FOREST INSECT DAMAGE AND COVER TYPES FROM HIGH-ALTITUDE COLOR-IR PHOTOGRAPHS AND ERTS-1 IMAGERY

J. Beaubien and L. Jobin
Laurentian Forest Research Centre, Canadian Forestry Service
Department of the Environment
Sainte-Foy, Québec G1V 4C7

ABSTRACT

Anticosti Island, Qué. has experienced two important outbreaks (1929-34 and 1971-73) of the Eastern hemlock looper (*Lambdina fiscellaria fiscellaria* (Guen.)). The most recent insect damage caused defoliation and high tree mortality in mature balsam fir (*Abies balsamea* (L.) Mill.) stands over some 875 sq. miles (2265 km^2). A remote sensing study was initiated and high altitude color-IR photographs (scale 1: 70000) were taken over the island in the summer of 1973. Tree mortality which occurred in 1971 can readily be evaluated in classes of 25% on these small-scale photographs with a standard mirror stereoscope. The 1929 damages can be seen on the photos as openings left in the forest; most of these areas are now regenerated. The images have also a surprising potential for identifying species growing in pure or nearly pure stands.

ERTS-1 imagery was also investigated. It shows promising possibilities for mapping broad vegetation cover types, and for monitoring at least severe insect damage to forest.

RESUME

L'Ile d'Anticosti a connu deux pullulations successives (1929-34 et 1971-73) de l'Arpenteuse de la pruche (*Lambdina fiscellaria fiscellaria* (Guen.)); la plus récente a défolié et ravagé plus ou moins intensément des peuplements de sapin baumier (*Abies balsamea* (L.) Mill.) sur une étendue de plus de 875 milles carrés (2265 km^2). Une étude fut entreprise à l'été 1973 dans le but d'évaluer le potentiel de la photographie aérienne couleur infrarouge prise à haute altitude (échelle 1:70000) pour détecter les dommages causés à ces peuplements par l'insecte. Il est relativement facile de déterminer le pourcentage de mortalité en classes de 25% à partir de ces photos à très petite échelle examinées sous un stéréoscope à miroir conventionnel. Dans plusieurs cas, il est également possible d'identifier les espèces d'arbre croissant en peuplements purs ou presque purs.

Les images captées par le satellite ERTS-1 offrent un potentiel étonnant pour localiser tout au moins les dommages sévères (mortalité) causés à la forêt sur de grandes étendues à la suite d'une épidémie d'insectes, et pour une cartographie générale du couvert végétal.

ZUSAMMENFASSUNG

Die Insel Anticosti Qué. wurde zweimal von *Lambdina fiscellaria fiscellaria* (Guen.) heimgesucht, und zwar von 1929 bis 1934 und von 1971 bis 1973. Während der letzten Periode wurden 875 quadrat Meilen (2265 km^2) des Tannenwaldes (*Abies balsamea* (L.) Mill)von diesem Insekt befallen und mehr oder weniger verwüstet.

Die Möglichkeit den Schaden auf einem, bei großer Höhe aufgenommenen (Mass Stab 1:70000), infraroten Luftbild, wurden im Sommer 1973 untersucht. Mit einem Spiegel Stereoskop ist es verhältismäßig leicht 25%-Mortalitätsklassen auf diesen Bildern, trotz des kleinen Masstabs, zu erkennen. In mehreren Fällen war es sogar möglich die Baumart einiger Reinbeständen zu bestimmen.

Die vom Satellit ERTS-1 aufgenommenen Bilder ermöglichen ebenfalls, in erstaunlicher Weise, die Lokalisierung auf größeren Flachen der schweren Insektenschäden sowie die Kartierung der Vegetationstypen.

INTRODUCTION

Two important outbreaks (1929-34 and 1971-73) of the Eastern hemlock looper (*Lambdina fiscellaria fiscellaria* (Guen.)) on Anticosti Island, Qué. were reported. The most recent insect damage caused light to severe defoliation and some tree mortality in mature balsam fir (*Abies balsamea* (L.) Mill.) stands over some 875 sq. miles (2265 km^2) (Beaubien and Jobin 1974). The current methods used to estimate the extent of forest insect damage over large areas rely on aerial visual surveys (sketch mapping) and various types of ground surveys. These are costly, time consuming, require considerable man hours of effort, and their accuracy varies with observers backgrounds and motivations (Rhode and Moore 1973). People responsible for control operations need more accurate surveys and more detailed information (such as tree species attacked, stand and site conditions) not always provided by sketch mapping. Remote sensing techniques can potentially provide the forest manager with a more rapid and accurate damage assessment, and permanent records of information useful in the study of ecological factors affecting forest insect pests.

According to many authors, color and chiefly color-IR aerial photographs are a valuable tool to evaluate forest damage (Murtha 1972, Ciesla et al. 1971, Rhode and Moore 1973). Until now, most of the studies carried out on this subject investigated the usefulness of large to medium photo scales for detecting forest insect damage. Recently Ciesla (1974) obtained encouraging results using high altitude color-IR photographs.

METHODS

In connection with an evaluation of the insect outbreaks on Anticosti Island, a remote sensing study was initiated by the Laurentian Forest Research Centre in Quebec, and the island was photographed in July 1973, at an altitude of 35000 feet (10670 m), with a RC-10 camera loaded with a Kodak Aerochrome infrared 2443 film; the 6-inch focal-length lens used gave an approximate scale of 1:70000. In October 1973 aerial photos were also obtained with the same sensor at 5000 feet (1525 m) over a part of the island where heavy damage occurred. Unfortunatly these photos at an approximate scale of 1:10000 were taken with a very low sun angle of about 20^o.

All the island, which has an area of about 3,100 sq. miles (8000 km^2), was examined through the small scale transparencies with a custom mirror stereoscope of a possible 3X magnification. An attempt was made to map tree mortality in balsam fir stands, following the two distinct outbreaks (1929 and 1971), in classes of 25%. Since nearly all attacked trees died at the time of the outbreak, and as defoliation was at its peak in 1971-72, it was impossible to see partially defoliated trees. Killed stands were quite easily detected through their blue, blue-green color as compared to healthy balsam fir which appeared in various tones of magenta.

Ground truth was obtained by a single crew of two men working for a period of three weeks. All areas accessible by road were visited. Stand composition was described for about 150 check points, 40 of which were sampled with a relascope (point sampling method) (Kendall and Sayn-Wittgenstein 1964) as an aid to evaluate the percentage of tree species and dead trees. Ground truth data were also taken from existing aerial sketch mapping records and from the color-IR medium-scale photographs.

ERTS-I imagery for mapping forest cover types and damage was also investigated by visual analysis on a light table of custom black and white and color composite transparencies.

RESULTS AND DISCUSSION

Aerial color-IR photos

Quality of imagery from both scales was excellent. Tree mortality, following the 1971 outbreak, could readily be evaluated on small-scale photographs (1:70000) with a mirror stereoscope. Heavily damaged stands were clearly visible without the aid of stereoscopic viewing. A map, showing the proportion of dead trees in balsam fir stands, is now in preparation. Medium scale photos are really an excellent ground truth tool as each individual dead tree is clearly visible.

The 1929 outbreak can easily be located on both sets of photos by the openings left in the forest. These clearings resemble blow-down damage and are now mostly regenerated.

Information about species composition of forest stands is very useful for determining insect damage. Furthermore, the capability of color-IR images to identify forest species was evaluated in the field while checking for damage. The forest cover of Anticosti Island is mostly composed of balsam fir stands including white spruce, white birch and some aspen; the poor sites are colonized with black spruce. Wetlands and bogs are quite abundant especially in the eastern part of the island. A boundary can easily be drawn on high-altitude images between pure or nearly pure stands of black spruce and balsam fir. Black spruce registered as gray-black and balsam fir as a tone of magenta depending on age and species composition. In many instances, white spruce, which usually grows in pure stands on Anticosti Island after cut-overs or heavy insect outbreaks, can be distinguished from black spruce and balsam fir stands by their intermediate dark magenta color. These color distinctions are hardly possible on the medium-scale photos. It may be that a low sun angle attenuates contrasts, but it is believed, as mentioned by Fox (1973) in the case of pine canopies, that flying height greatly affects the color rendition on color infrared vertical photographs and consequently changes, usefully in this case, the color pattern of a specific stand.

It would take too long and it would take us away from our main subject if we were to elaborate on all the other interesting forest features that can be identified from these high-altitude color-IR photographs. Some of these features are: degree of regeneration after cut-overs, burns, insect damage, to a certain extent species forming the regeneration, stand composition and density, etc....

ERTS-1 imagery

A paper on capability of ERTS-1 imagery for mapping forest cover types on Anticosti Island has been accepted for publication in a coming issue of The Forestry Chronicle. As this subject was also presented at the 2nd Canadian Remote Sensing Symposium, only a brief summary will be given here. Many satellite images of fairly good quality are now available for Anticosti Island. It was found that winter imagery accentuates tonal contrasts between forest cover types, due to a snow enhancement effect rather than to a result of leaf reflectance. For instance, winter scenes show a clear difference between black spruce and balsam fir-white spruce cover types; the lighter color tone of black spruce stands, which occur on poor sites on Anticosti Island, is probably the result of a more apparent snow cover than in the more closed balsam fir stands. This is also the cause of color tone difference between old and recent cut-overs. The regeneration in the old cut-overs masks part of the snow cover while recent cut-overs show lighter tones. A general forest vegetation map of the island, that can be useful for land use planning, was derived from visual analysis of a few winter color composites (mostly no. 12 53-14365).

Extensive insect damage areas at two levels of tree mortality (50% and 75%) were easily delineated from winter frames. Aerial sketch mapping of looper-killed areas on Anticosti Island was carried out by the Quebec Department of Lands and Forests in 1972 and light to severe tree mortality was reported for about 508 sq. miles (1315 km^2). The same mortality areas were measured from ERTS images and a slightly lower figure was obtained, 488 sq. miles (1264 km^2). This latter insect damage is also easily detected on snow free ERTS frames, especially in band 7 (infrared) where it comes out in particularly dark tone.

CONCLUSIONS

Small-scale color-IR aerial photographs (especially the transparencies) of good quality have a surprising potential for forest cover type appraisal, particularly for detecting and mapping tree mortality after a severe insect outbreak. This study is based on visual examination of photos through a standard stereoscope. Even if the scale is always a limiting factor for mapping small units with precision, in many cases we feel that they should be used more often for forest surveys instead of conventional larger scale photos as they permit photo interpretors to examine a larger land area at one time and to identify forest features with a good level of precision.

A study was initiated this year to evaluate the capability of registering various levels of defoliation caused by spruce budworm (*Choristoneura fumiferama* (Clem.)) with high altitude color-IR photos of two different scales (1:140000 and 1:70000 approximately). The areas being studied were photographed last summer.

ERTS-I imagery shows promising possibilities for mapping broad vegetation cover types, and for monitoring at least severe insect damage to forests.

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