THE ROLE, INFORMATIONAL REQUIREMENTS, AND MAJOR PEST PROBLEMS OF THE FOREST INSECT AND DISEASE SURVEY

B.H. Moody
Northern Forest Research Centre
Canadian Forstry Service
Environment Canada
5320 - 122 Street
Edmonton, Alberta T6H 3S5

ABSTRACT

The Forest Insect and Disease Survey (FIDS) of the Northern Forest Research Centre, in conjunction with provincial forest services, conducts annual surveys to detect and monitor the activities of forest pests. Data collected during these surveys are used by federal and provincial resource management agencies in their pest management programs. Described here are the major role and informational requirements of FIDS aerial survey techniques, including type and uses of data collected and major forest pests of the region. The possible role of remote sensing products and the interpretation techniques for standardizing and improving survey methods are discussed.

INTRODUCTION

Forest pest surveys in Alberta, Saskatchewan, Manitoba, and the Northwest Territories are conducted mainly by the staff of the Forest Insect and Disease Survey (FIDS) of the Northern Forest Research Centre, Canadian Forestry Service, in Edmonton. Cooperation and assistance are provided by personnel from many federal, provincial, and municipal agencies.

Various surveys are undertaken annually and include those that detect and assess tree damage from the air. Damage is seen as discolored trees with needles damaged or missing. Special surveys of damaged trees are done in more detail on the ground, but the extensive forests of the region require aerial surveys. The FIDS group has used aerial sketch mapping surveys for a number of years. These surveys, in which areas of damaged trees are sketched onto maps by observers in aircraft, permit an overview of tree damage and may be augmented by detailed ground surveys or observations.

Although aerial photography has been used occasionally to supplement aerial observation, the potential use of this method to refine present FIDS survey techniques needs to be investigated. Before this can be accomplished, the role and informational requirements of FIDS, the major tree-damaging agents, and existing surveys must be identified and stated.

THE ROLE OF THE FIDS GROUP

The main responsibilities of the FIDS group are as follows (Hiratsuka et al. 1981):

1. Contribute to a national overview of important pest conditions in the region and their implications;
2. Map, evaluate, and report on important forest pest infestations in the region;
3. Provide advisory services concerning forest insect and disease problems;
4. Conduct plant quarantine-related activities;
5. Conduct specific surveys of unresolved or potential problems; and
6. Provide an ornamental and shade tree pest extension service.

INFORMATION REQUIREMENTS

An annual national overview of important forest pest conditions would require the following information:

(a) distribution and general location of infestations within a province

(b) causal agent(s) and population level

(c) tree species affected and type of injury and/or damage

(d) area affected

(e) broad mortality volume estimates

(f) broad growth-volume loss estimates where available

(g) further breakdown of forest losses by maturity classes, broad cover types, accessibility, etc.

(h) forecast of pest and host conditions for next year

(i) control options.

MAJOR FOREST PEST PROBLEMS

The first step in designing a program to monitor forest pest damage should be a clear understanding of the pest(s) involved, especially the type of damage to the trees and the period of occurrence. Brief descriptions of some major pests and their damage are discussed in the following section.

DEFOLIATORS

Spruce budworm, Choristoneura fumiferana (Clemens):

Outbreaks of the spruce budworm usually occur in mature forests of white spruce and balsam fir but may infest black spruce and larch in the prairie provinces and Northwest Territories. The spruce budworm has one generation per year. In late July or August the female moth lays over 100 green eggs in clusters of 15-20 on the underside of needles. Eggs hatch in about 10 days, and the young larvae spin silken hibernation shelters (hibernaculae) on the twigs and bark where they overwinter.

The small larvae emerge in early May and first mine old needles, male flowers, or unopened buds. After a few days the larvae begin feeding on the developing needles within expanding buds. As the new shoots grow, the larvae spin fine silk among the needles and between shoots. During periods of high budworm populations, larvae may consume all current-year needles and then feed on the older needles. Heavy feeding causes trees to take on a red-brown appearance that can be readily seen from an aircraft in midsummer. When larvae are fully grown they change to pupae in the feeding sites. The pupae become moths from late June to early August.

Successive years of heavy spruce budworm attack result in repetitive removal of all new foliage and in extensive back-feeding of older needles once the new needles have been devoured. Extensive top-killing and tree mortality occur following a number of years of such defoliation. It will usually take from 3 to 5 years of severe infestation to kill a balsam fir and longer to kill white spruce.

Jack pine budworm, Choristoneura pinus pinus Freeman:

The jack pine budworm, a close relative of the spruce budworm, is the most important insect defoliator of jack pine forests and pine plantations in Manitoba and Saskatchewan. While its main host is jack pine, it also attacks red, Scots, lodgepole, and eastern white pines and occasionally spruce.

The budworm has one generation each year. Small larvae overwinter in their hibernaculae. The larvae commence feeding in late May to early June. They prefer the staminate (male) cone clusters and developing buds as their initial food source. Initial mining of old needles does not occur as in the case of the spruce budworm (Kulman and Hodson 1961). Later, the larvae migrate to the new foliage to complete feeding and development. Older foliage may be fed upon before completion of larval development.

Jack pine budworm larvae are wasteful feeders and rarely consume entire needles. Numerous clipped-off and partly chewed needles accumulate larva excrement and remain attached to the branches with silk webbing. This material turns reddish-brown as it dries in July and, when viewed on the whole tree, provides the basis for judging severity of defoliation during aerial or ground surveys. Defoliation typically spreads from the top of the tree downward, so that, top-kill and reduced annual growth are the most common effects.

Aspen defoliators, primarily Malacosoma disstria Hubner, Choristoneura conflictana (F. Walker), and Operophtera bruceata (Hulst):

Trembling aspen is subjected to severe defoliation periodically by the forest tent caterpillar, M. disstria, and less frequently by the large aspen tortrix, C. conflictana, and the Bruce spanworm, O. bruceata. The forest tent caterpillar is the major defoliator of trembling aspen and other hardwoods in the prairie provinces. This insect overwinters as a small larva in the egg and emerges in the spring to feed in large clusters on the developing foliage of aspen and other hardwoods. The larvae feed for 5 to 6 weeks, during which they pass through five stages or instars. Cocoons are spun about mid-June among the leaves of trees, shrubs, or other vegetation, and the moths emerge 8 to 10 days later.

In heavy infestations, infested trees in vast areas are completely stripped of foliage by about mid-June. If defoliation has been complete, trees may remain bare as late as August, but in general, by mid-July hardwood trees that have less than 60% defoliation begin to refoliate.

BARK BEETLES

Mountain pine beetle, Dendroctonus ponderosae Hopkins:

The mountain pine beetle is a major insect pest of the mature pine forests of western Canada: an outbreak exists in lodgepole pine forests in southern Alberta and may extend into southwestern Saskatchewan. Usually the beetle attacks pine trees older than 60-80 years and with stems over 20-25 cm diameter at breast height; however, when abundant the beetle may attack and kill younger trees.

The adult beetle is 5-7 mm long, black, and attacks live pine trees by boring through the bark. During its life cycle of one year it passes through egg, larval, pupal, and adult stages. All stages are spent under the bark of infested trees except for a few days in late July or August when adult beetles emerge and fly to attack new trees.

Beetle-infested trees are readily recognized from the air except in the earliest stages of infestation. Green trees are attacked by the mountain pine beetle in midsummer. The first noticeable foliage color change usually occurs in May and June of the following year, but occasionally crowns begin to fade in late fall of the attack year. The crowns fade first to yellow usually by June and July, then to red-brown in July and August. The tree is essentially dead at this point, about one year after initial beetle attack.

Trees killed by agents other than the mountain pine beetle usually show the same color changes; therefore, a ground survey is necessary, to confirm the causal organism. On the ground, infested trees can be recognized by reddish brown foliage, pitch tubes on the bole, boring dust at the base of the tree, and by the vertical egg galleries that have a slight hook at the bottom and are constructed by female beetles in the inner bark.

Outbreaks begin in infestations of individual trees or small groups scattered throughout the stand and tend to spread progressively from these centers. In active infestations older than 2 years, grey-topped trees that have lost their foliage may be scattered among red and fading crowns (Safranyik et al. 1974).

Dutch elm disease, Ceratocystis ulmi (Buisman) C. Moreau:

Dutch elm disease (DED) so far has been found only in Manitoba. The disease occurs on American elm but can affect Siberian (Manchurian) elm. Native stands of American elm are not common in Saskatchewan and do not occur in Alberta; however, both elm species have been introduced into all three prairie provinces, where they are widely planted as ornamental, shelterbelt, and shade trees.

Dutch elm disease is caused by the fungus Ceratocystis ulmi. Tiny spores of the fungus are carried by two species of bark beetles, Hylurgopinus rufipes (Eichh) and Scolytus multistriatus (Marsh.). The fungus invades the sapwood, and its spores rapidly spread through the tree's water conducting system, causing wilting and death of the elm tree. Early signs of the disease appear from mid-June to mid-July and include wilting and curling of the leaves on one or more branches. Later, the leaves shrivel and turn brown but may remain on the tree. By mid-August to early September, leaves on one or more branches become yellow and droop (flagging) and affected leaves drop prematurely.

Infected elms leaf out in the spring with smaller than normal leaves on one or more branches or over the entire tree. Some small branches may be dead. These signs indicate that the tree was infected with DED the previous year, but too late for signs of the disease to appear that year. Also, early and late signs may be present at the same time, and in late summer it is not possible to distinguish between autumn coloring and the late-season signs of DED.

Dwarf Mistletoes, Arceuthobium americanum Nuttal ex Engelmann and A. pusillum Peck:

Two species of dwarf mistletoes are widespread in the region and infect jack pine, lodgepole pine, black spruce, and white spruce. Only A. americanum on jack pine and lodgepole pine causes significant damage. The disease is caused by a parasitic green plant that may be easily recognized by its aerial stems growing from infected swollen branches. The most conspicuous indicator of infection is a proliferation of distorted branches on the host, called witches' broom. Because brooms can also be caused by other factors (rusts and genetic or stimulation factors), the presence of the small greenish yellow aerial shoots of the mistletoe is an important identifying character.

Dwarf mistletoes are seed-producing plants with limited spread potential, and their occurrence tends to be spotty but locally concentrated. All ages of trees are susceptible and losses are usually gradual, persistent, and progressive with time since infection. Little annual fluctuation occurs once the disease is established in a tree stand. For this reason, annual surveys are not necessary.

AERIAL SKETCH MAPPING PROGRAM

Most aerial surveys of forest pest damage involve sketch mapping, which is the principal technique used in the region. Observations are made by one or more persons in a fixed-wing aircraft or helicopter of the infestation boundaries and intensity of damage, which are marked onto maps. Prior to the flight, a plan is prepared indicating the flight lines and the observations to be made. Selection of the areas to be visited is usually based on earlier ground or aerial surveys. The aerial survey is primarily concerned with detecting and monitoring the more serious and economically important forest pests that produce symptoms that can be classified by aerial observations. The annual aerial surveys conducted by FIDS at NoFRC are listed by pest and location in Table 1.

Table 1. Annual aerial sketch mapping surveys conducted by FIDS at NoFRC

Pest	Location	Time	Outside cooperator[1]	Report
Mountain pine beetle	Southern Alberta Southwest Saskatchewan	June and August	AFS, Parks Canada, prov. parks	File reports with distribution maps
Spruce budworm	Manitoba	June-July	MDNR, Parks Canada	"
	Alberta	June-July	AFS	"
	NWT	July	NWTFS	"
Jack pine budworm	Manitoba	June-July	MDNR	"
Aspen defoliators	Alberta	June	AFS	"
	Saskatchewan	June		"
	Manitoba	June		"
Red belt survey	Alberta			As required

[1] AFS = Alberta Forest Service.
MDNR = Manitoba Department of Natural Resources.
NWTFS = Northwest Territories Forest Service.

Forest pests are classified in broad categories according to their method of inflicting damage.

Defoliators: Defoliation estimates in most surveys are based on ocular examination of defoliated trees and are, therefore, usually subject to considerable error

and variation. To adopt a more standard measurement for reporting, the following classifications have been used.

For deciduous trees, measurement of infestation is based on the total foliage eaten or defoliation classes as follows:

From the ground	From the air
Nil: no foliage eaten	Nil
Moderate: 21-60% foliage consumed	Moderate to severe: 30-100%
Severe: 61-100% foliage consumed	

Complete: all foliage on tree completely eaten

For coniferous trees, ground survey measurement of infestation is based on percent defoliations of new foliage or old foliage. For aerial surveys, infestation is measured by the intensity of discoloration perceptible and rated as follows:

Moderate: redness of foliage evident at about 300 m, but some green foliage mixed with it;

Severe: new foliage completely red-brown, no green foliage visible

Bark Beetle: Classified according to the numbers or proportion of susceptible trees currently displaying yellow or red-brown foliage (dead trees).

Application of Aerial Sketch-Map Survey Data

Sketch-map data are used for a variety of purposes by provincial and private forestry agencies and public resource management agencies. Some of the main purposes of aerial surveys are the following:

(a) detecting unknown pest problems

(b) identifying and mapping the boundaries of known infestations

(c) planning damage appraisal surveys and control operations

(d) planning salvage operations

(e) planning egg mass surveys for forecast

(f) assessing spread rate and estimating damage or impact of pests on the forests

(g) evaluating control measures, and

(h) providing a historical record of infestation.

CONCLUSION AND DISCUSSION

Difficulties in FIDS aerial pest surveys include: the irregular occurrence of pest problems or damage, the time lag between pest attack and tree mortality (1 year for bark beetles and 5 years for the spruce budworm), variability and discrepancies in the subjective estimates of tree counts, and the necessity for ground checks to confirm identifications of pests and to obtain limited mensuration data.

Because of cost, size of forests, and limited capability for determining causal agents, aerial photography is not well suited for detection surveys; however, after initial detection of an infestation is made by such means as aerial observation, aerial photography is recommended for more-accurate delineation of the infestation to provide a permanent record and as evidence of conclusions reached.

The aerial sketch-mapping technique used by FIDS will probably remain the best detection method because it is the most economical means of obtaining the information. Nevertheless, several proposed refinements to the present aerial surveys should be considered for future surveys by FIDS. Aerial photography could be used to supplement sketch-mapping and ground surveys of pests in high-value forest stands.

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ISSN 0704-7673

USES OF REMOTE SENSING IN FOREST PEST DAMAGE APPRAISAL

Proceedings of a seminar held May 8, 1981, in Edmonton, Alberta

COMPILED BY

R.J. HALL

INFORMATION REPORT NOR-X-238
FEBRUARY 1982

NORTHERN FOREST RESEARCH CENTRE
CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
5320 - 122 STREET
EDMONTON, ALBERTA
T6H 3S5

Hall, R.J. (Compiler). 1982. Uses of remote sensing in forest pest damage appraisal. Proceedings of a seminar held May 8, 1981, in Edmonton, Alberta. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-238.

ABSTRACT

A seminar was held to review experiences and concerns in the application of remote sensing techniques to forest pest damage appraisal. Papers were presented on detection and analysis of vegetative stresses; application of remote sensing to mountain pine beetle management in southern Alberta; practical applications of remote sensing for forest pest damage assessment; some recent developments in remote sensing at the Northern Forest Research Centre; the role, informational requirements, and pest problems of the Forest Insect and Disease Survey (FIDS); FIDS-related remote sensing studies in the Pacific region; and the uses of remote sensing in forest pest damage appraisal.

RESUME

Un séminaire a été organisé pour passer en revue les expériences réalisées et les sujets d'intérêt dans le domaine de l'application des techniques de télédétection à l'estimation des dégâts des ravageurs forestiers. Des communications ont été présentées sur la détection et l'analyse des agressions de la végétation; l'application de la télédétection à la répression du dendroctone du pin ponderosa dans le sud de l'Alberta; les applications pratiques de la télédétection pour la détermination des dégâts des ravageurs forestiers; les innovations récentes dans le domaine au Centre de recherches forestières du Nord; le rôle, les exigences en matière d'information et les problèmes suscités par les ravageurs au Relevé des insectes et des maladies des arbres forestiers (RIMAF); les études sur la télédétection ayant trait au RIMAF dans la région du Pacifique, et les utilisations de la télédétection pour évaluer les dégâts des ravageurs forestiers.