REMOTE SENSING FOR EVALUATING FOREST INSECT DAMAGE

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The current methods used to estimate the extent of insect damage over large forested areas rely on aerial visual surveys and various types of ground surveys. In some cases, remote sensing techniques have probably the potential of providing the forest manager with a more rapid and accurate damage assessment. Two main sensors will be considered: color infrared aerial photographs and Landsat imagery, in connection with two important insects in northeastern North America: Spruce budworm and gypsy moth. It is generally accepted that color-IR aerial photographs are superior to B+W and even normal color photos for vegetation damage analysis.

Color-IR aerial photographs

Using medium scale (≃ 1:10000) CIR photos, Rhode and Moore (1973) were able to delineate gypsy moth damages in northeastern United States according to three classes: light (between 25 and 50% defoliation), medium (between 50 and 80% defoliation) and heavy (between 80 and 100% defoliation). Results from other investigations have shown that this forest damage can be detected on smaller scale photography.

As spruce budworm destroys mainly the current year's foliage of conifers, damage is not so apparent, especially during the first few years of infestation. In an effort to improve current methods used to map levels of defoliation at a reasonable cost, a remote sensing study was initiated with small scale (1:60000) high altitude CIR aerial photographs (Beaubien 1976). a) The photos were taken over Gaspé peninsula in mid-August 1974. As the insect was present in the area since 1970, the balsam fir stands were defoliated at different levels when the area was photographed. As almost all current year insect clipped needles had fallen, cumulative past feeding was apparent at this period of the summer. In early spring 1975, all areas accessible by road were visited and 125 sample plots were described.

After a comparison of stand characteristics with their appearance on the photographs, it appeared that only very severe damage of one year feeding or more could be identified. Then balsam fir stands registered as bluish or greenish depending on plot location on images. It was also impossible to distinguish stands having 2, 3 or 4 years of severe defoliation. Color variations due to certain stand characteristics prevent the detection of damage which is less than severe. It seems that the main factor affecting color tonality is density, followed by length of annual shoot growth which is mainly a function of age and site quality. Generally the denser and/or younger stands will register more redish on CIR photos. As in an open stand the amount of unresolved shadow darkens a fir canopy, a moderately defoliated dense stand can easily be confused with a more open healthy one.

According to some investigators forest insect damage is more successfully detected on larger photo scales. Ashley *et al.* (1976) completed a study to find out at what minimum scale aerial photography can be used to assess spruce budworm damage. They used normal color and CIR photos, at scales ranging roughly from 1:63000 to 1:2500, taken in summer at height of browning of insect damage, and during fall after clipped needles had fallen.

Their main conclusions were:

- Normal color, summer imagery at scales of 1:15000 and larger was found to be best for evaluating current defoliation at the time insect clipped needles were brown and still held within the budworm's webbing;

- CIR fall photography taken when clipped needles had fallen was found to be best for evaluating overall tree condition and identifying mortality;

- heavy current past defoliation could be identified at scales of 1:31000 and larger;

- moderate and light past defoliation could not be detected at any of the scales;

- mortality was not consistently located at the scale 1:63000

In a study on Anticosti Island (Beaubien and Jobin 1974), after an hemlock looper outbreak, tree mortality was easily estimated at this latter scale of roughly a mile to an inch.

Landsat satellites data

The main sensor on board in the satellites is a multispectral scanner which divides reflected energy into 4 spectral bands: green, red and two bands in the near infrared. These data are stored on magnetic tapes and can be converted into photographic images. Visual interpretation of images can provide users with valuable information, but, in order to take full advantage of the resolution at ground level, it is preferable to use Landsat data directly from magnetic tapes and to have them processed by computer.

By measuring density values on black and white transparencies of the 4 spectral bands, Rhode and Moore (1974) were able to produce a gypsy moth defoliation map of an area of approximately 4000 sq. miles for a heavy deciduous forest in eastern Pennsylvania, giving 3 classes (heavy, moderate-light and light-moderate) at an estimated cost of \$0.04 per sq. mile instead of \$0.55

with conventional aerial visual pest detection surveys. In areas of diversed forest cover with mixed stands (hardwoods and conifers) detection of forest defoliation was not so easy; more research is needed. Light and moderate defoliation classes were not consistetly detected in areas other than adjacent to heavily defoliated areas. Interpretation was easiest on multidate color composites prepared from band 7 acquired in October 1972 and July 1973.

As far as we know, no results are available concerning the evaluation of level of spruce budworm defoliation through Landsat imagery. As mentionned above this kind of damage is even difficult to detect on aerial photography at a much larger scale! Multidate digital analysis may give information on damage level.

However, after 4 or 5 years of severe defoliation, dead stands should be apparent on Landsat imagery. After the hemlock looper outbreak on Anticosti Island, a digital classification of satellite data indicated 470 sq. miles of dead balsam fir (Beaubien 1976). After a visual inventory made by helicopter, the Quebec Department of Lands and Forests evaluated mortality over an area of 500 sq. miles.

Conclusions

For certain specific studies, remote sensing techniques seem valuable for evaluation of forest insect damage. However, I agree with Rhode and Moore (1974): aerial photography for pest detection surveys is generally not practical at this time. The need for total coverage in detection surveys can result in costs that are ten times greater than aerial visual surveys, especially if a large and medium scale photography is used which seems to be necessary to detect spruce budworm defoliation.

Landsat imagery, giving a synoptical view of large areas, can potentially provide the coverage needed for insect damage surveys at an acceptable cost. Results obtained concerning mortality mapping or gypsy moth damage are encouraging, but a detection program must provide more information on light and medium defoliation in various type of forest stands. Multidate approach by digital analysis should be investigated more deeply.

At present the severest limitation to the use of satellite data is the rarity of cloud-free images for a given date and area. This is particularly true for insect damage evaluation where the period of time for photography is often important, or for multidate analysis.

Additional research is needed to provide adequate techniques for an operational pest detection program by remote sensing.

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