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15. Supplementary Notes

COLOR ILLUSTRATIONS REPRODUCED IN BLACK AND WHITE

16. Abstract

The first ERTS 1, NASA supplied color composite made from MSS bands 4, 5, and 7, frame #1055-18055, was received on Dec. 15, 1972 and the U-2 RC-10 imagery on Dec. 3, 1972. Considerable emphasis has been placed on various enhancement techniques with the best system to date being making copies of 9 x 9 color compositive positives, using Kodachrome II 35 mm. film with electronic flash for the light source. These are then enlarged to the desired scale. It is possible to detect the following from color composite 9 x 9 prints at a scale of 1/1,000,000: damaged and undamaged forests and other details including timbered vs non-timbered areas, pasture and agricultural land, major stream courses, mountain meadows, desert, rock domes and possibly glaciers. It is difficult at this scale to differentiate true lakes from dome shadows. At the enlarged scale of 1/80,000, three degrees of tree mortality are detectable: heavy medium, and light, where dome shadows can now be differentiated from true lakes.

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Figure 2. Technical Report Standard Title Page

An ERTS-1 Project

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

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May 31, 1973
TYPE II PROGRESS REPORT
December 1, 1972 through May 31, 1973

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 20771

INTRODUCTION

This Type II Progress Report covers the period of December 1, 1972 through May 31, 1973 for the Investigation of the Detection and Monitoring of Forest Insect Infestations in the Sierra Nevada Mountains of California through the use of ERTS 1 imagery with support by U-2 and conventional aerial photography, Contract NAS5-21770, effective date of June 21, 1972.

On December 15, 1972, we received the first ERTS 1, NASA supplied color composite made from MSS bands 4, 5, 7, #1055-18055 for the Yosemite scene taken on September 16, 1972. The first U-2 RC-10 color IR was received on December 3, 1972. Considerable emphasis has been placed on various enhancement techniques with ERTS 1 imagery during this period.

The author prepared and presented the significant results of research on the Detection and Monitoring of Insect Infestations at the Symposium on Significant Results Obtained from ERTS 1 during the period of March 5 - 9, 1973. He also prepared and submitted for publication in the "Consultant" an article on the utility of ERTS 1 and underflight photography for Consulting Foresters. The author also presented an illustrated program on "The Contribution of ERTS 1, in the Field of Natural Resources Inventory and Management" to the Orinda Rotary Club on February 14, 1973.

This period has been devoted exclusively to office work since adverse snow conditions has prevented travel into the target area.

ERTS 1 Imagery Enhancement

ERTS 1, NASA supplied color composites, from bands 4, 5, and 7, frame #1055-18055 for the Yosemite scene, taken September 16, 1972 were received on December 15, 1972, figure 1. Various enhancement techniques have been investigated, including, (1) using the I2S Digitol color additive viewer with MSS bands, 4, 5, and 6; (2) copies from the color composites negative through the inter-negative route by commercial photo firms; and (3) copies of the color composite positives, in cooperation with Ralph McFarland Chief Photographer for the Pacific Southwest Forest & Range Experiment Station, using 35 mm Kodochrome II, with an electonic flash to make slides and then having enlarged prints made from these. Figures 1 and 2 are examples of this technique.

Of all those tested, the number three gave by far the best resolution at comparable scales.

Evaluation of ERTS 1 Imagery to Detect Insect Damage

A number of different scales were investigated to attempt to detect and delineate degrees of damage caused by forest insects from enlargements of the original NASA supplied color composite print #1055-18055. The scale finally adopted which gave the best combination of resolution and detail was 1/80,000.

Scale of 1/1,000,000

Using this scale it was possible to differentiate two degrees of damage from insects; damaged areas from areas with no damage, figure 1. Other details detected included, timbered and non-timbered areas, pasture land, agricultural land, desert, lakes, mountain meadows, riparial vegetation, rock domes, old burned areas,

major stream courses and possible glaciers. There was some confusion at this scale in separating true lakes from dome shadows which closely resemble lakes.

Scale of 1/80,000.

Using this scale it was concluded that three degrees of damage from insects could be detected with a reasonable degree of certainty, figure 2, but before this can be confirmed it will be necessary to check these assumptions by on-the-ground inspection of all areas delineated. Some are already confirmed by existing ground truth data while others must wait for the completion of two specific areas believed to be heavily damaged by insects. The dome shadows resembling lakes could be readily separated from true lakes at this scale.

Color Classification of Damaged Areas

Color classification on a visual basis was made at each of the scales tested using the Munsell Book of Colors as a basis of classification with the following results:

Scale	Classification	Color by Eye	From Munsell Book of Color
1/1,000,000 Figure #1	No Damage	Cherry Red	5R - 5 - 8
	Damaged Forest	Milk Chocolate Brown	10RP- 4 - 4
1/80,000 Figure #2	Light Mortality	Blood Red	5R - 4 - 8
	Medium Mortality	Chocolate Brown	10R - 5 - 4
	Heavy Mortality	Moldy Yellow	5YR - 6 - 4

NASA Underflight Support

NASA underflight support was found to be extremely useful in detecting timber areas damaged by forest insects, with RC-10 color

IR imagery being particularly effective. It was found that by enlarging the 9 x 9 RC-10 imagery from a scale of 1/62,000 to 1/18,500, figure 3, the results compared favorably with the 1/18,500 color IR which was taken of the same areas by our sub-contractor.

One minor problem with the RC-10 photos was that they tended to be underexposed and a bit dark for the mountainous areas, since they were on the same roll which covered desert and agricultural scenes.

It was concluded that the U-2 - RC-10 color IR imagery, by itself, will prove to be an extremely useful tool in detecting forest insect outbreaks and that the A-1 or A-3 is expected to be even better.

Future Work

Since the target area for the Insect Detection and Monitoring Project has been inaccessible during the winter months it has been impossible to check the ERTS-1 imagery in the field, and the spring work schedule calls for this to be done as soon as the area becomes accessible. The initial step calls for a fly over inspection, with ERTS 1 imagery in hand, in cooperation with Dr. Robin Welch of Earth Satellite Corporation. The next step will be to complete the ground truth data on two areas of heavy mortality left unfinished last fall due to an early snow fall. Concurrently, twig samples will be taken and analyzed by Dr. Thomas Koerber, our Cooperator from the Pacific Southwest Forest & Range Experiment Station, of all of the defoliated areas which were sampled last fall, to determine change in defoliation patterns.

In mid July all of the sample areas photographed at a scale of 1/5,000 will be re-photographed by Dr. Welch to assess any changes which might have taken place during the last year.

Hopefully we will have our second NASA supplied ERTS 1 Color composite imagery for mid June by mid July to monitor any changes which have taken place over a nine-month's period.

Significant Results

Results af analysis of ERTS 1 color composite made by NASA from MSS bands 4, 5 and 7, frame #1055-18055 at a scale of 1/1,000,000 indicate that forests damaged by insects can be delineated and mapped from areas with no damage; and at this same scale other details detected include timbered and non-timbered areas, pasture and agricultural land, deserts, lakes, mountain meadows, riparian vegetation, rock domes, old burned areas, and major stream courses.

Enlargements from the above to a scale of 1/80,000 have improved detectibility to the point that three degrees of timber mortality can be identified and mapped.

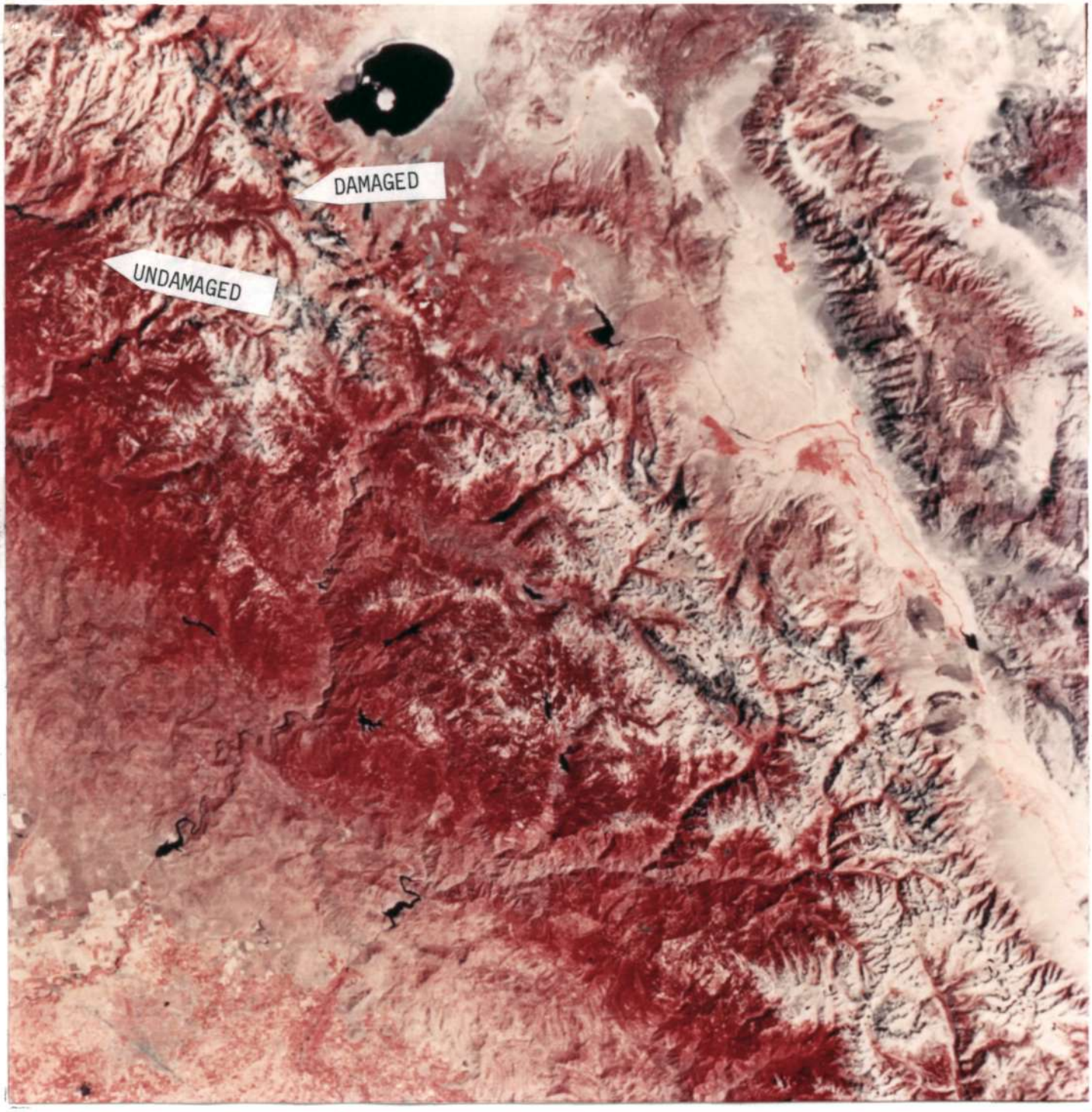

FIGURE 1

A Kodachrome II copy of a color compositive transparency supplied by NASA, frame #1055-18055, 16 September, 1972. Mono Lake, upper center, with insect damaged forest, milk chocolate brown, southwest from Mono Lake. Undamaged forest, cherry red. Crest of the Sierra Mountains running diagonally from northwest corner to southeast corner. Timbered area in a parallel band to the west, generally cherry red, farther to the west, a band of pasture land, generally lavender, with agriculture land in the extreme southwest corner. Immediately to the east of the Sierra Crest desert land, lemon yellow, with riparian vegetation along streams, and what is believed to be patches of agriculture land, blood red. White Mountains, diagonally in northeast corner.

FOREST INSECT DETECTION - SIERRA NEVADA MOUNTAINS, CALIFORNIA
ERTS-I IMAGERY GREATLY ENLARGED
SEPTEMBER 17, 1972

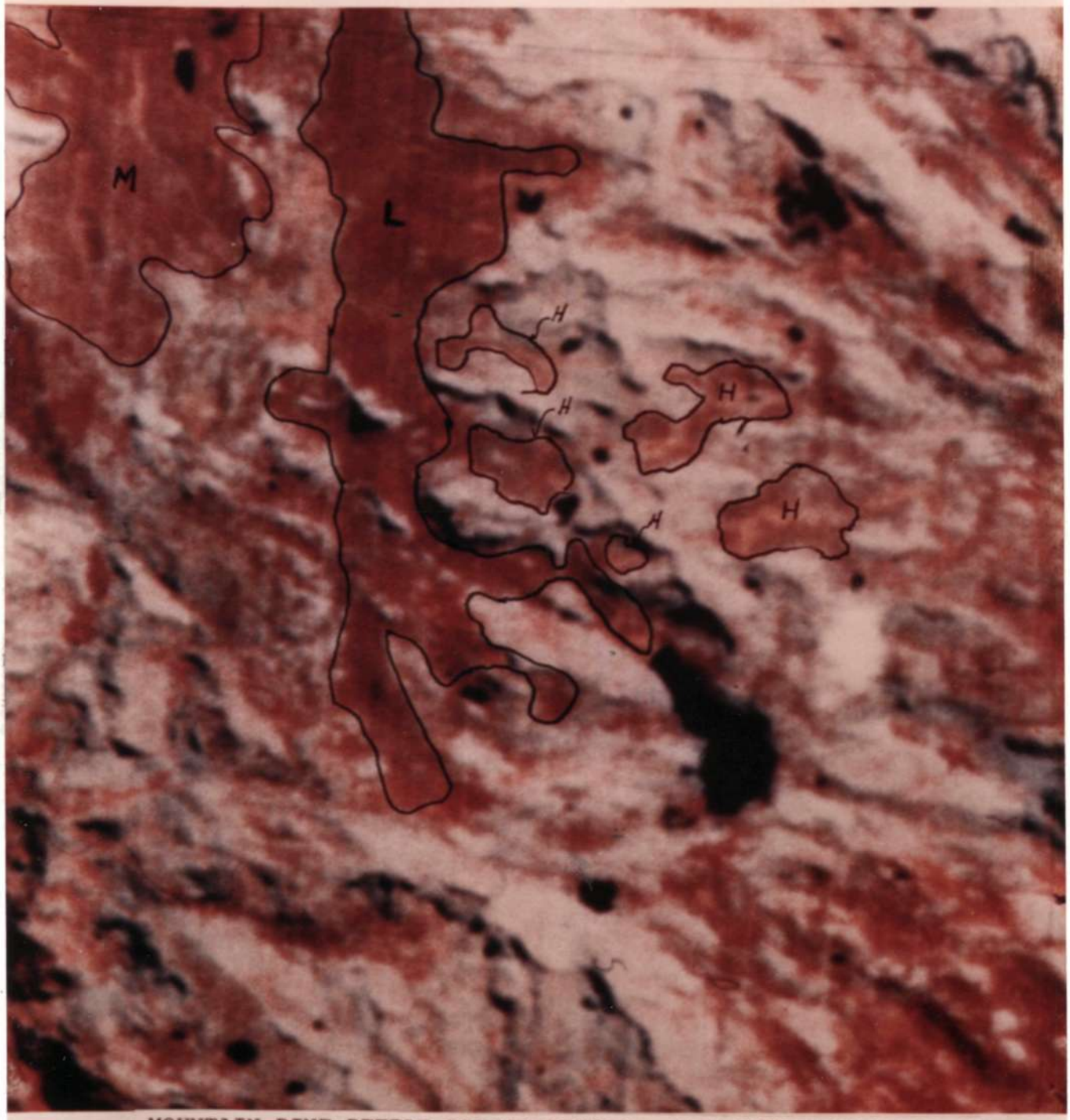

FIGURE 2

A Kodachrome II enlargement of the color composite in figure 1 to a scale of approximately 1/80,000, illustrating three degrees of insect damaged forests. Note the two dome shadows resembling lakes in the south central section of the lightly damaged area.

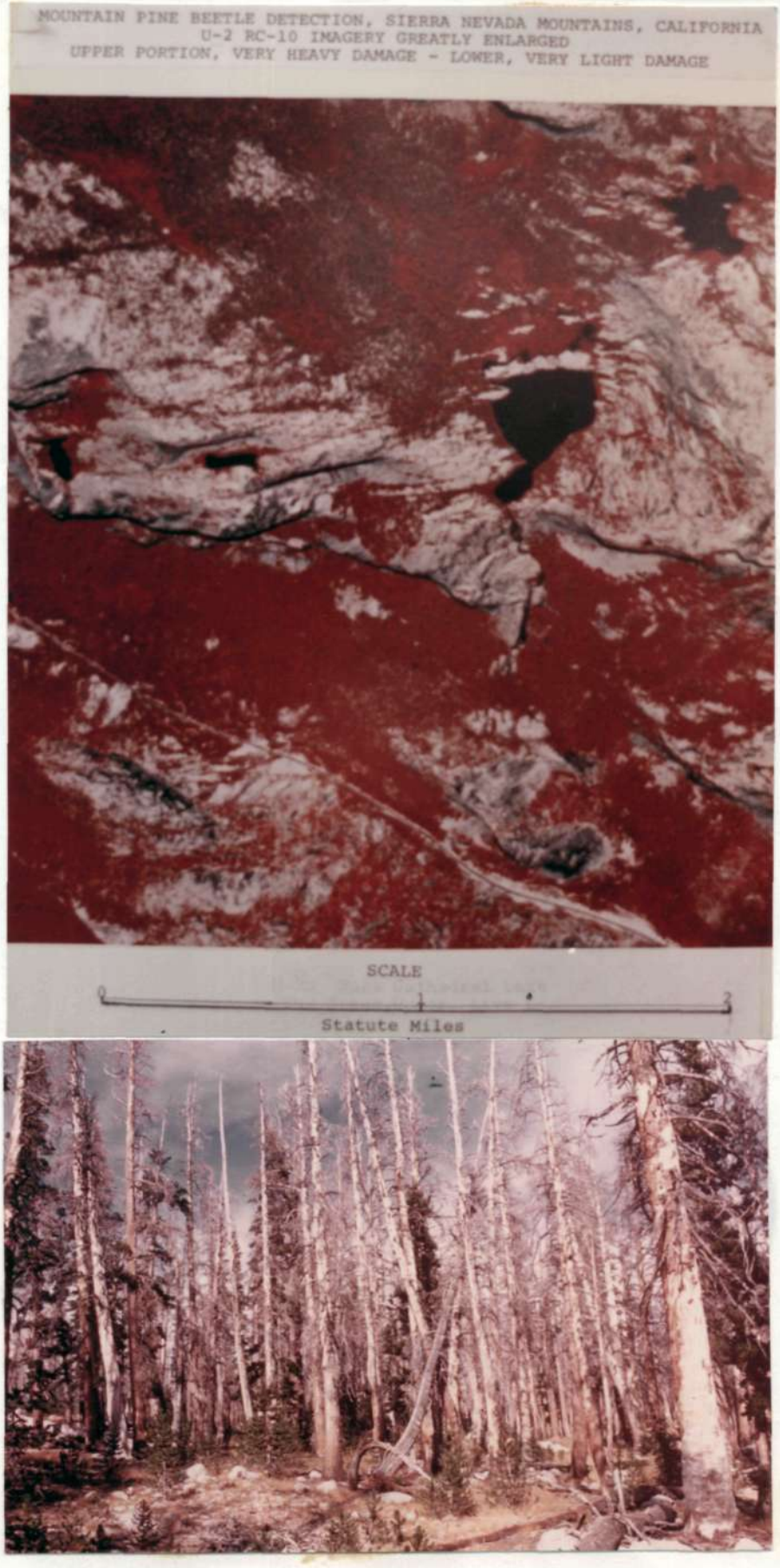

FIGURE 3

Note in A, moldy brown color of the heavily damaged forest in the upper portion compared to blood red color of the undamaged forest in the lower portion. Brick colored patches in damaged area are grassy areas in the timber. B is example of heavy damage in upper A.