSSC) supported a project for RSAC to work with BAER teams to evaluate and develop new methods to map burn severity using satellite imagery (Lachowski et al. 2001). A variety of imagery sources were evaluated, including Landsat 5 and 7, SPOT and MODIS. The 2001 RSSC project demonstrated how to use satellite based remote sensing to support BAER mapping. However, the funding provided by the RSSC was not sufficient to support field data collection, methods refinement, and validation.

During the 2001 fire season, RSAC made significant progress in an effort to quickly provide information derived from satellite imagery to BAER teams (Bobbe et al. 2001). This information is known as the Burned Area Reflectance Classification (BARC). Many of the advances made were procedural, allowing RSAC to rapidly acquire appropriate satellite imagery from a variety of sources at a low-to-moderate cost. Imagery sources for BARC product development included MODIS, ASTER, Landsat 5 and 7, and the SPOT constellation of satellites. RSAC also developed a procedure to track each satellite and predict the availability of the various imagery sources for BAER teams as the fire reaches containment. In addition to the fires supported in the initial project, RSAC identified stakeholders and supporters for remote sensing technologies on the BAER teams.

The selection of the imagery source for a particular BAER project depends on weather conditions (cloud cover), time of the overhead satellite pass in relation to fire containment, and geographic extent that needs to be covered. RSAC considers all sources of satellite imagery as potential candidates to support a particular BAER project. However, Landsat is the preferred source of imagery for BAER teams because:

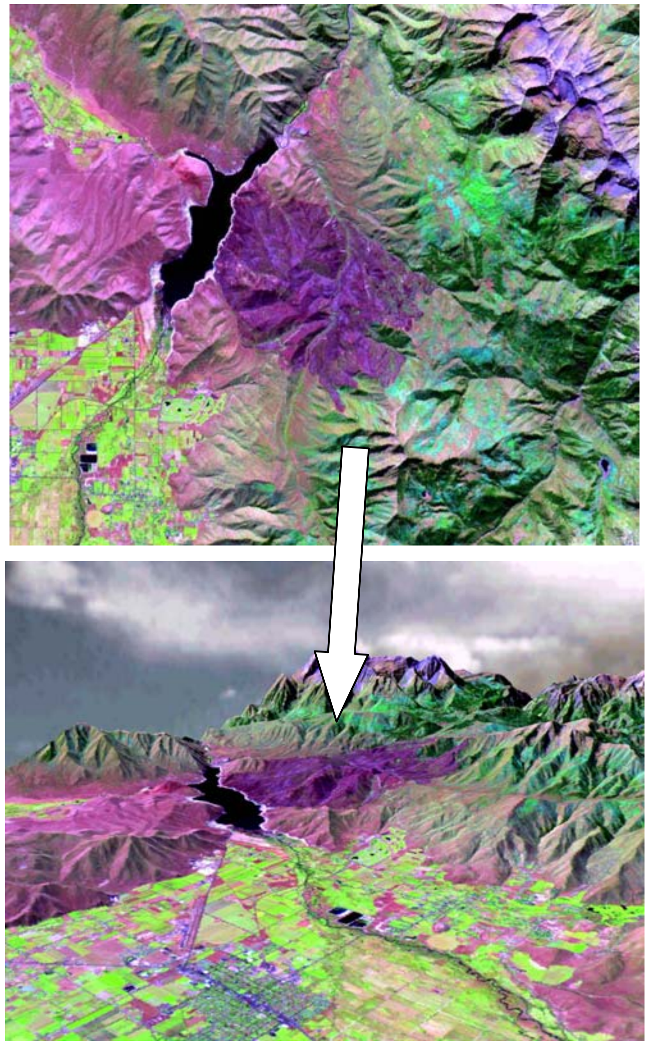
a) It provides sufficient geographic coverage (185 km x 185 km) with 30 m spatial resolution,

b) It has spectral resolution properties that include near infrared and short wave infrared bands useful for classifying burn areas,

c) It is relatively inexpensive, and,

d) It has an extensive archive of imagery available for pre-fire analysis and change detection.

As a result of prior project support to BAER teams, RSAC staff have learned that additional image-derived products are useful to the burn severity mapping effort. The most requested products are hardcopy BARC classification data and maps covering the burned area. In addition, 3-D geographic visualizations, like the one shown in Figure 3, proved to be valuable both analytically and for relating information to the public. RSAC staff have also recognized that on site incident remote sensing skills usually are not sufficient to work with the remotely sensed data itself and that BARC data in GIS vector polygon format are required at the incidents to successfully support BAER teams.



(a)

(b)

Figure 3. SPOT 4 imagery from the Cascade II Fire in northern Utah. (a) 2 dimensional view of the scene and (b) a 3 dimensional view of the image draped over digital terrain data of the area.

1.3. Project Objectives

This JFSP project collected field data to refine and validate the image classification methods developed during the 2001 fire season. In addition, this project provided an opportunity to interact with the BAER teams in the field on a more sustained and direct basis, facilitating a better understanding of the BAER team's information requirements for assessing and mapping burn severity.

The ultimate objective of RSAC's support program is to provide BAER teams with the best possible BARC data within the operational constraints of BAER activities. These BARC classifications are derived from remotely sensed data, rapidly available, unbiased, and repeatable. Only imagery that can be acquired and delivered within 3 to 5 days of fire containment is utilized. Additionally, the methodology for the development of BARC data and image-derived products must facilitate a quick response operational environment.

Another activity planned for this project was to hold workshops with BAER team members and other agency technical staff involved in BAER support. RSAC and the US Geological Society EROS Data Center (EDC) hosted a technical workshop on using remotely sensed data for BAER purposes at the RSAC facility in Salt Lake City, Utah on December 9 and 10, 2002. Participants in the session included RSAC remote sensing analysts, EDC researchers, and Forest Service Regional BAER coordinators and team leaders. Representatives from other Federal agencies including, the Bureau of Land Management and National Park Service also attended the workshop. BAER team geospatial data requirements, and methods for deriving BARC products were discussed during the workshop. The workshop attendees agreed to organize a second technical session at a national conference. A burn severity mapping session was held at the 2nd International Wildland Fire Ecology and Fire Management Congress in Orlando, Florida on November 18, 2003. Eight technical papers on burn severity mapping were presented and discussed during the session.

2. METHODS & RESULTS

2.1. Field Data Collection

2.1.1. Field Methods

Accurately geolocated points are critical for the development and assessment of remote sensing classifications. Initial plans considered using ground validation data from the BAER teams; however, the wide variety of interpretation procedures for burn severity in the BAER community made this approach undesirable. The objective of the field data collection was, therefore, to construct a geolocated dataset collected using a consistent set of criteria to assess burn severity. This was done with the understanding that there may be other equally valid methods for assessing burn severity, but at a minimum the classification method development and accuracy assessment was conducted using a consistent source of field data.

The data collection procedure had several criteria for locating field sites. Criteria for selecting field site locations included (a) a representative distribution among the burn severity classes, (b) size of selected site locations should be large relative to the pixel size, and (c) remove or minimize any attenuation of the GPS signal to ensure accurate geolocation information. Field plots were selected in the center of homogeneous areas estimated to be at least two acres in size.

Burn severity was evaluated at each field site after making qualitative evaluations of vegetative condition and quantitative measurements of soil properties. The field evaluation procedure was developed by Annette Parsons, who is a soil scientist and an experienced BAER team member. The members of this JFSP project team were taught the procedures by Ms. Parsons during a two-day training session at a contained wildland fire. A GPS data dictionary was developed and used to standardize the input to the field data collection database (Table 1). The "Burn Severity" attribute in the table was ultimately used to evaluate classification accuracy. The other attributes were collected to develop and support the overall assessment of burn severity.

Table 1: GPS data dictionary for burn severity assessment

Field Name: Description	Data Domain
Burn Severity: Overall assessment of soil burn severity in the area.	Unburned, Low, Moderate, High
Hydrophobicity Class: Depth of hydrophobicity.	None, Low (surface only), Medium (1-2.5cm), High (2.5-15cm)
Hydrophobicity Degree: Length of time that water bead remains.	None, Weak (<10 seconds), Moderate (10-40 seconds), Strong (>40 seconds)
Ash Color	Black, White, Red, Gray, Mixed
Ash Depth	In millimeters
Litter Condition	Unburned, Lightly singed, Charred, Ashed
Fuel Size: Size of fuels remaining.	Small (<2mm), Medium (2-6mm), Large (>6mm)
Tree Cover: Percent tree canopy consumed.	<40 percent, 40 to 80 percent, >80 percent
Needlecast: Needlecast potential.	None, Low, High

Shrub Condition	Lightly scorched, Some limbs left, All consumed
Root Condition: Presence of root crowns.	Not consumed, Consumed
Fine Roots: Condition of fine roots in soil	Consumed, Few, Common, Many
Soil Structure: How well soil clumps stay together.	Unchanged, Loose, Weak, Moderate, Strong
Surface Rock	None, Some, Lots
Pre-fire Vegetation	Bare, Grass, Shrub, Pinyon/Juniper, Conifer, True Fir Component, Hardwood, Other

Ground-based digital photographs were also taken from the site location center in the four cardinal directions for post-field data acquisition analysis (Figure 4). During the data analysis phase the ground-based photos from plot center were a valuable addition to the field assessment procedures. In addition to providing a good way to revisit the plot in the office, the photographs provided a comprehensive look at the site location in conjunction with the recorded field assessment data.

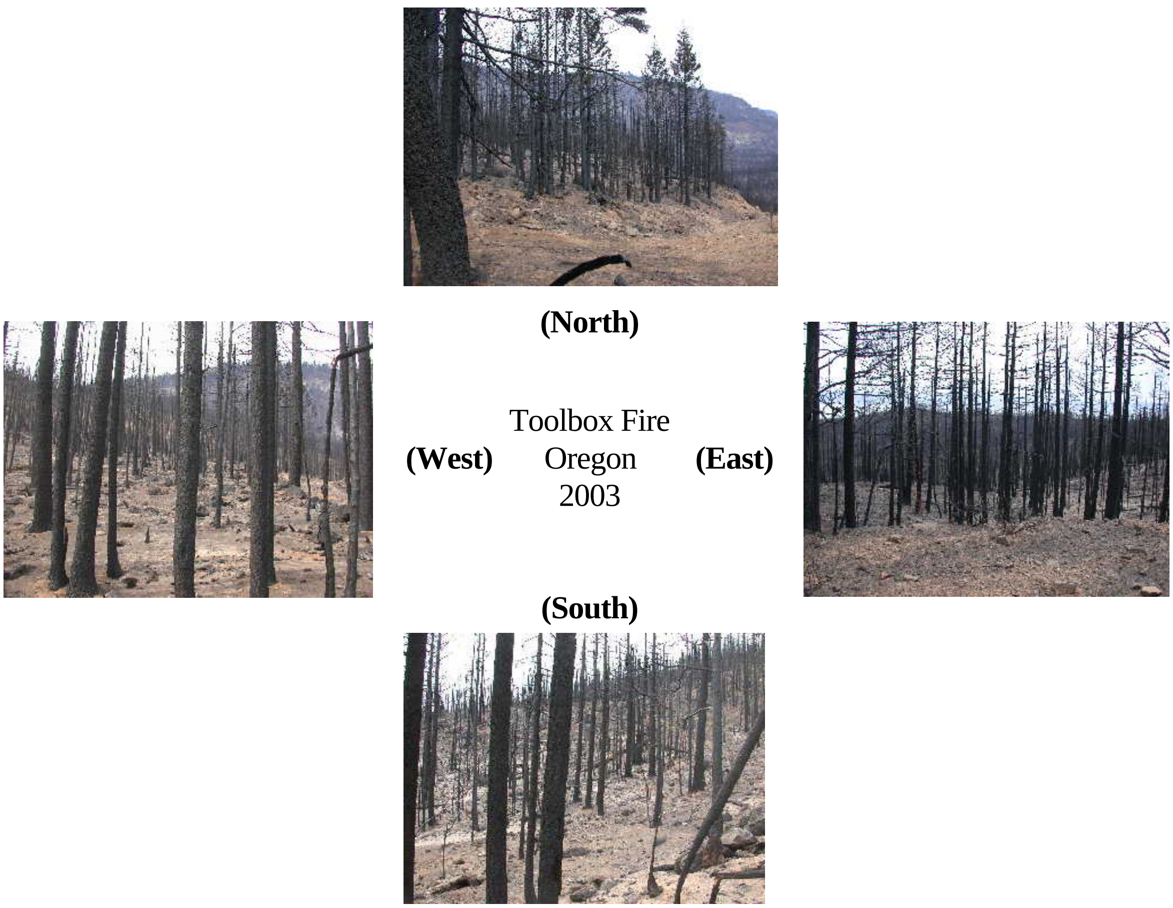


Figure 4. Example of field site location photographs taken for this JFSP project (Toolbox Fire 2002).

2.1.2. Field Data Discussion

Over the course of the 2002 fire season RSAC staff and University of Maryland researchers collected 202 field validation points from seven incidents in four states (Table 2). The field plot data can be viewed at http://www.fs.fed.us/eng/rsac/baer/jfs.html.

Table 2. Fires from which field data was collected in 2002.

Fire Name	**Location**
East Fork	Utah
Missionary Ridge	Colorado
Eyerly	Oregon
Winter	Oregon
Toolbox	Oregon
Silver	Oregon
Biscuit	Oregon, California

The project team had a chance to work with several BAER teams. As a result, they gained insight to similarities and differences in assessing burn severity. One factor in which BAER teams differed was the role of needle cast potential in assessing the degree of burn severity (Figure 5). For example, high needle cast potential is considered by some BAER team mappers as an indication that the area is no greater than a moderate severity burn. This is due to the premise that needle cast protects the soil and minimizes rill and interrill erosion. Other BAER team members only consider soil hydrophobicity measurements to assess burn severity and do not consider needle cast potential.

(a) High potential – Winter Fire

(b) Low Potential – Eyerly Fire

Figure 5. The potential for needle cast was considered by some BAER teams as an important variable in determining burn severity.

In addition to needle cast potential, the project team noticed that BAER teams also considered unmeasured, site-specific properties such as slope or proximity to a resource at risk in assessing the degree of burn severity. For example, if the fire impacts to a site were significant enough to warrant a high severity classification, but the site also had high needle cast potential and was located on a low to moderate slope, it could be evaluated as moderate severity by some BAER teams.

The subjectivity of the interpretation methods of individual BAER teams makes it difficult to attain a consistent burn severity map from incident to incident, thus confirming that the goal of the satellite-based mapping should be to provide an objective initial assessment of the general patterns of burn severity. The final burn severity maps will always be a product produced by BAER teams incorporating field data and a ground based understanding of the fire effects.

While in the field, it also became apparent that low and moderate severity burns classes would be a challenge to discriminate using remotely sensed imagery alone. Confusion in these classes can be a result of the mosaic of burned and unburned areas within the minimum mapping unit (MMU). For example, a MMU may be predominantly low or unburned. The same unit, however, may contain pockets of high or moderately burned areas such as single trees or small clumps of trees (Figures 6 and 7), which judged as a whole the unit would be low or moderate depending on the percentage of moderate and high severity pockets.

The hillside in the distance in Figure 6 shows a heterogeneous mosaic of burn classes in a relatively small area. Given the fact that BAER teams use a MMU of at least 40-acres it is easy to see how a majority, mode, or mean criteria could be used to develop burn severity polygons.

Figure 6. A mosaic of high, moderate, and unburned areas evident from East Fork Fire, Utah.

Figure 7. Highly mosaiced fire severity from the Winter Fire, Oregon.

In addition, some vegetation/land cover types, such as herbaceous or light grass types, are not classified by BAER teams as high or moderate severity burns regardless of the amount of vegetation consumed by the fire. Even if the herbaceous or light grass fuels are fully consumed, BAER teams consider these areas as low burn severity since the burn is short duration, has minimal impacts to soils, and recovers relatively quickly compared to other fuel types. This can produce confusion in remote sensing classifications if existing vegetation information is not used in the analysis.

2.2. Image Classification Methods

Since the BAER team final report is due within 10 days of fire containment, timeliness of the BARC map delivery is paramount. Two methods for classifying burn severity were evaluated in this JFSP project. All of the seven BAER projects included in this analysis utilized Landsat 7 imagery since the Landsat 7 acquisition times for each of these fires were adequate for the BAER teams.

The first BARC method uses a single date of satellite imagery acquired shortly before or immediately after containment of the fire. This method, developed by RSAC, meets the timeliness requirements of the BAER teams and can be used with a variety of satellite remote sensing systems. This method calculates a normalized ratio of shortwave infrared and near infrared spectral bands from the imagery which can be used to distinguish variations of burn severity. When Landsat imagery is used bands 4 (0.76 - .90 um) and 7 (2.08 – 2.35 um) provide the normalized burn ratio (NBR).

NBR = (Landsat band 4 - Landsat band 7) / (Landsat band 4 + Landsat band 7)

The NBR image is clustered into fifty classes that are subsequently recoded into the four burn area reflectance classes – unburned, low, medium and high. Post processing using the National Land Cover Dataset (Vogelmann, 2001) is used to make adjustments in burn severity for areas that were barren or grass/herbaceous. The result of this process is known as a single-scene (SS) NBR BARC map.

Two Department of Interior researchers developed the second method as a tool for assessing environmental impacts caused by fire and for long-term monitoring of the burned area (Key and Benson 2001). It was not developed as an input to BAER maps, but in recent years has been adapted to this application (McKinley 2002). The second classification method uses Landsat imagery exclusively. The Landsat bands 7 and 4 are used to calculate the NBR on a pre-fire image and a post-fire image. This method uses a comparison of two dates of imagery to assess the effects of the fire. As initially conceived by Key and Benson (2001), this method uses a post-fire image collected during the next growing season. This delay is not feasible for BAER mapping purposes; therefore, an image acquired shortly before or immediately after containment is used as the post-fire image. To be consistent with the two-scene method as described by Key and Benson, the pre-fire scene is selected to be at a phenologically similar time of year, preferably from the previous year, to the post-fire image (McKinley 2002).

The two-date comparison is performed by differencing NBR values from the two dates, which results in a delta NBR image (DNBR).

$$DNBR = NBR_{prefire} - NBR_{postfire}$$

A pre-specified set of thresholds are then used to recode the DNBR into the four burned area reflectance classes and the result is referred to as a two-scene, or DNBR BARC map. More information on this method can be found http://www.nrmsc.usgs.gov/research/ndbr.htm.

The BARC map, regardless of its methodological origin, becomes the basis of the final burn severity map produced by the on-incident BAER team. The BAER team compares field observations to the BARC map and adjusts the classification as necessary to more accurately reflect field conditions.

2.3. Accuracy Assessment Methods & Results

Two accuracy assessment analyses were performed to evaluate the BARC classifications. The following sections summarize the methods and results from each.

2.3.1. Forty-Acre MMU BARC Maps

The first accuracy assessment analyzed the BARC map that is typically delivered to BAER teams. Based on input from the BAER community, BARC maps are filtered to exclude polygons less than 40-acres in size through a process known as clumping and sieving. An assessment of accuracy is made by performing a geographic intersection of the field plot locations with the BARC classifications. The accuracy assessment matrices in Tables 3a and 3b are the result. The tables include both the producers and users classification accuracy. Producer accuracy is calculated by dividing the total number of correct sample units in a burn severity category by the total number of burn severity sample units determined by the field data (i.e. the row total). The users accuracy is calculated by dividing the number of correct classification units in a burn severity category by the total number of classification units in that category (i.e. the column total).

Tables 3a-b. Accuracy assessment matrixes for 40-acre MMU polygons.

Single Scene NBR BARC
Burn Area Reflectance Classification

Field Observed		UNBURNED	LOW	MODERATE	HIGH	Producers accuracy
	UNBURNED	9	1	1	1	75%
	LOW	9	11	17	6	26%
	MODERATE	2	4	33	26	51%
	HIGH	1	2	11	68	83%
	Users accuracy	43%	61%	53%	67%	60%

DNBR BARC
Burn Area Reflectance NBR Classification

Field Observed		UNBURNED	LOW	MODERATE	HIGH	Producers accuracy
	UNBURNED	9	0	2	1	75%
	LOW	16	8	13	6	19%
	MODERATE	5	12	28	19	44%
	HIGH	1	2	23	55	68%
	Users accuracy	29%	36%	42%	68%	50%

In this analysis the greatest difference between the SS NBR BARC and the DNBR BARC is the difference in the producers accuracy for the high severity burned areas. A majority of the confusion is between points that were identified as moderate in the field, but high by the image classification. This is believed to be due to the fact that despite a consistent evaluation of field conditions, there is still a mismatch between what can be seen on the ground and what is detectable by a satellite (i.e., the view from below the canopy versus the view from above). Because BAER teams focus on high severity sites, it is better for the BARC to over estimate high severity burned areas and have them eliminated through editing from the final BAER map, than to underestimate the high severity areas and have them missed by the BAER team.

The lowest producers accuracy was consistently in the low burn severity class. This is due to the fact that low severity burned areas are often combined with higher burn severity areas to form larger moderate severity polygons. This hypothesis is supported by a majority of the misclassification being in the moderate BARC class. The problems with the low and unburned areas could also be due to how the two classes were discriminated in the field. If an area showed any signs of fire in the field, it would minimally be assigned a low burn severity classification. Within a 30-meter pixel, however, the area would be classified as unburned because of the dominance of green vegetation.

Overall, the accuracy of SS NBR BARC is slightly better than the DNBR BARC. This is likely due to the complications in using multi-date imagery, namely co-registration, atmospheric correction differences, and phenological synchronization. However, the slightly lower overall accuracy of the DNBR BARC should not be overemphasized. Another factor that may account for the difference is that the DNBR method uses general predefined thresholds, which were defined by Key and Benson (2001). RSAC analysts determine specific thresholds for the SS NBR method based on the ecological characteristics of the fire area and from their extensive experience working with BAER team members.

2.3.2. Unfiltered BARC Maps

The second accuracy assessment analysis determined whether the elimination of polygons less than 40-acres in size had an effect on accuracy. Visual inspection of the field data locations and the BARC maps showed that, despite attempts to locate field plots in the middle of homogeneously burned areas, there were many field plots that were close to the edge of BARC polygons. The second accuracy assessment was performed on the BARC classification before the 40-acre MMU was applied. Tables 4a and 4b present the results of this classification.

Table 4a-b. Accuracy assessment using single pixel, unfiltered classifications

Single Scene NBR BARC
Burn Area Reflectance Classification

Field Observed		UNBURNED	LOW	MODERATE	HIGH	Producers accuracy
	UNBURNED	10	1	2	1	71%
	LOW	5	17	17	4	40%
	MODERATE	3	4	31	24	50%
	HIGH	1	2	17	62	76%
	Users accuracy	53%	71%	46%	68%	60%

DNBR NBR BARC
Burn Area Reflectance Classification

Field Observed		UNBURNED	LOW	MODERATE	HIGH	Producers accuracy
	UNBURNED	10	0	1	2	77%
	LOW	15	11	15	2	26%
	MODERATE	9	9	29	15	47%
	HIGH	1	4	23	54	66%
	Users accuracy	29%	46%	43%	74%	52%

The general trends in overall and by-class accuracies continue in this analysis. The application of a 40-acre MMU does not substantially affect the classification accuracy. Low severity plots still had the lowest producers accuracy and the SS NBR classification was slightly better than the DNBR method. This disproves the initial hypothesis that the clumping and sieving of the BARC classifications adversely affects the classification accuracy.

3. SUMMARY & RECOMMENDATIONS

The primary goal of this project – to consistently collect georeferenced field plots of burn severity – was successfully accomplished. The field data collected by this project provided valuable input for the refinement of classification methods and assessment of BARC maps.

The field procedures (Section 2.1) effectively captured the data required for this analysis. Recommendations for future field work would include:

a) Train field data collection personnel as much as possible in the field before the actual data collection phase to ensure consistency. Two days were spent reviewing field procedures for this project, which is the absolute minimum.

b) Develop a field data collection protocol where two individuals make independent calls, which are reconciled after the field visit. A comparison of the field calls would be an indication of the quality of the ground truth. For this project the protocol used a consensus approach in the field to determine the overall burn severity of a plot.

c) Include ground photos in the field data collection procedure. They are a valuable tool for analyzing plot data in the office.

d) Utilize a field capable device that links satellite imagery to current GPS position to expedite the site location selection. This will also facilitate selection of sites that are truly within the middle of a larger homogeneously burned area.

The results of this study were consistent with our expectations in terms of map accuracy, neither method was perfect but both met the needs of the BAER community as a consistent starting point for developing the final burn severity map. The one unexpected result was that the DNBR was less accurate than the SS NBR classification. Possible explanations are discussed in Section 2.3.1. The fact that low and moderate severity burns are confused is not as important to the BAER teams as confusion between high and moderate/low severity. Overestimation of the high severity areas is preferable to underestimation for reasons discussed in Section 2.3.1.

There is a need for a consistent intra- and inter-agency method for evaluating burn severity in the field. Consistency among the BAER team burn severity interpretation methods is a foundation for the long-term value and utility of the BAER process. An important advantage of using BARC data and maps is that they facilitate a more consistent method for mapping burn severity by BAER teams regardless of land ownership.

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