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ERTS Data Tested for Forestry Applications

In addition to the possibilities for producing timber inventory maps, the data have the advantage of providing sequential coverage.

Introduction

To evaluate the worth of Earth Resources Technology Satellite (ERTS) data, the L. B. Johnson Space Center mounted a large-scale disciplinary study of the early take from this historic satellite in 1973. The author had the good fortune to lead the forestry team in this broad investigation. The team was asked to take an independent, scientific look at a new resource inventory system, which now appears to be a revolutionary new concept in forest surveys.

The team used a portion of the Sam Houston National Forest, shown in the location map in Figure 1, as a test site. Although this investigation was conducted on a pine forest in east Texas, the results are generally applicable to forests in the rest of the southern pine region. The results are less applicable to forests in the rest of the country, but they are generally indicative of what may be expected.

The team tried conventional photo interpretation methods for producing timber type maps from the ERTS imagery, but this effort was largely unsuccessful. This was apparently because the eye could not separate all the fine gradations of tone that were needed. It then tried several types of computer-assisted methods, using the data tapes coming from the original telemetry, and these methods proved to be far more feasible.

The simplest of these methods was the recombining of three of the four ERTS channels on an electronic viewing device which displayed each channel in a different color, using red, green and blue in the additive process. This made it possible to create a composite image which could simulate color-infrared photography, or any other enhancement combination which was desired.

A more complex method was the use of a clustering algorithm in the computer which grouped all like wavelengths and intensities into clusters. This produced a map which could be related to ground features by comparison with a map where these features were known.

The third and most complex method used was the Purdue University method, called LARSYS, in which the computer is *trained* to classify known ground conditions by their correct names. Thus any desired timber fea-

Abstract: *The author led a NASA team of investigators determining the value of ERTS data to foresters. Tests showed that 14 timber types and land-use patterns of interest to foresters could be classified within reasonable accuracy limits. Computer methods were found to be better than conventional imagery interpretation methods in making these classifications. In addition it was learned that insect and fire damage could be detected in this data. Future satellite systems of this type hold a promise of real-time continuous inventories and many types of temporal studies, which will greatly improve management capabilities.*

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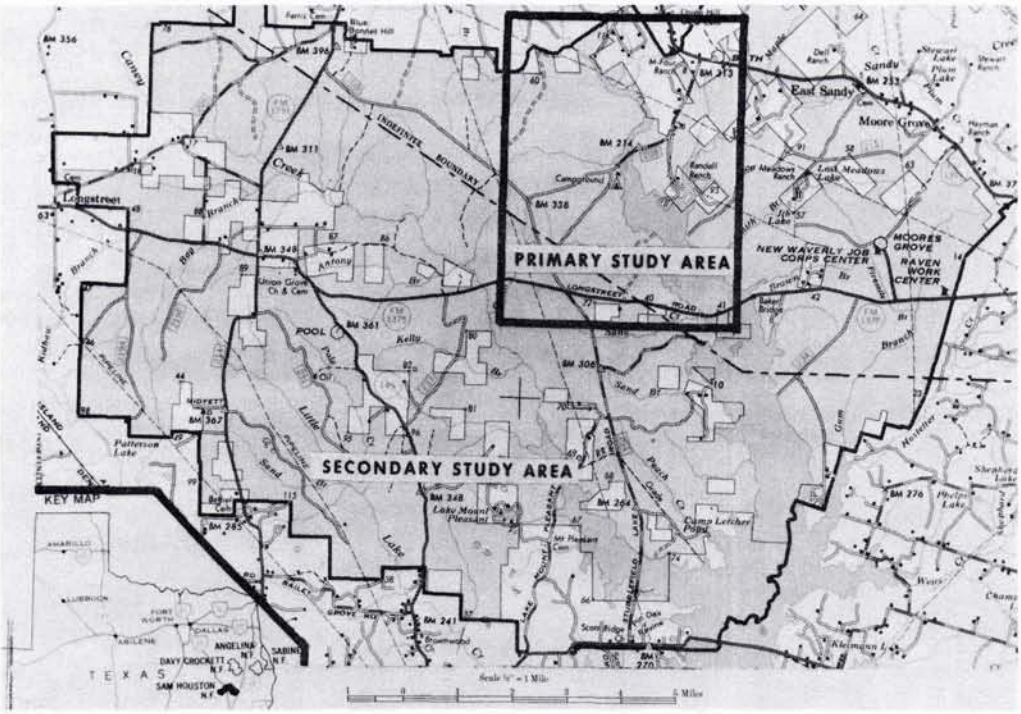

FIG. 1. The test site in the Sam Houston National Forest in eastern Texas.

ture could be automatically mapped if it had a distinctive spectral *signature*. Fortunately most forest features do have such signatures, and it is only where the forester wishes to get down to fine distinctions, such as age and vigor classes or distinctions between similar species, that he has difficulty.

The illustration that is shown in Figure 2 indicates the results of a timber mapping attempt using clustering, and beside it in Figure 3 is a *ground truth* map for comparison. It will be noted that the computer misidentified regeneration areas in many instances, calling them hardwood or hardwood, cutover, which they resemble due to the heavy sprouting of hardwoods between the planted pines.

The accuracy of these computer-generated maps was difficult to measure. By a simple point-by-point count of areas correctly and incorrectly classified, the highest accuracy achieved by these techniques was 74 percent. This is confusing because it allows no credit for classifications that are nearly right, nor does it allow credit for making a 14-class map, which is difficult, compared with only a 2- or 3-class map, which would be much easier. In fact, if only three primary classes were classified alone, accuracies rose into the nineties. This was a first attempt and higher accuracies are to be expected as techniques improve.

SERENDIPITY

It was also learned that the after effects of light ground fires could be detected in ERTS imagery. On one occasion, a prescribed burn was set in pine timber to clear out brush prior to marking the timber for sale. The fire occurred in mid-October 1972, and it was detected on the next cloud-free ERTS coverage on November 27, 1972. The fire covered approximately 40 hectares (100 acres). By this time some of the small trees had been weakened and even killed, and some of the needles throughout the stand had started to turn brown. However, the main cause of the spectral change was probably the temporary weakening of most of the trees. The effects caused the area to appear as a black smudge on otherwise red coloration (indicating healthy trees) on color composites. The precision with which this light fire was registered indicates that ERTS data may be used in the future in fire damage assessment, which requires that the perimeters of large fires be mapped.

During the course of the investigation a pine bark beetle epidemic occurred within the test area, and it would have been a finding of considerable significance if it could have been detected. However, the trees were killed in small groups, usually less than a hectare in size, and these groups were less

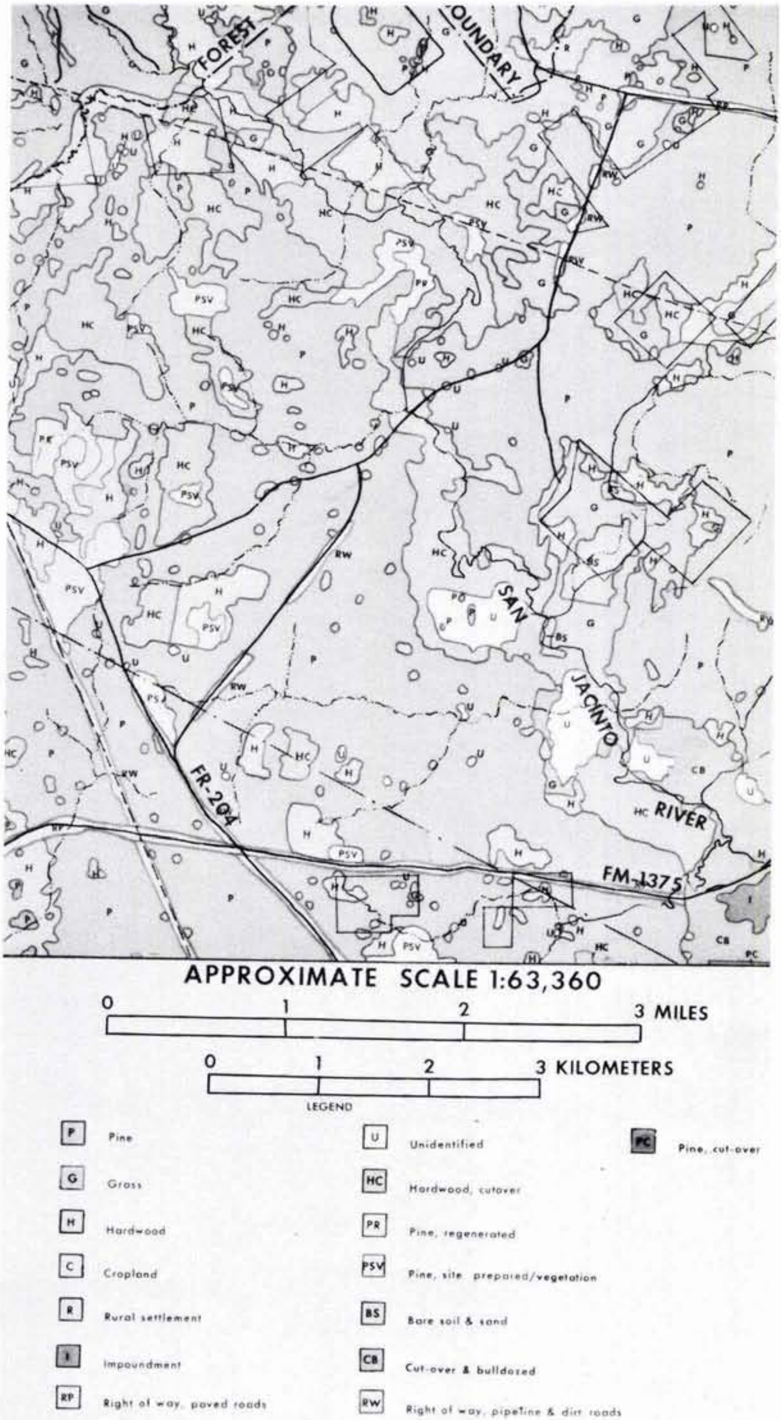

FIG. 2. An example of a timber-type map made by the computer technique called *clustering*.

than the ERTS resolution limit. Damage was detected in one instance, however, where approximately two hectares of pines were killed.

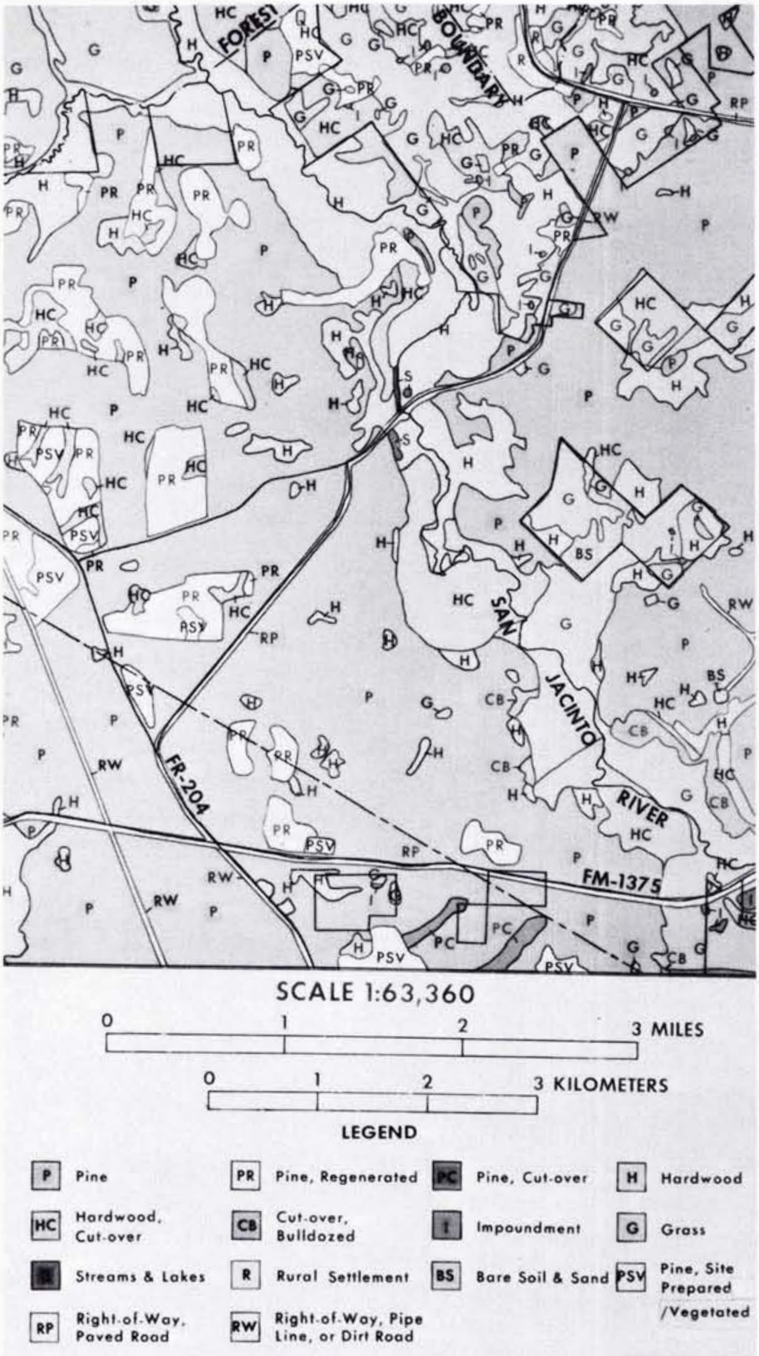

FIG. 3. The ground truth map of the test site by which the computer map was evaluated.

Continuous Inventories by ERTS

In addition to the possibilities for producing timber inventory maps, described above, the ERTS data have an outstanding advantage: that of providing sequential coverage. This is made possible by the identical scale and time of coverage, making registration of one coverage to another possible either visually or by computer. This provides an opportunity to make temporal studies of such changing situations as the progress of site preparation for planting, timber cutting and insect and disease damage, where the situation may be assessed in time to start control measures before it is too late. Such epidemics as the tussock moth in the northwest and the spruce budworm in the northeast, come immediately to mind as examples where ERTS might have helped if it had been applied in time.

This capability for repetitive coverage, if combined with various computer techniques, will make continuous forest inventories possible on a scale and scope never before imagined. In addition, various statistical techniques, such as multistage sampling, can be used with ERTS data to make extensive timber volume surveys. This flow of information will provide the opportunity for greatly improved management practices. This should aid in balancing supply and demand and preventing shortages.

The Potential

A whole new era of opportunities for forest inventories is around the corner, and foresters would do well to prepare for it. As this new concept will require a new technology and large investments in computers, it will not come about immediately, but planning and refinement of the technology should start now.