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Panoramic Aerial Photography in Forest Pest Management

The Itek KA-80A Optical Bar Camera Provides a Tool for Rapid Data Acquisition Over Large Areas of Forest Land

Abstract: *The role of aerial photographs for providing data required in forest pest management is reviewed. The Itek KA-80A optical bar panoramic aerial camera is introduced. Potential applications, advantages, and disadvantages of panoramic photographs in forest pest management are discussed.*

Introduction

Insects and disease are major factors affecting productivity of forest lands in the United States. For example, in 1978 the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, was epidemic on 985,912 acres of lodgepole pine forests in Montana alone and killed 10.2 million trees. These infestations destroyed 122.7 million cubic feet of timber (Bennett *et al.*, 1980).

Damage caused by many forest insects and diseases is visible from long distances. This is especially true of pests which cause tree mortality or damage foliage. For years aerial reconnaissance surveys, using trained observers, have been a cornerstone in detection systems designed for early discovery of outbreaks and will continue to be so in the future.

Aerial photography has also been an effective tool for mapping damage caused by forest insects and diseases. A number of applications and sampling methods are described in the literature. These are in various stages of development ranging from conceptualization to full operational use.

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Remote Sensing in Forest Pest Management

Minimizing effects of destructive pests is an integral part of forest resource management. Simply stated, the objective of forest pest management is to reduce losses to a level where management goals and objectives are not affected by pest activity through the use of techniques which have minimal adverse impact on the environment.

In recent years, the concept of integrated pest management (IPM) has received wide acceptance both in agriculture and forestry. A number of definitions of IPM appear in the literature. The one currently used by USDA Forest Service and contained in the planning regulations of the National Forest Management Act of 1976 (NFMA) is as follows:

> A process in which all aspects of a pest-host system are studied and weighed to provide the resource manager with information for decision making. Integrated pest management is, therefore, a part of forest or resource management. The information provided includes the impact of the unregulated pest population on various resources' values, alternative regulatory tactics and strategies, and benefit/cost estimates for these alternative strategies. Regulatory strategies are based on sound silvicultural practices and ecology of the pest-host system. Strategies consist of a combination of tactics such as stand improvement plus selective use of pesticides.

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The overriding principle in the choice of strategy is that it is ecologically compatible or acceptable.

As defined in the planning regulations of NFMA, IPM consists of two elements: a decision process and the implementation of one or more ecologically sound management tactics to reduce losses commensurate with management objectives. Sound data on the status and trend of destructive forest pests are needed for intelligent pest management decision making.

The concept of forest planning under NFMA recognizes three managerial or planning levels: the forest or local level, the regional level, and the national level. Management decisions made at these levels vary in scope from setting broad targets responsive to national needs for timber and other forest resources to scheduling specific units or stands for harvesting. Decisions on how to manage pest populations will also vary in scope relative to planning level. On the local level, a resource manager must decide what to do about a given pest problem in a stand or compartment. On a broader level resource managers, particularly those in the public sector, are concerned about allocating funds, projecting resource yields, reporting accomplishments, and responding to an environmentally conscious public, either as individuals or through their Congressional delegations (Table 1). To satisfy the latter need, broad summaries of the location, status, and trend of major pest species are required.

Color and color infrared aerial photographs are effective tools for mapping vegetation injury caused by a number of forest insects and diseases and have proven to be a valuable aid in providing data for pest management decision making. Applications include mapping of infestation boundaries (Ciesla, 1974), estimating infestation levels or loss (Klein *et al.*, 1979), planning salvage or control operations (Wert and Roettgering, 1968), evaluating the effectiveness of treatment tactics (Ciesla *et al.*, 1971), and rating hazard of stands to specific insect and disease pests or pest complexes (Heller and Miller, 1977). A number of classification schemes and approaches to sampling using combinations of aerial sketch mapping, aerial photography, and ground surveys have been described (Wear *et al.*, 1966; Murtha, 1972).

In response to national requirements for data on losses caused by major forest pests, a multistage survey has been designed to estimate losses caused by mountain pine beetle on a statewide basis. This consists of a combination of aerial sketch mapping, large-scale color aerial photography, and ground sampling. Data provided by this survey include estimates of acres infested, numbers of trees killed, and cubic-foot volume loss. The method has been used in both lodgepole and ponderosa pine forests throughout the Rocky Mountains (Ciesla and Klein, 1978; Hostetler and

TABLE 1. INFORMATION REQUIREMENTS FOR FOREST PEST MANAGEMENT DECISION MAKING.

Planning Level	Data Required	Uses of Data
Forest	In-place descriptions of current and anticipated losses on a management unit basis (i.e., stand, compartment) in a form that can be integrated with other resource data (soils, vegetation, topography, management constraints, etc.) for pest management planning and decision making.	Selection of most appropriate pest management tactics to reduce losses.
Regional National	Summaries of acres infested, mortality, and growth impact by major insect and disease agents and land ownership class on a statewide basis.	Provide basis for establishing priorities and funding of action and research programs. Integrate insect and disease damage into projections of resource outputs from forest lands. Provide data for accountability for expenditures, activities, and accomplishments. Respond to inquires from Congress and the public.

Young, 1979a, b; Klein *et al.*, 1979; Bennett and Bousfield, 1979; Bennett *et al.*, 1980).

The Panoramic Camera—A Potential New Tool

To date, most successful uses of aerial photography for mapping vegetation damage have been at large (1:600 to 1:2,000) or medium (1:4,000 to 1:12,000) photo scales. This has dictated that aerial photos be used only for sampling infestations rather than for 100 percent photo coverage. The availability of a high-resolution camera system might permit use of smaller photo scales, thus allowing more extensive coverage of infested areas.

The USDA Forest Service is currently engaged in a major developmental program which is investigating the application of a variety of remote sensing systems, including many advanced aerial camera systems. This developmental effort was prompted by the need to cover large areas such as a National Forest or a state at maximum image resolution.

Panoramic aerial cameras have been available since the 19th Century. It has only been during recent years, however, that intensive efforts began toward their design, development, testing, and routine application to aerial photography (ASP, 1966). The basic design of panoramic cameras, which is detailed in another paper (Liston, 1982), provides for high resolution of the center lens field over the total angle of scan.

One of the more successful of the advanced camera systems for Forest Service applications has been the KA-80A optical bar panoramic camera system which was designed by the Itek Corporation for the Department of Defense (DOD) over fifteen years ago (Figure 1). The design has proved successful in meeting DOD requirements. Later in the 1960's, NASA selected the KA-80A design to be used in the Apollo Program to provide high-resolution photographs of the moon. Again the design proved successful.

The KA-80A produces a panoramic image on standard five-inch wide aerial film which is 4½ by 50 inches in size. Lateral coverage is 120 degrees, 60 degrees each side of nadir. It is equipped with an *f*3.5, 24-inch focal length lens. From a flying height of 60,000 feet above mean terrain elevation, it produces an image at nadir at a scale of 1:30,000. At 60 degrees from nadir, intrack photo scale is 1:60,000 and crosstrack photo scale is 1:120,000. Forward ground coverage is 2.3 nautical miles at nadir and 17.1 nautical miles at 60 degrees off nadir (Figure 2). Flight planning is built around effective film utilization out to 35 degrees on each side of nadir.

In 1977 the Forest Service in cooperation with the NASA Ames Research Center, Moffett Field, California, began flying the KA-80A in a U-2 aircraft and photographing large areas of forest lands. These flights are continuing and are flown in response to specific program requirements which can best be satisfied by the unique capabilities of the KA-80A.

The first use of the Itek KA-80A optical bar camera by the USDA Forest Service was to estimate the volume of standing dead timber in a portion of northern Idaho (Weber *et al.*, 1977). Although this survey fell short of meeting all of its objectives, it established that the KA-80A had sufficient promise to warrant further development in forestry and particularly in forest pest management.

During the following year, an evaluation was conducted to compare the relative efficiency of two high-resolution cameras—the Itek KA-80A and the Hycon HR732 9 by 18 inch large-format frame camera—for detecting current tree mortality caused by bark beetles. This evaluation was conducted on a 40 by 110 statute mile test site along

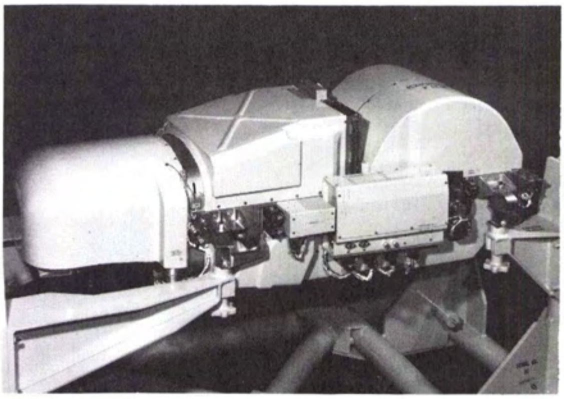

Fig. 1. Itek KA80A Optical Bar Panoramic Camera (Photo courtesy of Itek Corporation).

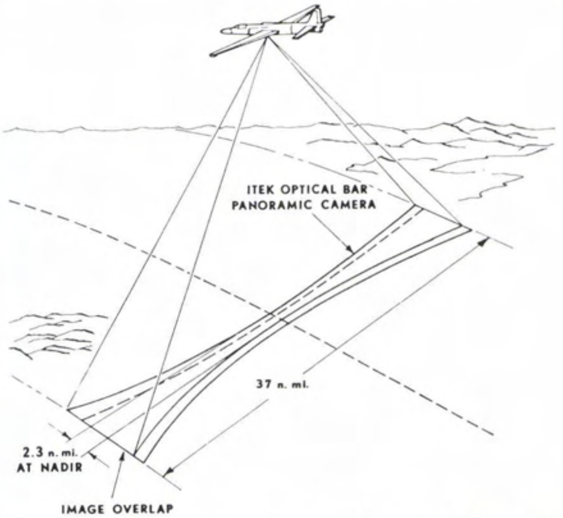

Fig. 2. Land area covered on a single frame of film with the optical bar panoramic camera.

the west slopes of the Sierra Nevada in central California. This evaluation showed that the panoramic camera format was superior to the large-format frame camera and showed sufficient promise to continue technology development (Klein *et al.*, 1978).

Results of the early studies summarized here and those detailed in the following papers in this issue (Klein, 1982; Dillman and White, 1982; Caylor *et al.*, 1982) indicate that panoramic photography offers the following opportunities for data acquisition in forest pest management:

- The combination of high-image resolution and large-area coverage inherent in panoramic photography provides the opportunity for 100 percent photo coverage of outbreak areas. This permits extraction of two stages of data, stratification and detailed crown counts, from one set of photos instead of conducting a sketch map survey followed by a photo mission.
- Use of high-speed, high-altitude aircraft, such as the U-2, permits rapid coverage of large areas of forest land. For example, during the 1978 test in the Sierra Nevada, panoramic photography was obtained over a 4,400 square mile test site in 16 minutes (Klein *et al.*, 1978). Rapid photo acquisition is essential for accurate monitoring of vegetation damage if continuous coverage of large areas is desired because damage patterns can change almost daily as insect feeding progresses, trees refoliate, or dying trees lose their foliage.
- Continuous coverage of forested areas provides the opportunity for photos acquired for vegetation damage assessment to be used by other disciplines such as land-use planning, watershed evaluation, road location, or timber sale planning. Therefore, an opportunity exists to share the cost of photo acquisition with other resource management specialists.

Potential disadvantages of panoramic photography in forest pest management include:

- The unusual film format (4½ by 50 inches) is cumbersome and requires special equipment for proper handling in both the office and in the field. In addition, the continuously changing photo scale requires special photointerpretation aides for extraction of data on areas of infestation, or for classifying damage intensity on grids of equal land area. Also there is a tendency for loss of photointerpretation accuracy as photo scale decreases.
- The Itek KA-80A optical bar panoramic camera is currently used in high-altitude aircraft (nominal flying height = 65,000 feet above sea level). Presently there are no civilian class aircraft capable of accommodating this camera in an efficient way. Therefore, photography can presently be acquired only through NASA. Photo acquisition, therefore, is dependent on NASA's workload and on the availability of a limited number of aircraft.
- Photo acquisition with panoramic photography is expensive in comparison to conventional photographic coverage. For example, in Colorado in 1980, photo acquisition cost for panoramic photography was $39,930 compared to $12,000 for aerial sketch mapping and large-scale sample photography over the same area in 1979. Higher cost is justified if the resulting photography can be used for applications other than forest pest management such as land management planning, vegetation type of mapping, or updating transportation system maps. If other resource disciplines can make effective use of this technology, photo acquisition costs can be proportioned among several users.

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PRELIMINARY NOTICE AND CALL FOR PAPERS

Remote Sensing and the Atmosphere

University of Liverpool
15-17 December 1982

The purpose of the meeting, sponsored by the Remote Sensing Society (England), will be to promote dialogue between those who sense the atmosphere and those who are obliged to remove atmosphere distortion before interpreting surface data. There will be some general sessions to permit discussion of other research. There will also be an opportunity to offer material in poster sessions.

Those proposing to present papers or poster sessions should address their comments specifically to atmospheric observations and/or inversion techniques with reference to

- Atmospheric dynamics, state, and constituents
- Climatology and climatic variables
- Minimization/removal of atmospheric effect
- Air pollution monitoring from remote platforms
- Planetary atmospheres

Contributors must submit title and 200-word abstract by *31 May 1982* to

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