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COMPARISON OF SATELLITE IMAGERY AND CONVENTIONAL AERIAL PHOTOGRAPHY IN EVALUATING A LARGE FOREST FIRE

G.R. MINICK

University of South Carolina
Columbia, South Carolina

W.A. SHAIN

Clemson University
Clemson, South Carolina

The 1976 Horry County forest fire consumed approximately 37,000 acres of woodlands. The burned area was located in the northeastern coastal plain of South Carolina with the boundary being generally based on a triangle where the northern boundary is S. C. Highway 90, the southern boundary is the intracoastal waterway, and the western boundary is Highway 501. It burned for a total of six days before being pronounced out on April 15, 1976. A trail of smoke could be seen at one time rising to the northeast for 40 miles over North Carolina and the Atlantic Ocean. This area was dominated by forests even though there were very few high-quality timbered areas. Included in this area are three distinct forest types, the Carolina Bays, with their evergreen shrub bogs or 'pine pocosins', the cypress-tupelo gum, and the old beach sandy ridges that would probably naturally climax to oak-hickory, but currently are being managed for southern pines.

The day after the fire was declared out, color infrared aerial photographs were taken of this area. From these aerial photos, a planimetric map was made and an overlay was constructed classifying the area into unburned, slightly burned, moderately burned, and intensively burned, based on image color and density. Intensively burned areas were found to be totally charred and had very little reflectance. They appeared blue to black in the color infrared photographs. Moderately burned areas contained some mortality and considerable scorched vegetation when appeared blue to gree on the photographs. Slightly burned areas had no mortality but had some signs of scorching in the crown and burned understory material. It appeared green with shades of red throughout, while unburned areas appeared red.

I. SATELLITE IMAGERY

On May 26, 1976, about six weeks after the fire, a computer compatible tape (cct) was made of this fire and a copy of this tape was purchased by Clemson University. From this tape a map was produced of the burned area that showed the various vegetative types. Steps involved in producing this map included processing the cct using an image processing system supported by a minicomputer. Actual data manipulation initially involved displaying the data as an image on which ground features became distinguishable. This imagery, first of all, was composed of shade-of-gray prints from a standard computer line printer, and false color infrared composites generated on a COMTAL digital plotter at Georgia Tech. From these images, fourteen areas of known conditions, commonly called training samples, were located and delineated based on ground observations and low-altitude aerial photographs. Each training sample included at least thirty contiguous picture elements (pixels) which closely matched the ground features being classified. Normally, one training sample was selected for each class. These included the three classes of burned area plus eleven classes of surrounding land use. As each pixel was printed, a tally was automatically included in the program to summarize the total pixels in each of the fourteen different vegetative classes. This allowed quick and easy access to a summary table of the acreages in each type.

II. GROUND SAMPLES

To help develop accuracy estimates for comparing the two types of mapping (Landsat and aerial photographs), a system of ground samples was taken at random over the burned area and included some samples in the surrounding unburned area. These samples were first located on aerial photographs and then transferred to their respective stand maps obtained from the forest manager. Using these stand maps, the samples were located on the ground using a hand compass and pacing. Each stand was estimated for stocking age, and salvageability. Also, the area around the sample was classified into one of the fourteen land use categories to match those on the Landsat imagery.

Even though the fire occurred in April, 1976, and aerial photographs were taken shortly thereafter, the actual study was not approved for funding until the winter of 1976-77, one growing season after the time of the burn. It was not until the following summer and autumn that the 150 ground samples were actually taken. Thus, two full growing seasons had elapsed between the time of the fire and the actual ground sample measurements. This emphasizes another of the advantages of the Landsat program. Each satellite takes images of the burned area every eighteen days, and these tapes are available at any later date.

III. RESULTS

The major emphasis in this study has been centered around the initial determination of burned versus unburned areas, as well as a differentation of the burn area into the different burn intensities. From Table 1, it is apparent that all three methods of determining the total burn area produce very similar results. Unofficial reports from the owner of the burned land indicate that 37,000 acres were burned. The figure of 36,999 acres, as determined from aerial photographs, almost matches this figure, but it includes all area within the perimeter, thus excluding the unburned islands within. The Landsat classification estimate is somewhat lower because aerial determination from Landsat is based on a per acre reflectance pattern; therefore each acre is considered separately. Aerial interpretation, on the other hand, generally limits the minimum size of each delineated area to about five acres as determined by ocular examination.

Table 1. Acreage burned by class as determined by each method.

Class	Air	Satellite	Owner Est.
1	983	942	--
2	12,243	12,857	--
3	12,489	10,888	--
4	11,284	12,165	--
Total (2-4)	36,016	35,910	37,000
Total (1-4)	36,999	36,852	--

The acreage of 35,910 acres burned, according to Landsat figures, is possibly somewhat low. With this system of examination, the reflectance of each pixel, representing about 1.1 acres on the ground, is classified according to the average spectral reflectance which is received by the satellite. This spectral reflectance is unbiased by reflectance from the adjacent pixels. Therefore, if there is a single acre in the center of the fire that is unburned, it will be classified unburned by the satellite method instead of being grouped into the average category surrounding it by both aerial photographic interpreters and the foresters on the ground. On the other hand, there were a few acres in the burned area that were definitely burned, yet they were classified as unburned by the satellite method. The reason for this is an acre which had live vegetation in the overstory may not rate an unburned category even though the fire moved through the understory and scorched some of the lower branches.

Even so, it appears that each of the three methods (ground examination, aerial photographs, and Landsat imagery) will produce similar estimates of total burned area. Economic consideration in selecting which of the three methods to use.

IV. STUDY AREA SAMPLES

Data concerning burn intensity were recorded on 150 samples for all three information sources - ground control, aerial photographs, and Landsat imagery. Two-way contingency tables were then compiled to help compare aerial photographic and Landsat data to ground control (Table 2).

Table 2. Two-way contingency table from raw data comparing ground control data to both aerial interpretation data and Landsat data classification.

Aerial Photo Burn Classes	Ground Control Burn Classes 1	2	3	4	Total
1 (unburned)	26	12	4	0	42
2 (slightly)	3	14	8	7	32
3 (moderately)	1	11	20	18	50
4 (intensively)	0	2	7	17	26
Total	30	39	39	42	150
Landsat Burn Classes					
1 (unburned)	29	10	4	1	44
2 (slightly)	0	22	8	8	38
3 (moderately)	1	4	22	10	37
4 (intensively)	0	3	5	23	31
Total	30	39	39	42	150

In comparing overall burn classes against non-burned classes, it is first apparent that there is close agreement between unburned class 1 versus a composite of the other three classes of burn. From column 1, 295 of 300, or over 98 percent, of the ground samples were correctly classified as burned compared to non-burned on both the aerial photos and Landsat imagery. Of the five samples incorrectly classified, four were located close to the edge of the burn and a small error in locating the ground samples by hand compass and pacing could easily have led to error.

For the accuracy of the other classes of slightly, moderately, and intensively burned, 77 of 150, or 51 percent, of the aerial photo observations, and 96 of 150, or 64 percent, of the Landsat observations were correctly identified. This means that 173 of 300 plots (58 percent) were classified on the ground and on either aerial photos or Landsat imagery in exactly the class of burn intensity as the ground sample. At first glance, this accuracy level is not extremely high. But when you take time to recognize that a ground observer was expected to travel to a given point on the ground, examine the area within visual sight, and then give it an arbitrary classification of burn intensity based on a word description, then you can recognize that there is some fallibility in this system of classificating ground plots. Also, the ground samples were not taken until the second growing season following the fire. It would have been much better and certainly more accurate to take these samples immediately following the fire to correspond to the aerial photographs and Landsat imagery. Still, most ground plots were definitely and accurately classified. But when 150 ground plots are selected at random and visited for classification, there are bound to be a number of plots, especially those located in the transition zone between two classes where identification is questionable, where the observer is hard pressed to correctly classify a given sample.

This leads to an examination of those plots which were classified with an error of plus or minus one class (say an area was classified as 2 or 4 instead of 3). If the scale of this study were widened by plus or minus one class, then the accuracty levels increase from 58 percent to 90 percent (269 or 300), certainly an acceptable level of accuracy.