AN--ERTS-I Project

INVESTIGATION OF THE DETECTION & MONITORING OF FOREST INSECT INFESTATIONS IN THE SIERRA NEVADA MOUNTAINS OF CALIFORNIA

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16. Abstract

Since the signing of the contract on June 21, 1972, work has proceeded on the planned schedule. Underflight photos in color and color IR, at scales of 1/5,000 and 1/18,500 have been obtained and interpreted. U-2 imagery for July 27, 1972 was received on November 1, 1972 and have been partially interpreted. Only partial imagery for ERTS I has been received and we have been unable to complete the interpretation. Acquisition of ground truth for the fall period has been completed and partially analyzed. It has been determined that all classes of tree mortality and degrees of defoliation are readily and accurately identified from under flight photos in both scales of 1/5,000 and 1/18,500. Preliminary analysis of the U-2, RC-10, color IR indicates considerable promise that this imagery will compare favorably with the larger scale photography. There has been a major change in product orders from RBV to MSS due to the malfunction of the former.

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INTRODUCTION

This report covers activities for the period of June 21 through November 30, 1972 for the Investigation of the Detection and Monitoring of Forest Insect Infestations in the Sierra Navada Mountains of California through the use of ERTS I imagery, Contract NAS5-21770, effective date of June 21, 1972.

These activities have included underflight photo coverage, photo interpretation of underflight photography, both that supplied by our contract and of NASA U-2 support; preliminary investigation of ERTS I imagery; selection of ground truth sample plots; field checking of photo interpretation; and collection and analysis of ground truth information.

Since the signing of the contract on June 21, 1972 work has proceeded on the planned schedule, as outlined in the Proposal, with no major exceptions. One minor exception was changing the scale of the underflight photography from 1/20,000 to 1/18,500 due to the limitation of the plane used in the photography. Another exception was changing the date of the underflight photography from early August to late July.

Dr. Ralph C. Hall, Principal Investigator, has met and conferred with members of his team of investigators on numerous occasions and has prepared a work plan for office and field procedures on the project. He has also held numerous conferences with his Technical Monitor, Mr. Ed Crump, and his Scientific Monitor, Mr. Robert Heller.

It was necessary to make a project order change from RBV to MSS due to the malfunctioning of the former.

Change in Product Orders

In our original product order, ID-PR-516, Proposal No. MMC #027 submitted under the date of December 20, 1971, we requested RBV coverage. Through phone conference with Technical Monitor, Edward Crump, in early July, 1972, it was learned that the RBV system was not functioning and it was agreed that we would substitute MSS, bands 4, 5, and 6. This change resulted in a substantial delay in our receiving ERTS imagery of our target area.

Underflight Photo Coverage

Dr. Robin Welch, Earth Satellite Corporation, took all of our underflight photography as specified in our proposal. Initially the whole target area was covered by 9"x9" color IR and sample coverage by 70mm color at a scale of 1/18,500 on July 28, 1972 to coincide with U-2 coverage on the same date. Following interpretation of these photos by Stephen Wert, Earth Satellite Corporation, sample photos were taken into the field by Hall, Wert and Dr. Thomas Koerber, a cooperator from the Pacific Southwest Forest & Range Experiment Station, on August 14 through 16, to check on the accuracy of office interpretation. From this it was determined that the photo interpretation was consistently accurate in delineating the different classes of insect infestations.

Subsequently on August 28, 1972, Welch took color and color IR 9"x9" photos of selected target areas of differing degrees of insect damage, at a scale of 1/5,000. These were interpreted and used as a basis of random plot selection by Philip G. Langley, Earth Satellite Corporation, through a multistage forest sampling system.

U-2 underflight support was flown on July 27, 1972 and again late in October, 1972. The July 70mm imagery was received on October 5 and the 9"x9", RC-10 imagery was received on November 1, 1972.

To date we have not received the imagery from the late October flight but this has been promised for late December.

Photo Interpretation

Photo interpretation has been conducted on all of our own underflight photos at scales of 1/5,000 and 1/18,500 in color IR and on the U-2 July imagery as well as preliminary analysis of ERTS I imagery.

Scale 1/5,000

Photo interpretation has been completed on all of the photos at the scale of 1/5,000 and these were used as a basis for the selection of random field plots and also used in the field for purpose of precise plot location.

Scale 1/18,500

Some additional work needs to be done on our 1/18,500 scale photos and this work is expected to be completed in about two weeks. We have determined that all classes of tree mortality and needleminer defoliation can be readily identified from both scales in color and color IR, with the latter appearing to be superior in most classes of damage.

U-2 Underflight Support

We have been particularly impressed with the quality and resolution of the U-2 - RC-10 color IR 9"x9" photos taken on July 27, 1972. We still have some addiitonal interpretative work to do on these, but from our preliminary examination we feel that we will be able to detect all classes of tree mortality and

probably the extremes in defoliation from heavy to light. Since these photos were taken July 27, 1972 when evidence of defoliation was minimal due to the early stages of insect development, we are hopeful that the late October 1972 U-2 coverage will furnish us with clearer delineation of defoliated areas. We have noted visually, in mid October that the heavily defoliated areas show a marked contrast in color over that observed in late July.

ERTS I September 27, 1972 Imagery

Stephen Daus, Earth Satellite Corporation has been doing some preliminary evaluation of ERTS I imagery in the MSS bands 4, 5, and 6. He reports: "To date delineations have been made on a false color infrared simulation. It must be noted that this simulation was obtained by photographing the screen of an I^2S adcol viewer. Therefore, the quality of the image will not approach that being sent from NASA/Goddard. The image was prepared only so that interpretation could begin and no final results or conclusions should be drawn.

After delineation was completed, it was adjusted to the scale of the U-2 RC-10 photography using a vertical sketchmaster. After this adjustment, it was evident that a major portion of the delineations corresponded to division between high contrast features For example, consistently delineated were areas of water or shadow from all else, forest-bare ground interfaces, and forest vegetation densitites. This capability relied more on the amount of white granite showing through rather than the amount of vegetation present. This type of delineation could only by done where vegetation density differences were great.

These preliminary results apply only to the placement of the delineation lines. I have not as yet identified homogeneous areas nor deduced their significance in terms of ground conditions. This work is now in progress."

If it develops that different vegetation densities can be delineated on the ERTS imagery, then we could expect that at least our "dead" areas, where more than 80% of the tree volume has been killed, has a good chance of detection.

Daus is continuing to work on this problem, but as has been pointed out earlier, we will delay our report on Significant Results until we receive the color composites from Goddard.

Ground Truth Results

Ground truth data for tree mortality were collected from random plots, averaging 5 acres in size, selected from our 1/5,000 color and color IR photos, by a six-man field crew and covered a period of two weeks. All trees larger than 6 inches in diameter were measured and classified as to their condition into classes of living, green infested, recently faded and older dead.

Ground truth data for defoliation were obtained by Dr. Koerber by random sampling of ten twig samples, collected at mid crown, on ten sample trees from all infested areas. All the needles from each twig were examined and classified as to their condition into damaged or undamaged and the presence of living and dead larva, percent of damaged needles, and the oven dried weight of all the needles on each tip.

Preliminary analysis of the mortality data from sample plots in areas differing in intensity of tree mortality have shown significant differences in damage in our arbitrary classification of damage of "dead", dying and light damage. These data have shown

that 72% of the trees and 82% of the volume have been killed in the "dead" areas; 47% of the trees and 61% of the volume killed in the "dying" areas; and 15% of the trees and 18% of the volume in the light areas.

We arbitrarily classified the defoliated areas into three groups of, light, medium, and heavy damage. Our field data shows that the heavy areas had 64% of the needles damaged, with an average oven dried weight of 2.1 grams per tip. The medium areas had 38% of the needles damaged with a dry weight of 3.8 grams and the light areas had 9% of the needles damaged, with an average weight of 4.3 grams. Since the larva will continue to mine additional needles until they reach their full development in early July of 1973, we anticipate that significant additional damage will occur, particularly in the heavy area. This will also mean that the foliage color will become increasingly brown by next spring when the faded foliage should be more easily detected by all types of imagery.

Additional field twig samples will be collected in the spring of 1973 to verify this assumption. An early fall snow storm prevented our completing the field sampling on mortality in two areas, and these will be completed in the spring as soon as weather conditions permit.

Ground Checking Of Imagery

We have ground checked our underflight photos at scales of 1/5,000 and 1/18,500 in our target area to verify that we have properly identified areas of different degrees of tree mortality caused by the combined action of needleminer defoliation and attacks by the mountain pine beetle, as well as degrees of defoliation by the lodgepole needleminer.

Our U-2 and ERTS I imagery was received too late to check these out in the field both because the target area was inaccessible and also because the ground imagery had changed significantly because of the blanket of snow throughout the area.

Significant Results

Due to the fact that we have not received all of our ERTS I imagery at this date we will delay our evaluation of this until all imagery is in hand.

We have determined that our arbitrary classification of tree mortality into "dead," "dying" and light damage is sound in that each class is significantly different in terms of number and volume of trees killed. We have likewise determined that our different classes of defoliation of light, medium and heavy are significantly different in terms of the percent of damaged needles per tip and oven dried weight of the needles per tip.

We have found that all classes of tree mortality and degrees of defoliation are readily and accurately identified from underflight photos in color and color IR in both scales of 1/5,000 and 1/18,500.

Our evaluation of U-2 imagery is incomplete. We have determined, however, that through the use of RC-10 color IR we expect to be able to detect all three classes of tree mortality and probably at least two extreme levels of defoliation.

Future Plans

Our work load for the next six months will be realtively light and our activities will be concentrated on further evaluation of ERTS I, September 27, 1972 and U-2, July 27, 1972 and late October, 1972 imagery.

Due to the inaccessibility of our target area during the winter months, no significant field work is planned. As soon as environmental conditions permit, which means snow free sample areas in all classes of tree mortality and defoliation, we will take our ERTS I and U-2 imagery into the field to check on the various delineations obtained through photo interpretation techniques.

Acquisition of additional ground truth data are planned about June 1, 1973 if road and weather conditions permit.

Respectfully submitted,

Ralph C. Hall

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Principal Investigator

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