https://ntrs.nasa.gov/search.jsp?R=19760013513 2020-03-22T15:23:33+00:00Z

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

01

"Made available under NASA sponsorship in the interest of early and wide dissemination of Earth Resources Survey Program information and without liability for any use made thereof."

E7.6-10254 III
CR-146626
ERTS

GYPSY MOTH DEFOLIATION ASSESSMENT

Forest defoliation is detectable from satellite imagery

Harry J. Moore
PPQ:APHIS:USDA
Federal Building
Hyattsville, MD 20782

(E76-10254) GYPSY MOTH DEFOLIATION ASSESSMENT: FOREST DEFOLIATION IN DETECTABLE FROM SATELLITE IMAGERY Final Report, 1973 (Agriculture Dept., Hyattsville, Md.) 18 p HC $3.50 CSCL 02F G3/43

N76-20601

Unclas 00254

September 1975
Final Report - 1973

Original photography may be purchased from:
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

Prepared for

GODDARD SPACE FLIGHT CENTER

Greenbelt, Maryland 20771

1679A

RECEIVED
NOV 11 1975
SIS/902.6

1. Report No.

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

GYPSY MOTH DEFOLIATION ASSESSMENT - Forest defoliation is detectable from satellite imagery

5. Report Date

September 1975

6. Performing Organization Code

7. Author(s)

Harry J. Moore

8. Performing Organization Report No.

9. Performing Organization Name and Address

PPQ/APHIS - USDA
Federal Building
Hyattsville, Maryland 20782

10. Work Unit No.

11. Contract or Grant No.

S-70251AG-9

12. Sponsoring Agency Name and Address

Mr. E. F. Szajna
Goddard Space Flight Center
Greenbelt, Maryland 20771

13. Type of Report and Period Covered

Final Report - 1973

14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with: Wayne G. Rohde, EROS Data Center, Sioux Falls, South Dakota

16. Abstract

In 1973, the gypsy moth (Porthetria dispar) at least partially defoliated an estimated 1.7 million acres of forests in the northeastern United States. The impact of defoliation on the forest as well as the location and timing of suppression efforts is now assessed each year by conventional visual surveys and ground data collection techniques.

Analyses of Earth Resources Technology Satellite (ERTS-1) data over Pennsylvania obtained in July 1973, indicates that heavy defoliation and light-moderate defoliation can be distinguished from undefoliated forests. Light defoliation is only detectable when adjacent to areas that are heavily or moderately defoliated.

ERTS-1 imagery provides those agencies responsible for planning and managing suppression projects with a regional synoptic view of the total extent of defoliation. Such imagery also allows rapid identification of the potential spread of the insect by mapping the distribution of forested land.

Results of our analyses in Pennsylvania suggest that satellite imagery, acquired and disseminated to users within an acceptable time frame, could be implemented in an operational pest detection program involving satellite, aircraft, and ground data, for assessment of gypsy moth damage. Such data could result in cost savings from more efficient planning of aerial visual surveys. With additional research and more frequent cloud-free imagery, satellite imagery can become a significant tool in pest detection programs.

17. Key Words (Selected by Author(s))

18. Distribution Statement

19. Security Classif. (of this report)

20. Security Classif. (of this page)

21. No. of Pages

22. Price*

PREFACE

The objectives of this study are as follows: (1) To test the theory that ERTS imagery will permit identification of areas defoliated by the gypsy moth. (2) To evaluate the applications and limitations of ERTS-1 satellite imagery for detecting and mapping various degrees of forest defoliation caused by the gypsy moth. (3) To determine the gains to be made in using satellite imagery, as compared to the present airborne visual method.

The original plan to map all of the gypsy moth defoliation in New England was reduced to cover only Eastern Pennsylvania because this was the only area where cloud-free conditions coincided with ERTS passes during the rather critical period of mid-June to mid-July.

This study indicates that forest defoliation is detectable from satellite imagery and correlates well with aerial visual survey data. In areas of heavy deciduous forest cover, it now appears that two damage classes (heavy and moderate-light) and areas of no visible defoliation can be detected and mapped from properly prepared false color composite imagery by human interpreters.

Satellite imagery, acquired and disseminated to users within an acceptable time frame, could implement an operational damage detection program involving satellite, aircraft, and ground data, for assessment of gypsy moth damage in the Northeast.

INTRODUCTION

The gypsy moth (Porthetria dispar) is a forest insect pest introduced into the United States at Medford, Massachusetts, in 1869. In the larva stage it feeds on almost any forest foliage and annually defoliates up to 800,000 hectares (2 million acres) of woodlands in New England and adjoining States. A 1952 gypsy moth impact survey established a probable potential range of 40 million hectares (100 million acres) in the Eastern United States. Defoliated areas are commonly large enough to allow easy visual detection from an airplane. The Plant Protection and Quarantine Division of Animal and Plant Health Inspection Service, U. S. Department of Agriculture has, since 1938, conducted an annual airborne visual defoliation survey as part of its overall insect survey program. Certain New England States cooperate in conducting this survey. Results of these surveys are published annually in the form of a regulatory map (Figure 1). Airborne surveys are conducted by a two or three-man crew in a light plane, flying parallel lines, spaced no more than six-miles apart, at altitudes between 500 feet and 2,500 feet, dependent on visibility. Defoliated areas are penciled in on a map as the aircraft proceeds and depicted as light, medium, or heavy defoliation.

OBJECTIVES

1. To test the theory that ERTS imagery will permit identification of areas defoliated by the gypsy moth.

2. To evaluate the applications and limitations of ERTS-1 satellite imagery for detecting and mapping various degrees of forest defoliation caused by the gypsy moth.

3. To determine the gains to be made in using satellite imagery as compared to the present airborne visual method.

TEST SITE

Imagery was requested for all of the New England States plus the eastern halves of New York and Pennsylvania and the entire State of New Jersey. Detailed study was planned in the Cape Cod, Massachusetts area, where extensive defoliation blocks of various intensity classes were anticipated and ground truth data would be available.

No cloud-free imagery was obtained over the Cape Cod area during the defoliation "season" of June 15 to July 20. However, cloud-free imagery was obtained over Northeastern Pennsylvania on July 7 and 8, 1973. Aerial visual survey data in this area was sufficient to justify moving the detailed study area from Cape Cod to Northeastern Pennsylvania.

PROCEDURES

Aerial visual survey data was collected by the Forestry Section of Pennsylvania's Department of Environmental Resources and recorded on 1:62,500 scale county highway maps. This data was collected as part of the cooperative annual State/Federal defoliation survey (Figure 2). Data collection varies from State to State. Pennsylvania separates defoliation into only two classes--heavy (60 - 100 percent) and medium (30 - 60 percent). Areas of known defoliation, as recorded on aerial visual surveys, were located on ERTS-1 imagery (Figure 3). These areas were used for training interpreters to recognize broad defoliation classes.

Further attempts were made to "quantify" damage classes through densitometric analysis of film positives. Image density values of various levels of defoliation within selected areas were measured with a Macbeth TD-504 densitometer on MSS bands 4, 5, 6, and 7. Film density values for areas of known defoliation levels are shown in Figure 4. Defoliated forests imaged lighter toned than nondefoliated forests on MSS bands 4 and 5 and darker toned on MSS bands 6 and 7. These results are consistent with results from other studies to detect forest stress conditions. It has been reported that stressed ring porous hardwoods (e.g., Quercus spp., Carya spp.) image lighter toned on panchromatic photography and darker toned on near infrared photography than similar species growing under normal conditions (Rohde and Olson, 1970). Similar results were reported in an analysis of low altitude aircraft photography for detecting gypsy moth defoliation (Rohde and Moore, 1972).

Although differences in film density values were recorded for different defoliation damage classes within the selected areas, visual inspection of imagery over other known areas of damage would not permit consistent discrimination of moderate and light damage classes. These classes were subsequently identified as either moderate to light (areas of predominantly moderate defoliation) or light to moderate (areas of predominantly light defoliation) by the interpreters.

ERTS imagery acquired on July 8, 1973, at or near the peak of gypsy moth defoliation, clearly shows defoliated areas as light toned on MSS band 5 and dark toned on MSS band 7 (Figure 5). On black-and-white imagery, it is possible to consistently identify areas of heavy defoliation and areas with no apparent defoliation. It appears that intermediate damage classes are most readily detected when adjacent to heavily damaged areas. Consistent detection of light and moderate defoliation classes in areas with no heavy defoliation has not yet been demonstrated.

Single date and multi-date false color composites prepared from an I^2S additive color viewer provided better contrast between detectable levels of defoliation than any single black-and-white image. The I^2S additive color viewer allows one to view multiband images in color through superimposition of individual bands illuminated through different colored filters. The basis of the additive color process is thoroughly explained in Appendix I of the American Society of Photogrammetry's Manual of Color Aerial Photography. The use of the same band of imagery, acquired on different dates, departs only slightly from the original concept of the additive color process.

As mentioned earlier, when such forest canopies are subjected to stress, they generally become more reflective in the visible and less reflective in the near infrared. Multispectral images, when superimposed on an additive color combiner will often enable enhancement of defoliation. Figure 6 is a 2-band color composite prepared from ERTS-1 MSS bands 5 and 7 acquired in July 1973. MSS band 5 was illuminated through a blue filter. Forested areas which appeared light toned (defoliated forest) on the black-and-white film positive transmitted the blue light and areas which appeared dark toned (nondefoliated forest) transmitted very little of the blue light. MSS band 7 was illuminated through a red filter. Forested areas which appeared light toned on this band (nondefoliated forest) transmitted the red light. Since these areas corresponded to the dark toned areas on band 5 which transmitted very little of the blue light, superimposing the 2 images causes nondefoliated forests to appear reddish in color. Similarly, forested areas which appeared dark toned on MSS band 7 (defoliated forest) transmitted very little of the red light. Since the corresponding areas on MSS band 5 were light toned and transmitted the blue light, the 2-band color composite depicts defoliated areas in various blue-gray colors depending on damage intensity.

Figure 6 is a typical false color composite image available as a standard product from the EROS Data Center. False color composites can also be prepared by illuminating MSS bands 5 and 7 in red and green, respectively. Defoliation would then be expected to image in various reddish colors as opposed to the green nondefoliated forest (Figure 7). Although either false color composite provided excellent enhancement of forest defoliation, other terrain features exhibiting a similar tone reversal in MSS bands 5 and 7 caused confusion. For example, the valley in which Wilkes-Barre and Scranton, Pennsylvania, are located, images very similar to defoliated areas. Aerial sketch maps indicate no defoliation in this valley (Figure 2).

Multidate color composite images were prepared from an October 1972 MSS band 7 and July 1973 MSS band 7 illuminated through a red and green filter, respectively. Gypsy moth defoliation is never apparent in October. Because forest vegetation reflects strongly in the infrared, the nondefoliated forested areas image light toned on black-and-white MSS band 7 imagery. When the October MSS band 7 is displayed on an additive color viewer through a red filter, the light toned forested areas will appear red. The July MSS band 7 image shows nondefoliated forest vegetation as light toned and defoliated areas as dark toned. When this image is displayed on an additive color viewer through a green filter, the light toned nondefoliated forested areas will appear green. Thus, when both images are superimposed, the additive combination of green and red results in a greenish-yellow color rendition for nondefoliated forests. Those forested areas that were light toned in October and dark toned in July, i.e., defoliated areas, will image reddish color on the color composite since the dark toned areas on the July image will not readily transmit the green light. This technique then permits rapid discrimination of defoliated areas from other features which image dark toned on infrared imagery and do not exhibit any temporal change in infrared reflectance (Figure 8).

DISCUSSION

Extensive gypsy moth defoliation developed in eastern Pennsylvania in July 1973. Aerial visual surveys indicated that 347,000 hectares (857,000 acres) were defoliated in Pennsylvania. Figure 2 is a map of the eastern half of Pennsylvania indicating the extent of defoliation as recorded on aerial visual surveys.

Film density values for areas of known defoliation levels are shown in Figure 4. In the green and red spectral regions, defoliated forests imaged darker toned than undefoliated forests. In the near infrared spectral bands, defoliated forests imaged darker toned than undefoliated forests. These results are as expected, based on our studies in 1972. Although differences in film density values were recorded for different defoliation damage classes within the selected areas, visual inspection of imagery over other known areas of damage would not permit consistent discrimination of moderate and light damage classes.

ERTS imagery acquired on July 8, 1973, at or near the peak of gypsy moth defoliation clearly shows defoliated areas as light toned on MSS band 5 and dark toned on MSS band 7 (Figure 5). On black and white imagery, it is possible to consistently identify areas of heavy defoliation and areas with no apparent defoliation. It appears that intermediate damage classes are most readily detected when adjacent to heavily damaged trees. Consistent detection of light and moderate defoliation classes in areas with no heavy defoliation has not yet been demonstrated. Increased resolution, possibly by analysis of the digital tapes, could possibly result in improved detection of light defoliation.

Single date false color composites prepared from MSS band 5 and 7 imagery provided better contrast between detectable levels of defoliation than any single black and white image. However, on the black and white imagery and the single date false color composite, areas of defoliation were often confused with dark toned areas associated with mining activity and certain agricultural areas.

A multidate false color composite was prepared from MSS band 7 imagery acquired in October 1972 and July 1973. It provided excellent enhancement of defoliation and eliminated the mining/agricultural confusion.

A map showing the zones of defoliation was prepared from the black and white and multidate false color composite imagery (Figure 9). Since discrimination of moderate and light damage classes was not consistently feasible, these classes were identified as moderate to light (areas of predominantly moderate defoliation) or light to moderate (areas of predominantly light defoliation) by the interpreters. The map was prepared at a scale of 1:1,000,000 and compares favorably with the map prepared from the aerial visual surveys.

While preliminary results in eastern Pennsylvania are quite encouraging, it must be noted that the area mapped in Figure 9 is an area of heavy deciduous forest cover, dominated by oak (Quercus) species. Detection of forest defoliation is not as dramatic in areas of diverse forest cover such as mixed hardwoods and conifers. Aerial visual surveys over New Jersey in July 1973 indicated extensive defoliation in many mixed forests, dominated by maple (Acer) species. Defoliation was not readily detected on ERTS imagery.

It must be noted that weather conditions have restricted the acquisition of ERTS-1 imagery over many areas defoliated by gypsy moth in 1973. The passes over eastern Pennsylvania, just prior to and after the July 8 pass, were cloud covered. The defoliation in central Pennsylvania developed later in July. Because of cloud coverage, this area could not be mapped, More frequent satellite passes would undoubtedly afford more effective utilization of such data in gypsy moth detection surveys over extensive areas.

Nichols, Pennsylvania Department of Environmental Resources estimates that $25,000 was spent in 1973 for all aerial-visual pest detection surveys in the State. This represents a cost of approximately $.55 per square mile. The estimated cost to map defoliation from ERTS-1 imagery over a 3,923 square mile area was approximately $.04 per square mile.

SUMMARY

ERTS-1 imagery obtained over eastern Pennsylvania during July 1973, indicates that forest defoliation is detectable from satellite imagery and correlates well with aerial visual survey data. It now appears that two damage classes (heavy and moderate-light) and areas of no visible defoliation can be detected and mapped from properly prepared false color composite imagery by human interpreters.

In areas where maple is the dominant species or in areas of small woodlots interspersed with agricultural areas, detection and subsequent mapping is more difficult. Locating and mapping the forest cover throughout the gypsy moth range on satellite imagery prior to defoliation would improve substantially the ability to detect defoliation by preparing multidate color composites from satellite imagery acquired at the appropriate time.

The advent of an earth resources satellite system provides a new tool which acquires an enormous amount of imagery in a cost effective manner.

Results of our analyses suggest that satellite imagery, acquired and disseminated to users within an acceptable time frame, could be implemented in an operational damage detection program involving satellite, aircraft, and ground data, for assessment of gypsy moth damage in the northeast. Such a system could result in cost savings with more efficient planning of aerial visual surveys.

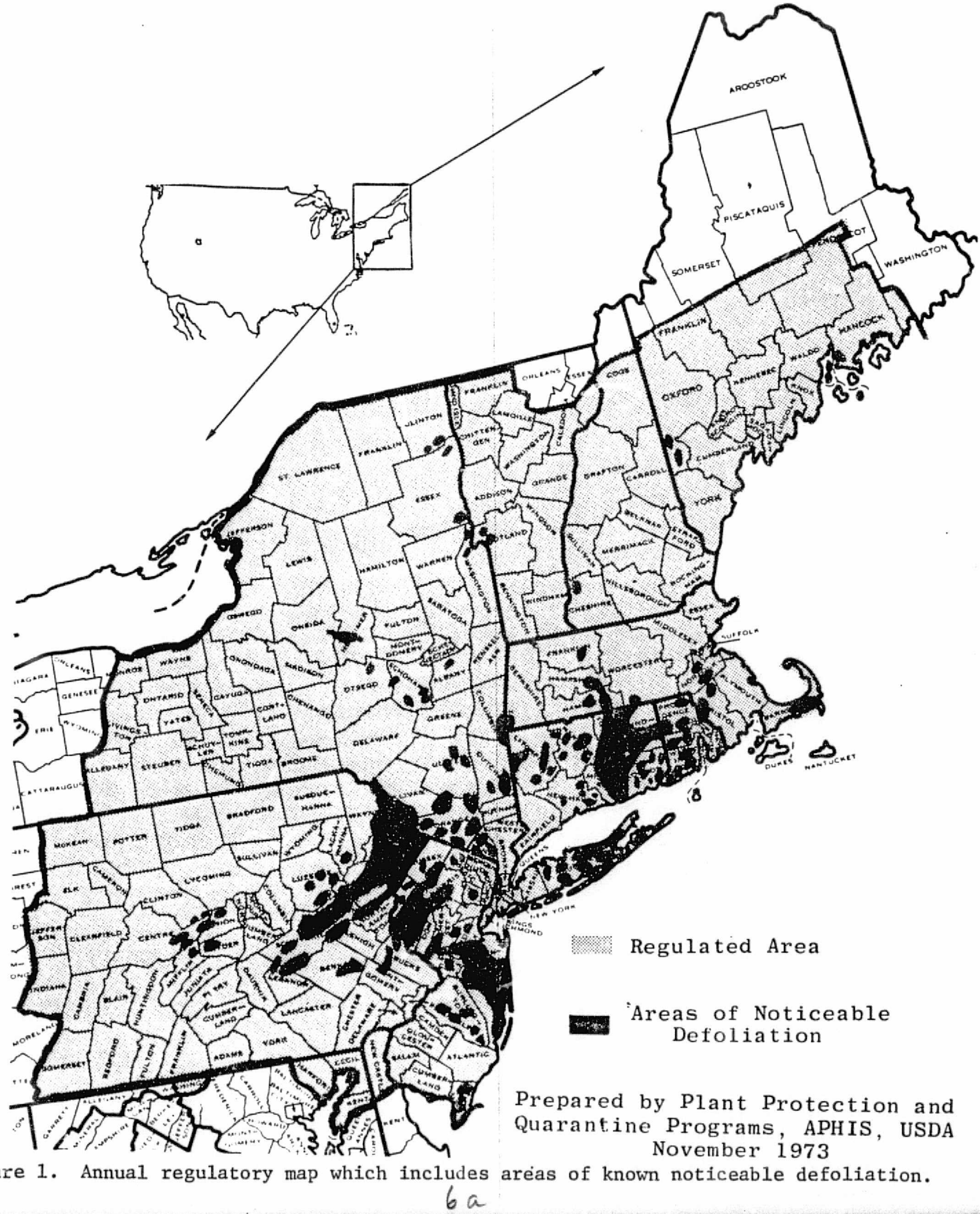
REFERENCES

Rohde, W. G. and C. E. Olson, Jr., 1970. Detecting Tree Moisture Stress. Photo. Eng. 36: 561-566.

Rohde, W. G. and H. J. Moore. 1973. "Evaluation of Gypsy Moth (Porthetria dispar) Damage With Remote Sensing Techniques," In: Proc. of Fourth Biennial Workshop on Color Aerial Photography in the Plant Sciences. American Society of Photogrammetry. pp. 207-225.

Smith, J. T., Ed., 1968. Manual of Color Aerial Photography. American Society of Photogrammetry, Washington, D.C.

GYPSY MOTH DEFOLIATED AREAS 1973



Prepared by Plant Protection and Quarantine Programs, APHIS, USDA
November 1973

Figure 1. Annual regulatory map which includes areas of known noticeable defoliation.

ORIGINAL PAGE IS
OF POOR QUALITY

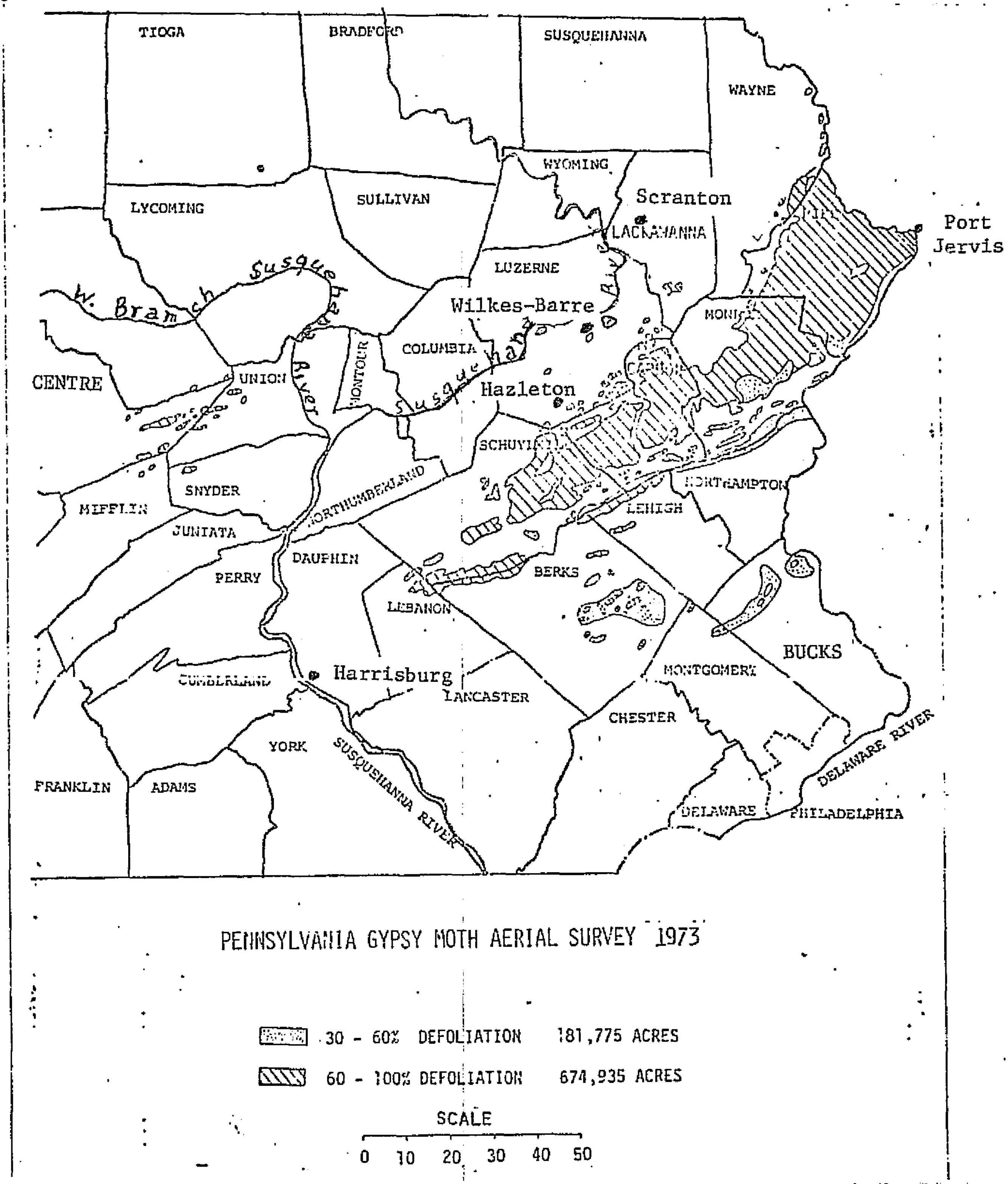


Figure 2. Gypsy moth defoliation in Pennsylvania—1973. This map was compiled from data recorded on aerial sketch map surveys.

MAPPING FOREST DEFOLIATION WITH ERTS-1 SATELLITE IMAGERY

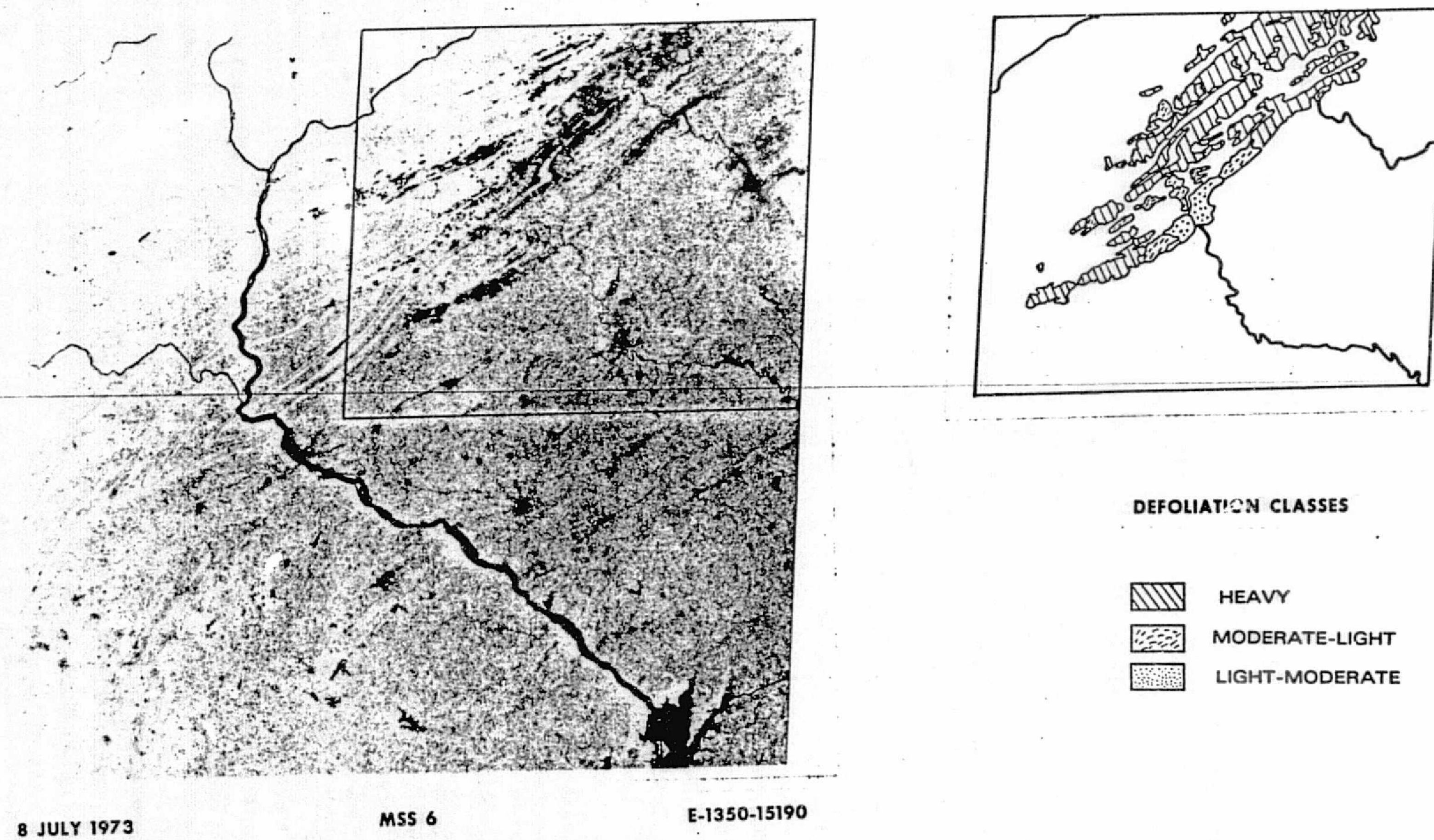
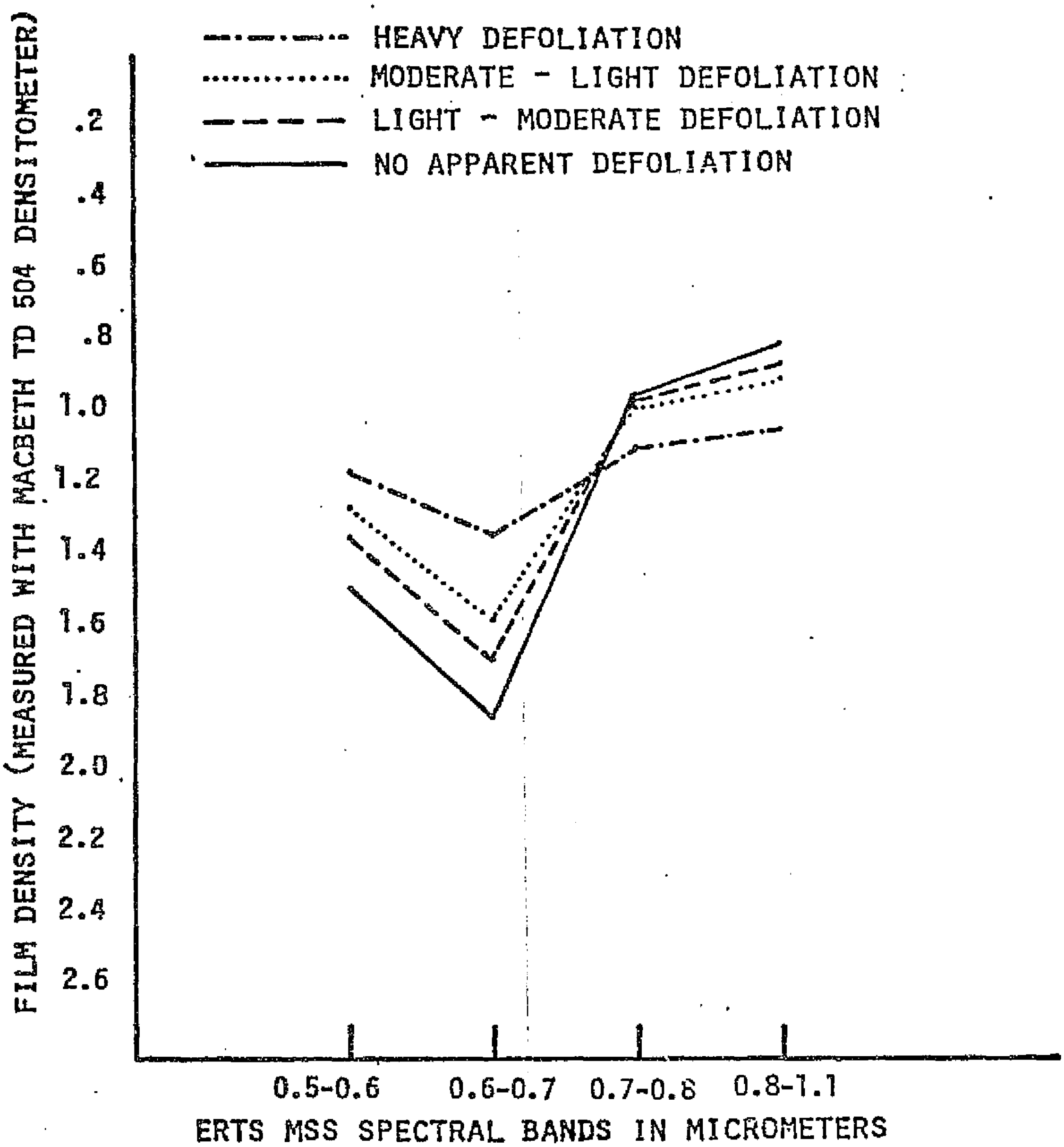


Figure 3. Areas of known defoliation, sketch-mapped on right, imaged dark on ERTS imagery (left).

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

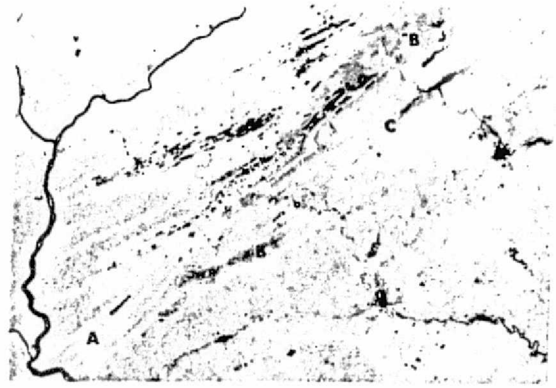


HEAVY DEFOLIATION
MODERATE - LIGHT DEFOLIATION
LIGHT - MODERATE DEFOLIATION
NO APPARENT DEFOLIATION
FILM DENSITY (MEASURED WITH MACBETH TD 504 DENSITOMETER)
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
0.5-0.6
0.6-0.7
0.7-0.8
0.8-1.1
ERTS MSS SPECTRAL BANDS IN MICROMETERS

Figure 4

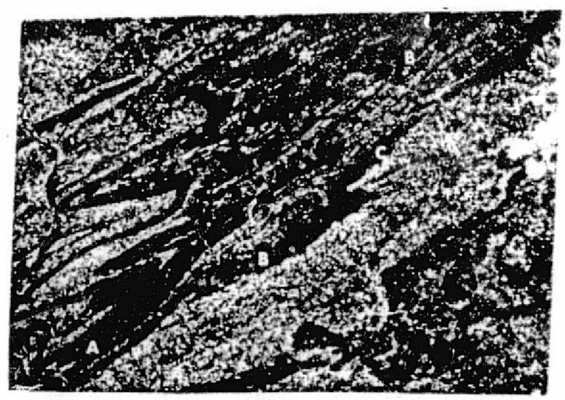
SATELLITE MONITORING OF GYPSY MOTH DEFOLIATION

11 OCT 1972 MSS 7 E-1080-15185-7



08 JULY 1973 MSS 7 E-1350-15190-7

11 OCT 1972 MSS 5 E-1080-15185-5



08 JULY 1973 MSS 5 E-1350-15190-5

ERTS-1 IMAGERY ACQUIRED ON 11 OCTOBER 1972 CLEARLY SHOWS EXTENT OF FOREST STANDS AS DARK TONED ON MSS 5 AND LIGHT TONED ON MSS 7. REGIONAL FOREST MAPS CAN BE MADE RAPIDLY FROM SUCH IMAGERY. IMAGERY OBTAINED ON 8 JULY 1973 INDICATED EXTENSIVE GYPSY MOTH (<u>PORTHETRIA DISPAR</u>) DEFOLIATION OF FORESTED LANDS. UNDEFOLIATED FOREST IS AT (A), HEAVY DEFOLIATION (80-100%) AT (B), AND MODERATE-LIGHT DEFOLIATION AT (C).

EARTH SATELLITE CORPORATION

Figure 5.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

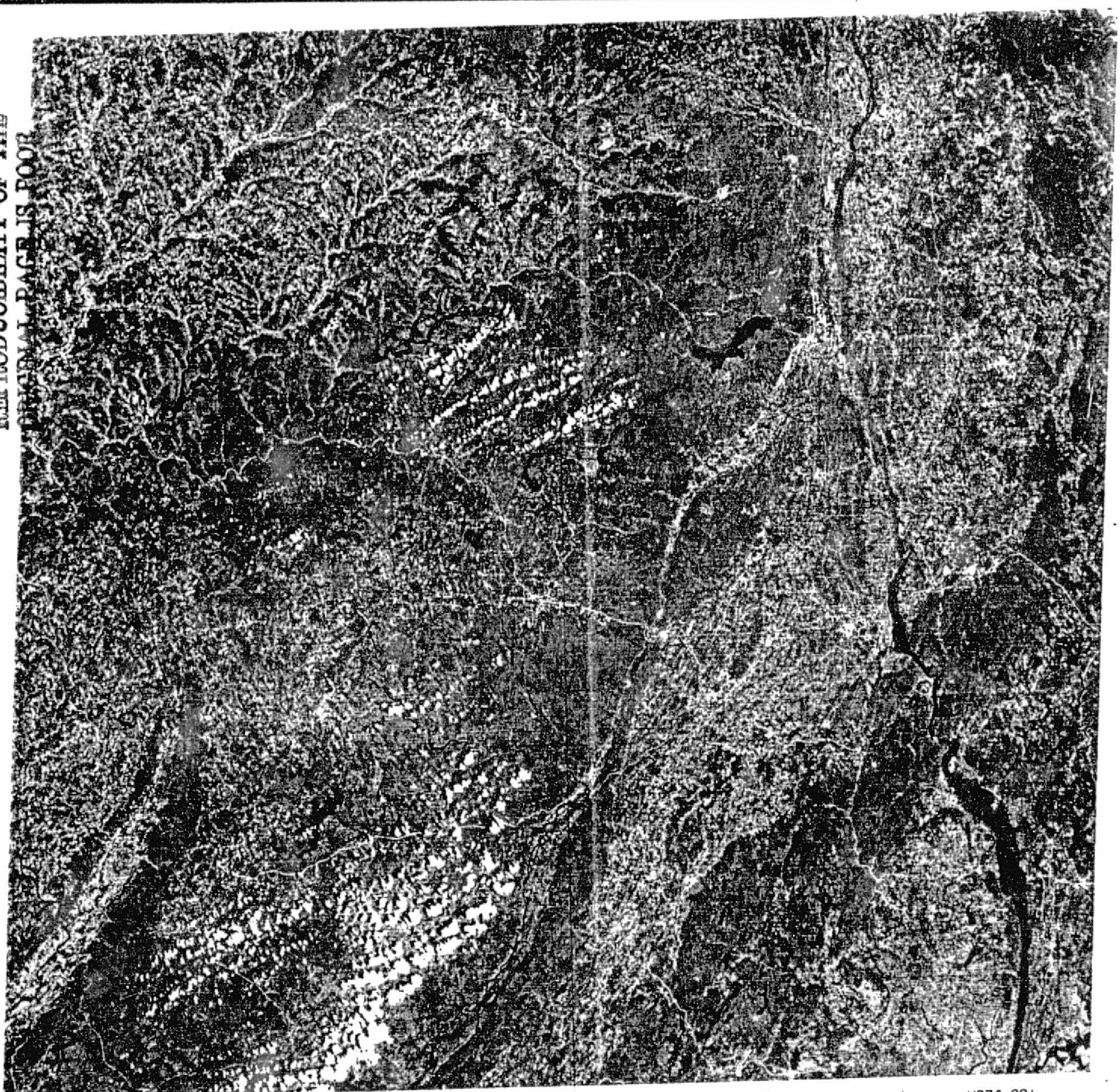


Figure 6. Two-band color composite. MSS band 5 was illuminated through a blue filter. MSS band 7 was illuminated through a red filter.

Figure 7. Two-band color composite. MSS band 5 was illuminated through a red filter. MSS band 7 was illuminated through a green filter.

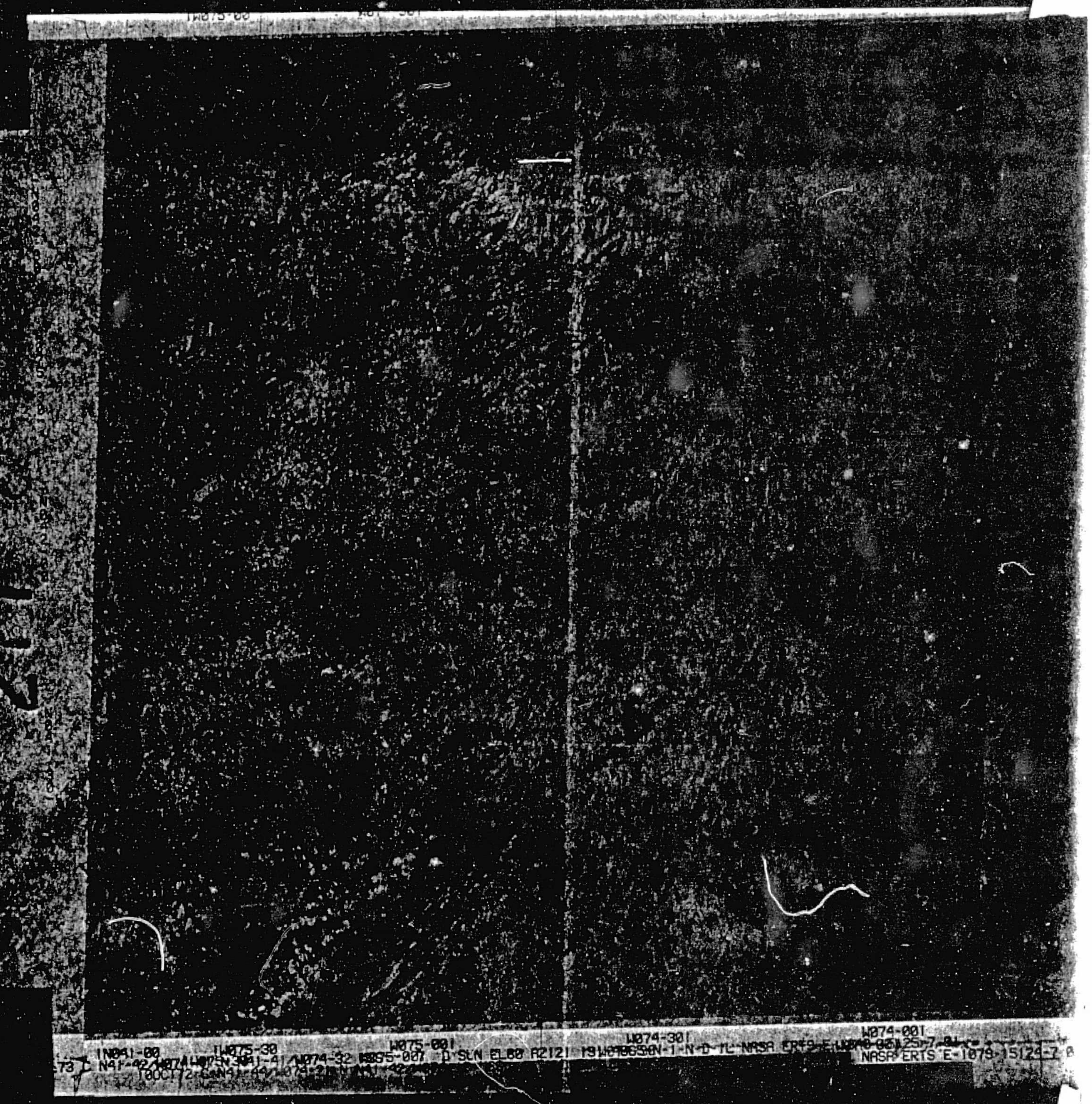


Figure 8. Multidate-color composite. October band 7 was illuminated through a red filter. July band 7 was illuminated through a green filter.

ORIGINAL PAGE IS POOR

DETECTION OF FOREST DEFOLIATION WITH SATELLITE IMAGERY

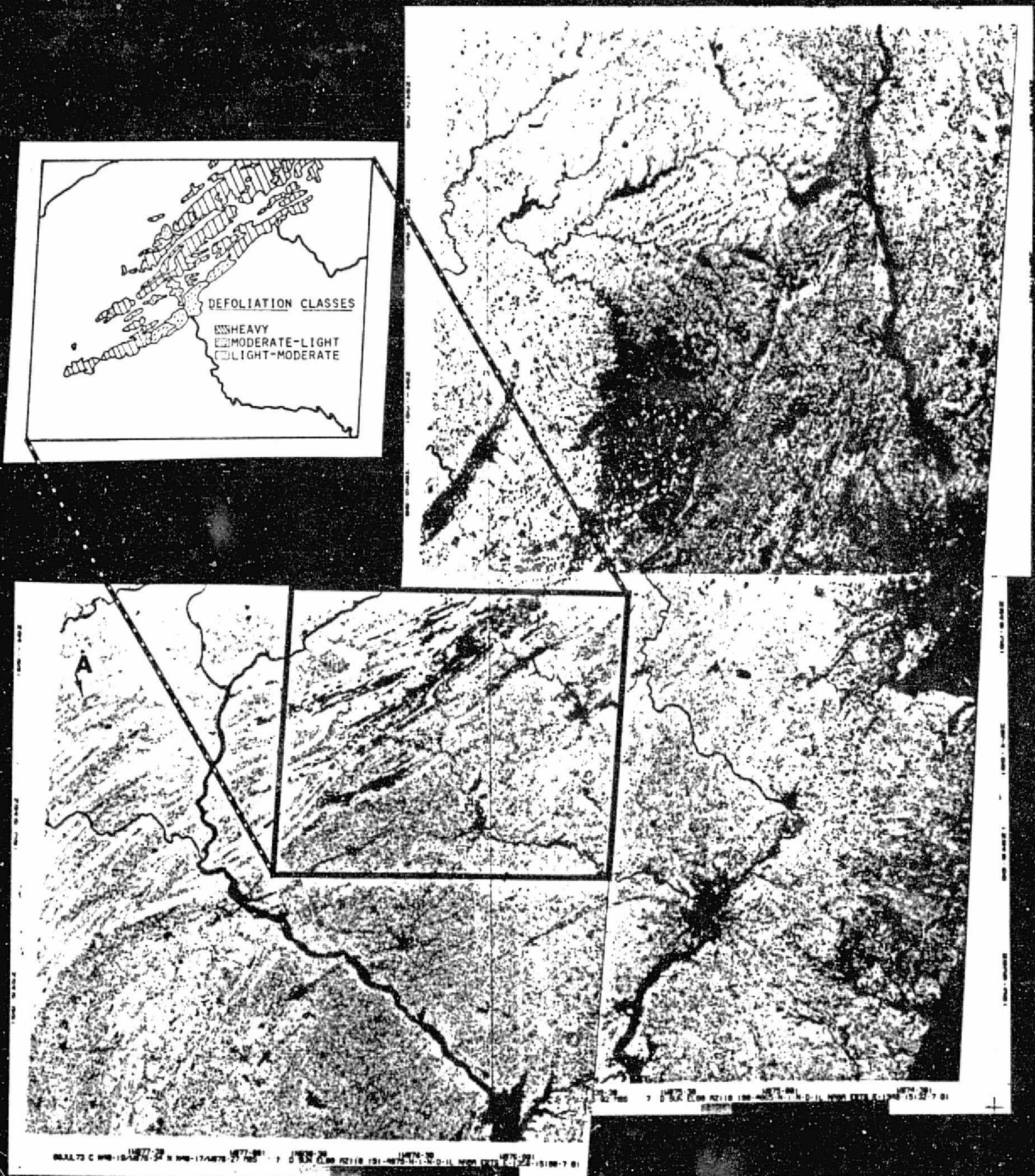


Figure 9. THIS ERTS-1 MOSAIC WAS PRODUCED FROM MSS BAND 7 IMAGERY ACQUIRED IN EARLY JULY, 1973. FOREST DEFOLIATION IN AREAS OF DENSE FOREST COVER APPEAR DARK TONED ON MSS BAND 7. DEFOLIATION OF SMALL WOODLOTS IN PREDOMINATELY AGRICULTURAL AREAS IS NOT READILY DETECTED BY HUMAN INTERPRETATION OF SINGLE DATE IMAGERY.

ORIGINAL PAGE IS POOR