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Optical Bar Panoramic Photography for Planning Timber Salvage in Drought-Stressed Forests

Panoramic photographs were a valuable aid for planning salvage sales in California.

ABSTRACT: *Panoramic aerial photographs were obtained over 40 million acres of forest land in northern California during the period July 1978 through September 1979. These were used, as an aid in planning timber salvage sales, to locate concentrations of bark beetle-caused tree mortality following a severe drought. Several innovative procedures devised to effectively use these unconventional format photographs under field conditions are described. The photos were used in 223 salvage sales, resulting in a harvest of 532.2 million board feet of bark beetle killed timber during the period July 1978 through May 1979.*

INTRODUCTION

THE NATIONAL FORESTS in northern California sustained an estimated loss of 13.4 million trees (9.5 billion board feet—1.6 billion cubic feet) between mid-1975 and June 1979†. These were attacked and killed by several species of bark beetles; especially, the California five spined ips, *Ips paraconfusus*, and the western pine beetle, *Dendroctonus brevicomis*, following stress caused by a severe drought which occurred in 1975 and 1976 (Plate 1).

This mortality represented a substantial portion of the merchantable timber produced on these lands. Individual trees can be worth several hundred dollars each, depending on size, species, condition, and location. A gross dollar estimate of the value of standing dead trees associated with this drought (before deductions for defect, access, etc.) exceeded $900 million. An unusually large effort was required to salvage this volume of dead and dying timber rapidly in order to minimize loss of value due to deterioration.

A current inventory of the volume and location of mortality is vital to an effective salvage program. Foresters were using traditional methods such as driving to mountain tops or chartering aircraft to gain vantage points from which they could locate and assess tree mortality. Standard aerial photographic methods were considered as an aid to detection and salvage planning. We soon realized, however, that conventional aerial photography from low altitudes would take months to acquire and that the cost of complete coverage would be prohibitive. Since mortality typically occurred in groups of no more than 200 trees, Landsat imagery, even if properly timed and immediately available, was considered unsatisfactory because its spatial resolution and spectral characteristics are not capable of resolving a target of this size.

In 1978, the USDA Forest Service, Pacific Southwest Region, participated in a test to evaluate small scale photographs taken with two high-resolution cameras for detecting tree mortality caused by bark beetles (Klein *et al.*, 1978). Results

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† These estimates do not include tree mortality on private or other public lands, which together nearly equal the area of the National Forest land which was surveyed.

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 48, No. 5, May 1982, pp. 749-753.
0099-1112/82/4805-0749$02.25/0

PLATE 1. Group of ponderosa pine on the west slopes of the Sierra Nevada in California killed by bark beetles following the severe drought of 1975-76.

of this test indicated that the KA-80A optical bar panoramic camera showed considerable promise as a tool for mapping tree mortality caused by bark beetles. Therefore, it might be an effective means of locating groups of dead and dying trees for salvage sales. Characteristics of this camera system and its potential uses in forest pest management are discussed by Ciesla *et al.* (1982) and Liston (1982).

PHOTO MISSIONS

Photo missions were flown July 1978, September-October 1978, and September 1979 (Figure 1). Nearly 40 million acres of northern California forest land were covered during each mission. A NASA U-2C aircraft equipped with an Itek KA-80A optical bar panoramic camera based at the NASA Ames Research Center, Moffett Field, California, was used. Complete coverage of the area required about eleven hours flight time using this aircraft. High-definition aerial Ektachrome infrared film (SO 131) was used. Forward overlap of 55 to 65 percent between successive frames along nadir was obtained for stereoscopic viewing.

Total cost to USDA Forest Service for the three overflights and three duplicate film copies of each flight was approximately $275,000, or $0.007 per acre.

Each overflight produced 50 to 60 thousand feet of original and duplicate film. This severely taxed film processing facilities at the NASA Ames Research Center. Film from the September-October 1978 overflight was processed by the Environmental Protection Agency—Environmental Photographic Interpretation Center (EPIC) in Warrenton, Virginia. Processed film was in the hands of users an average of 2½ months after flight date.

PREPARATION OF KA-80A PHOTOGRAPHS FOR FIELD USE

Several factors affecting usefulness of the resulting photographs for tree mortality salvage planning needed attention before field work could begin.

Panoramic photos cannot be viewed stereoscopically with conventional equipment unless the frames are cut and repositioned. Also, field sites, i.e., Ranger Stations or Forest Supervisors' Offices, at which the photographs would be used had no provisions for expeditiously handling panoramic photos on rolls. Therefore, we separated each frame and devised a standard technique to catalog and access them by mission and frame number.

To prepare photos for rough field use, we laminated both sides of each roll with heat-bonded, clear 1½ mil plastic film. This effectively protected the film and caused little loss in interpretability of the photo image. Cost of lamination was approximately $0.075 per foot of film.

Next we estimated ground coverage of each photo and prepared a spot map to aid in cataloging, locating, and retrieving photos for use.

We then cut each frame into five equal segments using selected scan elevation markers on the photo margins. Each segment was labeled and located on an index map.

VIEWING KA-80A PHOTOGRAPHS

Positive transparency film must be illuminated by transmitted light for viewing. Basic fluorescent light boxes, such as the General Electric Model 11FV1 X-ray illuminator, were used as light tables in the office. These viewers are equipped with fluorescent ringlights which are available in a variety of light colors. Color of photo illumination was selected to best suit film color balance and density from each photo mission by changing the bulb in the light box. The most generally useful lamp color was cool white, although daylight (furnished with the illuminator), white, and warm white were required for maximum flexibility. In the field, illumination was accomplished by fastening the photograph segments to a translucent plastic board, using paper clamps, and holding the board toward a cloud, a brightly illuminated rock or bare ground, or obliquely toward the sun so the sunlight strikes the board at a sharply grazing angle. Care must be exercised to avoid viewing directly toward the sun.

Stereoscopes affording 2×, 4×, and 10× magnification were used for office and field interpre-

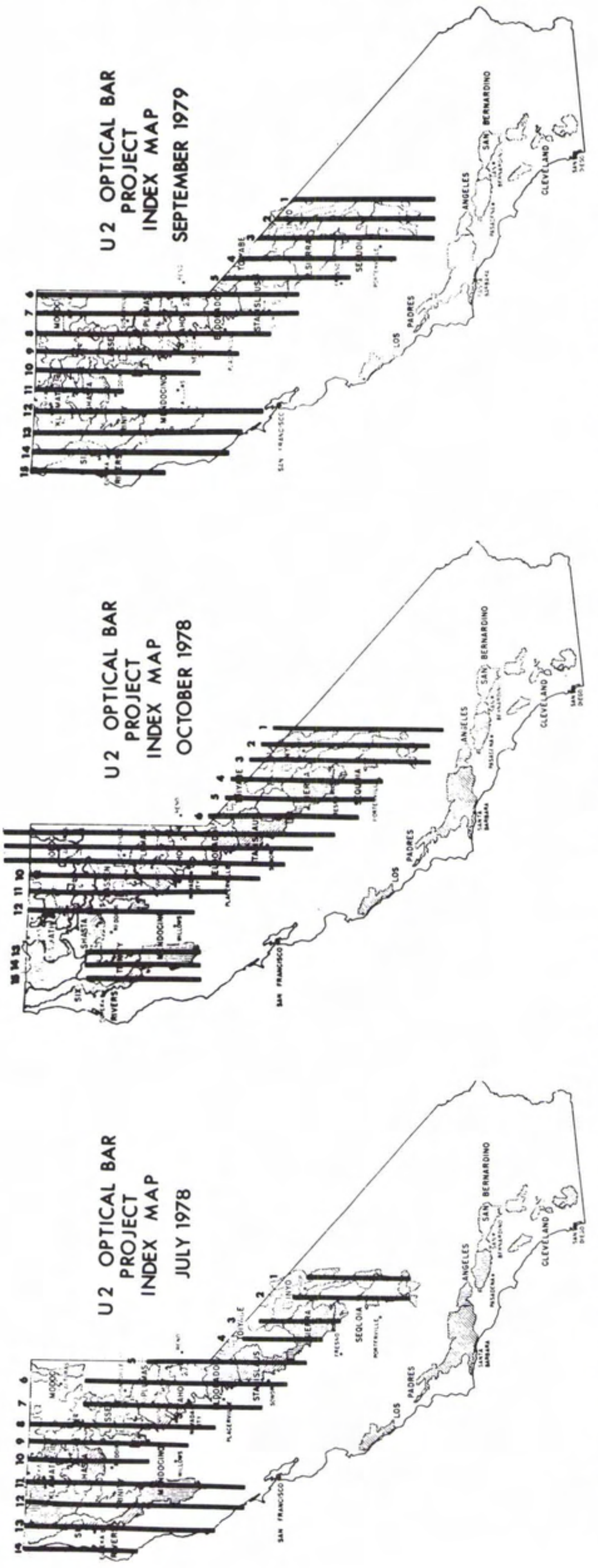

FIG 1. Forest land in California covered by KA-80A optical bar panoramic photography in July 1978, September-October 1978, and September 1979.

tation. We used the Abrams CB-1 stereoscope as provided by the manufacturer because it affords both 2× and 4× magnification in a single compact inexpensive unit which can be carried in the field. Greater magnification than 4× is occasionally needed for interpretation.

Technology Transfer

The transfer of this technology to users was the most challenging step to implement. All equipment and supplies necessary were provided to users along with the photography and necessary training. As techniques for distributing and utilizing the photography were devised, training materials were prepared, and supplies and equipment were ordered and distributed. A field coordinator was designated from each Forest. They met prior to the photo missions and were given information about the project along with actual instruction and examples of the photography.

Forest coordinators in turn identified specialists in Ranger Districts who would receive photographs and training. District specialists selected for training were experienced photo interpreters.

Film from the July 1978 mission was received in late July and early August. It was laminated and hand carried, on the rolls, to selected Ranger District personnel gathered at specified work/training sites. Each District received the frames covering the lands they administered and equipment needed for photo interpretation and field checking. After instruction, they indexed, labeled, and separated the photos of their areas, and practiced interpretation of dead trees at this photo scale. They spent a day in the field, learning and practicing field location and identification techniques.

Through these work/training sessions, key personnel from approximately 60 Ranger Districts were organized, equipped, and instructed over a period of several weeks. Thus, a very laborious chore of indexing, cutting, and labeling miles of film was accomplished with minimum time and effort. Also, field personnel grew familiar with the aerial photographs needed for their unit.

With minimum training and field experience, foresters and forestry technicians already accustomed to viewing conventional aerial photos in their work could efficiently use this new photography to identify dead and dying conifers.

Results and Conclusions

We found that periodic overflights with the panoramic camera system were invaluable for planning salvage operations. Using characteristic signatures of dead and dying conifers on color IR film (Ciesla, 1977; Murtha, 1972), National Forest personnel could easily detect faded trees and plot their location and approximate number on area maps. Accuracy of detecting discolored tree crowns at these photo scales is discussed in companion studies (Klein *et al.*, 1978; Klein, 1982; Dillman and White, 1982). Since the objective of this work was to provide a product from which to plan timber salvage sales and was operational in nature, no attempt was made to obtain additional data on photointerpretation accuracy.

Reports received through May 1979 indicated that KA-80A photos were used for 223 salvage sales, resulting in a harvest of 532.2 million board feet of dead timber. Several Ranger Districts reported savings in man-hours ranging from 94 to 300 man-hours per District, and two Districts reported monetary savings of $4,000 and $10,000. Most users identified the immediacy and broad area coverage as factors enhancing its usefulness. It was universally considered a valuable tool in planning salvage sales.

Users from most Forests agreed that late fall flights were preferable to summer flights because:

- Up to date photography is vitally important to users dealing with rapidly changing conditions. Delay between flight date and delivery of images to users is far more harmful in the busy summer season than in the less hectic fall and winter seasons. Biological activity slows in winter, and work shifts move toward office and planning activities. Preparation and organization is required before new photographs can be used. Therefore, photographs taken late in fall appear to be the most useful planning tool.
- Photographs obtained in late fall showed mortality which occurred over the summer. This is useful in planning salvage of the mortality the following spring.
- Errors in classification of vegetation, and vegetation changes induced by dynamic environmental factors and residual snowfall, are minimized by fall flights. Long sequences of days which are cloud free can be expected in September and early October over California forests. Fall coloration of hardwoods is not a confusing factor for photo interpreters except at very high elevations.
- Users of high altitude photographs in California have determined that much time and effort can be saved even under normal mortality conditions with use of appropriately timed U-2C flights. Therefore, the value of KA-80A photos may become even greater when tree mortality declines to normal levels.

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(Received 29 November 1980; revised and accepted 11 December 1981)

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Description will be published in June, 1982 Issue