# Forest Health Aerial Overview Survey Standards for British Columbia

The B.C. Ministry of Forests adaptation of the Canadian Forest Service's FHN Report 97-1 “Overview Aerial Survey Standards for British Columbia and the Yukon”

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and

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for the
Resources Inventory Committee

Version 2.0

June 2000

Published by the
Resources Inventory Committee

## Canadian Cataloguing in Publication Data

Main entry under title:
Forest health aerial overview survey standards for British Columbia
[computer file]

Available on the Internet.
Issued also in printed format on demand.
Includes bibliographical references.
ISBN 0-7726-4312-1

1. Trees - Diseases and pests - Aerial photographs - Standards - British Columbia. 2. Aerial photography in forestry - Standards - British Columbia. 3. Forest surveys - Standards - British Columbia. I. British Columbia. Forest Practices Branch. II. Forest Health Network (Canada) III. Resources Inventory Committee (Canada) IV. Title: Overview aerial survey standards for British Columbia and the Yukon.

TR810.F67 2000 778.35 C00-960253-4

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# Preface

The Resources Inventory Committee members are resource specialists from a number of professional disciplines and represent Provincial, Federal, First Nation and private sector agencies and other resource interests. RIC's objectives are to develop a common set of standards and procedures for provincial resource inventories, as recommended by the Forest Resources Commission in its report 'The Future of our Forests".

Funding of the Resource Inventory Committee work, including the preparation of this document, is provided by the Corporate Resource Inventory Initiative (CRII) and by Forest Renewal BC (FRBC). Preliminary work of the Resources Inventory Committee was funded by the Canada-British Columbia Partnership Agreement of Forest Resource Development FRDA II.

For further information about the Resources Inventory Committee and its various Task Forces, please visit the RIC website at http://www.for.gov.bc.ca/ric.

# Abstract

This report provides provincial standards for aerial overview mapping to be used in British Columbia. Aerial overview surveys are broad landscape level assessments of symptoms caused by forest pests. Aerial overview surveys are typically recorded on 1:100,000 to 1:250,000 scale topographical maps and while the scale of the survey may lack the accuracy required for operational purposes, they provide valuable information on historical patterns and landscape impacts of pests, diseases and other abiotic factors. In addition, aerial overview surveys are sufficient and timely for regional and provincial summaries, national requirements for the Forest Health network such as Criteria and Indicators and to help indicate where more detailed surveys are required. Finally, an aerial overview survey meets the minimum forest health data requirements for operational plans as required by the Forest Practices Code.

Aerial overview surveys are generally conducted from early July through August to coincide with the optimum damage expression of major forest pests and damage in British Columbia and the Yukon. The overview surveys are usually conducted in a fixed wing aircraft at low flight line intensities. These standards provide guidelines for planning, conducting and completing aerial overview surveys.

# Acknowledgments

The authors would like to thank the staff of the Canadian Forest Service Forest Health Network (formerly the Forest Insect and Disease Survey) and the Ministry of Forests' regional and district forest health specialists for their input and review of this document.

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# Purpose for establishing standards

- to provide information that is consistent, quantifiable and comparable with the requirements for both Criteria and Indicator reporting and the British Columbia Forest Practices Code, Operational Planning Regulation
- to provide an accurate historical record of pest, and other major disturbances
- to accurately assess current forest health
- to record and highlight changes in forest health over time
- to increase overall efficiency of surveys, thereby resulting in decreased costs
- to provide an accurate data base on which to make decisions
- as an aid to training personnel in the objectives and performance of an aerial survey
- to assist aerial surveyors in all aspects of producing quality maps for analysis and regional and national compilations.

# Aerial Pest Detection Surveys

## Planning

Aerial overview surveys are generally conducted from early-July through August to coincide with the optimum damage symptom expression of major forest pests and damage in British Columbia and the Yukon. By that time sufficient knowledge about current pest conditions has been gained from early season surveys and anecdotal reports, so that the most efficient coverage of known and historically likely outbreaks can be planned. Occasionally special flights are conducted to address specific pests that express themselves either earlier or later than the mid-summer period.

Coordinated planning is essential to a successful aerial survey. Generally, for overview flights being performed by the BCFS, initial aircraft selection and charter arrangements are done by the BCFS through the Regional Fire Centre who will ensure that aircraft and pilots meet specific training and safety requirements. Aircraft reservation should be made well in advance of the expected flight as planes could be in short supply during fire season and alternate arrangements may have to be made. Mapping personnel should also be given as much advance notice as possible to accommodate flight scheduling. Aircraft charter companies should be informed that surveys are weather dependent and final decisions on suitable flying conditions cannot be made until the day of flight.

## Flight Preparation

### Maps

Map scale will be determined not only by availability, but also by product requirements. For both national and provincial overviews, pest information is usually recorded on colored provincial or national topographic series maps of 1:100 000 or 1:125 000 scale or on 1:250 000 when those scales are not available. While larger scale maps allow for greater accuracy and detail, the use of scales such as 1:40 000 or 1:50 000 are more appropriate for operational surveys that require far greater accuracy. At the time of writing, the 1:100 000 topographic maps produced by the BC Ministry of Environment, Lands and Parks were in short supply across the Province. More lead time may be required to gather the necessary maps if they are scarce. The preferred option is to have customized maps created on a GIS to depict the same features as on the NTS maps plus the location of cutblocks and forestry roads. Availability of these maps is highly variable or may take a long lead time if workloads are high. Consult the local forest district office to determine if maps are available at the scale required.

At least two copies of each map are needed - one as a working map (see fig. 11) and the other as a clean summary for digitizing (fig. 12). As an aid to detection, the working copy may include the previous years infestations plotted by GIS. This enables the observer and pilot to plan the flight efficiently and accurately locate areas where pest damage is to be mapped. It also allows any more expansions and changes over time to be checked and better identified. Flight lines with directional arrows are recorded on the map as the flight progresses. The date of the survey and the names of observers should also be noted on the map. Since space in an aircraft is at a premium, excess paper on the map edges is often trimmed away and the maps folded.

## Equipment

Each observer should be equipped with a supply of pens and sharp pencils, binoculars, camera, extra film, amber-tinted sunglasses, a lunch, and motion sickness medication if needed. If the aircraft is not equipped with radio headsets, foam earplugs or some other form of hearing protection should be used. Aircraft must be equipped with a radio programmed for BC Forest Service District and Air Operations/Fire Centre check-ins.

## Aircraft Selection and Safety

Aircraft selection may be largely determined by local availability, but should be of high-wing configuration for ease of lateral and downward viewing, have seating capacity for at least four and be capable of sustained flight of 80 to 90 knots. In remote coastal applications and some northern locations, a float or amphibious version is often more desirable due to better fuel availability and landing opportunities. In the central and southern interior of the province, wheeled aircraft with fixed or retractable landing gear are preferred.

Performance characteristics of the aircraft will be determined by type of terrain and area of coverage. Over flat and rolling landscape or small drainages, a Cessna 180 or equivalent may be sufficient, while in mountainous terrain, an aircraft with stronger performance such as a Cessna 210 or twin-engine Cessna 337 is more appropriate for climbing out of steep valleys although this situation should be avoided whenever possible.

Though aircraft availability and type may be a limiting factor, safety should never be compromised. To avoid fatigue and loss of concentration, daily flights should be limited to 5 hours duration. Also ensure you are well rested before flight and avoid changes in diet prior to flying. For overview surveys helicopters are not cost effective and are usually limited to the occasional pest identification or assessment in otherwise inaccessible areas or as a follow-up after the initial fixed-wing flight.

## Weather

Weather is one of the most critical factors governing the success of an aerial survey and an essential part of preflight planning. Regardless of the prevailing weather, a daily weather forecast describing flying conditions should be obtained to ensure there is good visibility and a minimum ceiling of about 3000 feet. Local weather information can be obtained by calling the Forest District office in the area scheduled for mapping. Clear and sunny days are preferred to maximize detection of defoliation and bark beetle-killed trees for mapping and photography, but solid high overcast giving the forest a monochromatic look, is also acceptable. Broken cloud conditions where one is constantly shifting between sun and shade are extremely difficult to map under, as the eyes are forced to adjust every time the light changes. Such conditions are very fatiguing, and important infestations can be missed in the blind spots. Since shadow from low sun angle can obscure features early or late in the day, especially in areas of significant topographic relief, the optimum flight period is between mid-morning and mid-afternoon when the sun angle is highest. Typically, some flight adjustments may be required when dealing with unstable air in the afternoon.

## Safety

All Ministry of Forests personnel who use aircraft should be familiar with the BCFS *Aviation Safety Manual* (June 1997) produced by the Aviation Management Section, Protection Program.

This document describes Ministry of Forests policy on minimum requirements for air carriers, pilots, specialty flying, flight safety and guidelines, and other safety matters.

Prior to each flight, onboard personnel and the ground communications centre should know the intended flight plan and duration. Known as “positive flight following” or “flight watch”, location updates are radioed every 30 minutes to either the B.C. Forest Service Fire Centre or the appropriate district office, depending on the local protocols. Emergency equipment such as a first-aid kit, emergency locator transmitter beacon and survival gear must be in place and emergency procedures gone over by the pilot prior to flight. Radio headsets are highly recommended if available, for both hearing protection and flight communication. At the very least, in the event the aircraft is not equipped with radio headsets, noise abatement equipment such as foam earplugs should be used.

Amber-coloured sunglasses are often used for both eye protection and to enhance color differentiation on the ground. Clothing should be worn that is made of natural fibres or some other flame-retardant material whenever possible. Be in frequent communication with the pilot regarding direction, altitude changes, air speed adjustments, fuel considerations, meteorological conditions and ferry time estimates. Do not hesitate to ask questions or discuss with the pilot anything which causes you concern. While the observer who chartered the aircraft has jurisdiction over the basic flight procedure, the pilot is ultimately responsible for the aircraft and the safety of the passengers, and may overrule any aspect of the survey plan with respect to aircraft operation and safety. Conversely, if you feel that the aircraft is not being flown in a safe manner, you should terminate the flight and report the incident to the B.C. Forest Service Fire Centre and the charter company.

While the normal flying height is usually between 1500 (500 m) and 3000 (1000 m) feet above the terrain, a minimum flying height of 500 feet (160 m) above ground level must be observed as a safety precaution, such as when crossing ridges between drainages. Depending on the type of aircraft used, minimum airspeed should range between 70 and 90 knots.

# Aerial Survey Procedures

## Limitations

The primary limitation of the overview aerial survey is one of perception, particularly as it pertains to bark beetles. Some forest managers may expect to be able to make stand level decisions on the basis of the overview, when this is clearly beyond its scope. Generally, only estimates of current damage are given, while older tree mortality is usually not included in the total acreage figure. However, mortality estimates are made, if applicable, following the collapse of defoliator infestations. If the intent of the overview survey program has been consistently met, estimates can also be made of cumulative mortality caused by bark beetles in specific stands by overlaying successive years of damage. Additional ground survey assessments are needed to calculate the total extent of pest incidence and damage. In the absence of more detailed information, aerial-sketch mapping results should not be extrapolated beyond reasonable bounds and expectations.

## Mapping

Ideally two observers are used, one on either side of the plane, to expedite coverage and improve accuracy. The forward observer is usually the more experienced individual for the particular area, and has the overall responsibility for flight direction, altitude, and speed. With attention to elevation, map contours, and natural features, the location, relative size, severity and damage, and probable cause are delineated on topographic maps. As infested areas are detected, they are plotted on the map either as a polygon, or as a dot representing infestations of less than one hectare.

Plan a flight line that covers the survey area. Topography will usually have an influence on the route. Over level terrain, flight lines are usually flown on a parallel grid with some overlap, so that no area is missed. In mountainous terrain, contour flying is most efficient with one or more passes through a watershed depending on its size and lighting. In some instances a zigzag flight through a valley may be sufficient when only one pass is made. This action gives the opportunity to map pest damage behind and below the aircraft as well as laterally. Flight lines should always be marked on the map with arrows showing direction. Some oblique photography or video is recommended for a visual record, a training guide, and occasionally to refine sketch maps and assessment of damage. After each flight, both mappers are to compare their respective maps and produce a composite that later will facilitate GIS entry at the office.

The detection and location of damage should be accurate to the scale of the map used. However, when using smaller scale maps such as 1:250 000, the size of infestations is frequently exaggerated, especially when small pockets comprised of 5 to 50 trees each are mapped.. This was found to be true in comparisons of selected outbreaks shown on aerial photographs versus sketch mapping. Harris and Dawson (1979) found the total area sketch mapped to be 34% larger than measured on photographs and similar results were obtained by Gimbarzevsky et al.(1992) in comparison data from ground plots, aerial sketch mapping and various types of remote sensing. As a rule the largest topographical map scale available should be used, normally up to 1:100 000. Occasionally larger scale maps up to 1:50 000 are used, but the large number of maps required for overview coverage makes organization and sorting in the cramped environment of a small plane difficult and time consuming.

## Classification Of Damage

While classification of damage is a subjective judgment by the observer, past surveys have shown that experienced personnel can estimate damage intensities fairly accurately. Accuracy and consistency can be maintained by referring to photo standards (see photos), taking periodic flights with others, and through quality check flights.

Observable damage symptoms can vary among the different bark beetles and between bark beetles and defoliators. Even some defoliators can be differentiated by their damage patterns. It is important that the observer recognize these differences. Some of the types of damage visible from the air include:

- defoliation (budworms, loopers, tussock moths, tent caterpillars, larch casebearers, etc.)
- fading or discoloration of foliage (needle miners, aphids, climatic)
- single or groups of dead trees (bark beetles, porcupine, root rot, flooding, lightning)
- flagging of foliage (animal, fire, herbicides)
- blowdown

## Bark Beetles

Pine killed by mountain pine beetle, initially appear chlorotic, then gradually turn yellow and fade to red within one year of attack. By the last stage of color change in mid-summer the trees are mostly without brood, as is also the case with Douglas-fir beetle. Trees killed by spruce beetle have variable colour and red or brown trees can still contain live beetles. As new attacks are not detected by aerial surveys, ground assessments are made to determine current infestation status. For aerial survey purposes a red tree is one that was attacked and killed the previous year. These are the trees that are mapped. Grey trees are those that have been dead for two or more years and should have been mapped during a prior survey. Small infestations of up to 50 trees may be located on the map as a dot, with the number of trees and the abbreviation for the appropriate tree species beside it. All dots (point sources) are classified as severe. For GIS input the following scale is applied to area estimates:

2 - 30 trees = 0.25 ha;

31 - 50 trees = 0.50 ha.

For larger areas, a polygon is drawn around the infested trees and marked with the appropriate damage classification which is as follows (only red trees are recorded - or note if otherwise):

***Light*** = 1-10% of trees recently killed

***Moderate*** = 11-29% of trees recently killed

***Severe*** = 30%+ of trees recently killed

***Grey*** = (Old): tree mortality 2 or more years old (generally not mapped)

## Defoliators

Defoliated trees, stands, or hillsides assume a reddish tinge as a result of active feeding on the foliage. Only the current year's feeding damage is mapped. In areas where severe defoliation has occurred for several years, trees with little or no remaining foliage may appear grey. In light infestations close observation is necessary because defoliated trees do not readily stand out. Defoliation intensities also tend to fade into each other and subjective delineation must often be

hastily made between areas of differing intensity. When possible, ground checks should be done to verify identification of the defoliator, particularly in new infestations. Following are the severity classes normally used to help classify an infestation (see also photo standards in Appendix).

***Light*** discolored foliage barely visible from the air, some branch tip and upper crown defoliation.

***Moderate*** pronounced discoloration, noticeably thin foliage, top third of many trees severely defoliated, some completely stripped.

***Severe*** bare branch tips and completely defoliated tops, most trees sustaining more than 50% total defoliation.

Classification of *tree mortality* caused by defoliators is the same as that for bark beetles. Accurate classification of mortality for deciduous trees is difficult to achieve from the air unless the trees are either obvious "snags", the surveyor has prior knowledge about the previous year's defoliation, or a ground truthing is available.

## Other Pest And Abiotic Damage

While bark beetle and defoliator infestation assessments are the main targets of the aerial survey flights, other types of damage are noted if the observer considers this damage significant. Other forest disturbances mapped during regular aerial surveys include blowdown, winter damage, animal damage, flooding, foliage diseases, root rots, and pollution damage. Observable damage symptoms can vary considerably between each, or be very similar.

Where blowdown and flooding are usually easy to recognize due to their physical characteristics or association, others such as winter damage and foliage diseases are more difficult to identify as they can mimic other types of damage such as defoliation (and vice-versa). Root rot disturbances also are difficult to map, due to the scattered nature and various stages of decline of infected trees.

In summary, the following damage agents sometimes observed during aerial surveys can be confused with damage caused by insects:

- porcupine feeding
- bear damage
- herbicide application
- weather related (wind, winter drying, frost, red belt, hail, drought, sunscald, lightning)
- large cone crop
- needle diseases
- root rots
- fire damage
- flooding
- pollution, ground level ozone

## Aerial Survey Timing

The overview aerial survey is designed to incorporate mapping of visible damage from as many forest pests as possible in one flight. However, the period when damage (primarily insect) is most visible varies with the pest species and its geographic distribution. In most cases there is sufficient overlap of defoliator damage and bark beetle-kill to properly schedule both types of damage in the same survey. The normal aerial survey period (the "biological window") in British Columbia and Yukon is between early July and late August, which provides maximum detection of common pests with a minimum of duplicate flying (Table 1). Winter moth, tent caterpillars,

spruce aphid and lodgepole pine needle disease are examples of some common pests that do not fit the general biological window and may require separate surveys prior to July 1.

**Table 1 - The biological window for aerial survey mapping of bark beetle-killed tree and defoliator damage in British Columbia and Yukon. Pest codes with a ? indicates that a standard code is not available.**

| Tree Species | Pest Code | Pest | Peak Period |
|---|---|---|---|
| **Bark Beetles** | | | |
| **Pine:** *lodgepole* | IBM | mountain pine beetle | early July -early Sept. |
| *western white* | IBM | mountain pine beetle | early July -early Sept. |
| *whitebark* | IBM | mountain pine beetle | early July -early Sept. |
| *ponderosa* | IBM | mountain pine beetle | early July -early Sept. |
| *ponderosa* | IBW* | western pine beetle | early June - mid-Aug. |
| *lodgepole* | IB? | engraver beetles (Ips spp.) | July -September |
| **Spruce:** *Engelmann, white* | IBS | spruce beetle | mid-June - early Sept. |
| **Douglas-fir** | IBD | Douglas-fir beetle | mid-June - late Aug. |
| **True firs:** *sub-alpine fir* | IBB | western balsam bark beetle | anytime |
| *grand fir* | IB? | fir engraver | early July - late Aug. |
| **Defoliators** | | | |
| **Douglas-fir** | IDW | western spruce budworm | late June - mid-Aug. |
| | IDT | Douglas-fir tussock moth | mid-July - late Aug. |
| | IDZ | false hemlock looper | mid-July - late Aug |
| **Hemlock***: western* | IDH | western blackheaded budworm | mid-July - early Sept. |
| | IDL | western hemlock looper | mid-July - early Sept. |
| | IDG | green-striped forest looper | mid-July - early Sept. |
| | ID? | saddleback looper | mid-July - early Sept. |
| | ID? | phantom hemlock looper | early July - late Aug. |
| | ID? | gray spruce looper | late Aug. - early Oct. |
| **True firs:** *sub-alpine* | IDE | 2-year-cycle spruce budworm | mid-July - mid-Aug. |
| | IAB | balsam woolly adelgid | Aug. through Sept. |
| *amabilis fir* | IAB | balsam woolly adelgid | Aug. through Sept |
| *grand fir* | IAB | balsam woolly adelgid | Aug. through Sept. |
| **Pine:** *lodgepole* | IDI | pine needle sheathminer | late June - mid-Aug. |
| | IDS | conifer sawflies | mid-July - late August |
| | ID? | pine butterfly | July through August |
| **Spruce:** *Sitka* | IAS | Spruce aphid | March through June |
| **Larch***:* | IDC | larch casebearer | mid-May - mid-June |

| Tree Species | Pest Code | Pest | Peak Period |
|---|---|---|---|
| *western* | | | |
| | IDP | larch sawfly | late July - early Sept. |
| | ID? | larch budmoth | early July - mid-Aug. |
| **Deciduous** | IDF | tent caterpillars | early June - early July |
| | IDU | satin moth | early June - mid-July |
| | IDX | large aspen tortrix | early June-mid-July |
| | IDN | birch leafminers | early-June - mid-July |
| **Other Damage** | | | |
| **Pine:** | DFL | pine needle cast | May through June |
| *lodgepole* | | | |
| | | winter drying | April through June |

# Map Processing

## Composite Map

Daily mapping results should be compared among observers and a composite (master map) drawn after each flight while visual image retention is still good. The product should be a quality sketch map suitable for digitizing or photocopying. Each map should have a standard color-coded legend (see appendix) representing each pest mapped. Additional data includes dates of flight, names of observers, and type of aircraft used. Upon completion of the composite map, current infestations and areas of damage are entered into a Geographic Information System (GIS), from which the completed data is ultimately distributed. Because GIS generated maps appear clean and professional, it is easy to make assumptions regarding their veracity, but it must be emphasized that the results are only as good as the data entered.

## GIS Activities

Pest data from maps is recorded by digitizing the polygons and assigning attributes of pest severity, year, forest region, and map reference. From these data, searches or compilations of any combination of desired attributes can be made. During digitizing, the current and previous year's infestations can be viewed on the screen, providing an opportunity to make changes before entry into the database. A final edit of the digital map against the sketch map is required. A legend should be produced to accompany the map according to the standards outlined in the appendix. Observers are generally responsible for input of their own data, so errors and omissions can be minimized. However, increasingly, the input of map data will be by people other than those participating in the actual mapping and will leave little basis for decision making if discrepancies occur. GIS reproductions at various map scales are distributed to cooperating agencies such as the B.C. Forest Service, Canadian Forest Service, forest industry and Parks. Using report generators, area and polygon tallies can be derived for selected areas, map sheets, administrative regions or the entire province/territory.

## Data Preparation

The B.C. Ministry of Forests has now assumed the data custodianship responsibility for recording, reporting and storing aerial overview survey information. A set of digital data standards has been produced that will be followed to facilitate the seamless roll-up of all new overview survey data collected throughout the province.

# Spatial and Attribute Data Capture (Digitizing) Standards

## General:

Forest Health 'points' and 'polygons' as recorded on the paper mapsheets during the overview survey flight (scale typically 1:100,00 or 1:250,000 but can be larger - Cariboo Region uses 1:40,000 mapsheets for example) will be digitized on an appropriate electronic map base (typically 1:100,000 scale) - including simultaneous capture of associated attributes. Attributes will include pest code, damage class, etc.

## Specifications:

### File Format:

All spatial data provided to the Ministry of Forests must be in Intergraph Design File (IGDS) format Version 8.0 or later. Spatial data in the IGDS (.DGN) files will be in 2D format with the Universal Transverse Mercator (UTM) projection (Clarke Spheroid) with no data linkages attached.

### Input Scale:

The tile size for digital data capture will be 1:100,000 (1/4 letter blocks - 6x5 1:20,000 per mapsheet) using TRIM base in the NAD 83 datum, however, circumstances may require the use MOF 1:20,000 graphics (.fc1) mapsheet files as the base reference.

### Positional Accuracy:

Captured spatial data must have a positional accuracy of 1mm at map scale (for 1:100,000 this is 100 m on the ground) when compared to the original paper map 90 percent of the time.

### File Content:

The Positional Files will contain linestrings, centroids (textnodes) and annotation for the polygonal information and centroids (textnodes) and annotation only for the point data. The data will be structured, topologically valid, and tied (one-to-one relationship) appropriately to an external attribute database. The textnode numbers will provide the link to the attribute database file (TAGID). The database will be provided in MS Access format (posted on the MOF ftp site) and consist of the following attributes:

**Database structure:**

**Table 2 - The biological window for aerial survey mapping of bark beetle-killed tree and defoliator damage in British Columbia and Yukon. Pest codes with a ? indicates that a standard code is not available.**

| Attribute | Description | Type | Length | Values |
|---|---|---|---|---|
| Node_number | Unique centroid Number | Integer | 5 | Unique number per mapsheet in the range 1-32,000 |
| Region | Region code | Character | 3 | 3 letter Region code (e.g. RVA = Vancouver Region), see Appendix I |
| District | District code | Character | 3 | 3 letter District Code (e.g. DKA = Kamloops District), see Appendix I |
| Year | Year of Infestation | Integer | 4 | |
| Map_number | BCGS Mapsheet | Character | 9 | e.g. 082fse (1:100,000)<br>092b105 9 (1:50,000)<br>104H002 (1:20,000) |
| FHF | Forest Health Factor (aka: pest code, damage agent and condition code) | Character | 3 | 3 letter code as per FS 747 HSP 99/1 form |
| Severity | Severity (aka damage class, attack intensity class | Character | 1 | L(ight), M(oderate), S(evere)<br>NOTE: spot infestations always assigned S(evere) |
| Polygon_area | Large area of infestation | I*2 | 8 | calculated from positional data, largest area = 99999.99 ha |
| Spot | Spot (aka point) infestation | Character | 1 | Y (es) or N(o) |
| Num_trees | Number of trees in spot infestation | Integer | 2 | Number between 1 and 50, value only if spot = Y |
| Spot_area | Area of spot, assigned depending upon num_trees | I*2 | 4 | Value only if spot = Y,<br>1-30 trees assigned value of 0.25 ha<br>30-50 trees assigned value of 0.50 ha |

## Table 3 - Feature Descriptions for 1:100,000 IGDS format aerial overview maps

| Feature Description | | | IGDS Specification | | | | | | | Text | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Feature_Ty** | **Component_Ty** | **Type** | **Class** | **Level** | **Colour** | **RGB Triplet** | **Weight** | **Style** | **Font** | **Just** | **Size** | **Cell** |
| Pest Polygon Infestations | Polygon | Boundary | 4 | P | 20 | | Varies | 0 | 0 | | | | |
| Pest Polygon Infestations | Polygon | Centroid | 7 | C | 20 | | 116 | 0 | 0 | 25 | CC | 120m | |
| Pest Polygon Infestations | Polygon | Annotation | 7 | P | 21 | | 3 | 0 | 0 | 25 | CC | 300m | |
| Pest Spot infestations | Point | Point | 7 | P | 60 | | 3 | 0 | 0 | 25 | CC | 120m | Pest |
| Pest Spot infestations | Point | Annotation | 7 | P | 21 | | 3 | 0 | 0 | 25 | CC | 300m | |
| The following Feature_components relate to the main feature class of Aerial Survey Pest Polygon Infestations (Boundary) Feature Class | | | | | | | | | | | | | |
| AB - Bear | Polygon | Boundary | 4 | P | 20 | 2 | 255,0,0 | 0 | 0 | | | | |
| AD - Deer | Polygon | Boundary | 4 | P | 20 | 148 | 168,255,255 | 0 | 0 | | | | |
| AP - Porcupine | Polygon | Boundary | 4 | P | 20 | 88 | 168,0,0 | 0 | 0 | | | | |
| NB - Fire | Polygon | Boundary | 4 | P | 20 | 151 | 168,192,255 | 0 | 0 | | | | |
| ND - Drought | Polygon | Boundary | 4 | P | 20 | 126 | 0,89,126 | | | | | | |
| NF - Flooding | Polygon | Boundary | 4 | P | 20 | 154 | 214,168,255 | 0 | 0 | | | | |
| NGK - Frost | Polygon | Boundary | 4 | P | 20 | 75 | 0,205,173 | | | | | | |
| NW - Windthrow | Polygon | Boundary | 4 | P | 20 | 231 | 168,115,129 | 0 | 0 | | | | |
| DFH - Larch Needle Cast | Polygon | Boundary | 4 | P | 20 | 6 | 255,0,255 | 0 | 0 | | | | |
| DFL - Pine Needle Cast | Polygon | Boundary | 4 | P | 20 | 156 | 255,168,255 | 0 | 0 | | | | |
| DMP - Pl Dwarf Mistletoe | Polygon | Boundary | 4 | P | 20 | 199 | 137,156,205 | 0 | 0 | | | | |
| DRA - Armillaria Root Disease | Polygon | Boundary | 4 | P | 20 | 110 | 168,0,115 | 0 | 0 | | | | |
| DSB - White Pine Blister Rust | Polygon | Boundary | 4 | P | 20 | 17 | 255,115,0 | 0 | 0 | | | | |
| IBW - Western Pine Beetle | Polygon | Boundary | 4 | P | 20 | 4 | 255,255,0 | 0 | 0 | | | | |
| IBI - Ips (engraver) Beetle | Polygon | Boundary | 4 | P | 20 | 65 | 205,96,0 | 0 | 0 | | | | |
| IBB - Western Balsam Bark Beetle | Polygon | Boundary | 4 | P | 20 | 2 | 255,0,0 | 0 | 0 | | | | |
| IBD - Douglas-fir Beetle | Polygon | Boundary | 4 | P | 20 | 6 | 255,0,255 | 0 | 0 | | | | |
| IBM - Mountain Pine Beetle | Polygon | Boundary | 4 | P | 20 | 2 | 255,0,0 | 0 | 0 | | | | |
| IBS - Spruce Beetle | Polygon | Boundary | 4 | P | 20 | 2 | 255,0,0 | 0 | 0 | | | | |
| IAB - Balsam Woolly Adelgid | Polygon | Boundary | 4 | P | 20 | 23 | | 0 | 0 | | | | |
| IAS - Spruce Aphid | Polygon | Boundary | 4 | P | 20 | 136 | 255,168,168 | 0 | 0 | | | | |
| ID - Defoliator | Polygon | Boundary | 4 | P | 20 | 140 | 255,255,168 | | | | | | |
| IDB - Two-year Budworm | Polygon | Boundary | 4 | P | 20 | 69 | 173,205,0 | 0 | 0 | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IDC - Larch Casebearer | Polygon | Boundary | 4 | P | 20 | 45 | | 0 | 0 | | | | |
| IDE - Eastern Spruce Budworm | Polygon | Boundary | 4 | P | 20 | 187 | 205,190,137 | 0 | 0 | | | | |
| IDF - Forest Tent Caterpillar | Polygon | Boundary | 4 | P | 20 | 3 | 0,255,0 | 0 | 0 | | | | |
| IDG - Greenstriped Forest Looper | Polygon | Boundary | 4 | P | 20 | 117 | | 0 | 0 | | | | |
| IDH - Western Blackheaded Budworm | Polygon | Boundary | 4 | P | 20 | 23 | 115,255,0 | 0 | 0 | | | | |
| IDI - Pine Needle Sheath Miner | Polygon | Boundary | 4 | P | 20 | 73 | | 0 | 0 | | | | |
| IDK - Northern Tent Caterpillar | Polygon | Boundary | 4 | P | 20 | 120 | 0,126,0 | 0 | 0 | | | | |
| IDL - Western Hemlock Looper | Polygon | Boundary | 4 | P | 20 | 142 | 214,255,168 | 0 | 0 | | | | |
| IDN - Birch Leaf Miner | Polygon | Boundary | 4 | P | 20 | 5 | 0,0,255 | 0 | 0 | | | | |
| IDP - Larch Sawfly | Polygon | Boundary | 4 | P | 20 | 75 | | 0 | 0 | | | | |
| IDS - Conifer Sawflies | Polygon | Boundary | 4 | P | 20 | 7 | 0,255,255 | 0 | 0 | | | | |
| IDT - Douglas-fir Tussock Moth | Polygon | Boundary | 4 | P | 20 | 10 | | 0 | 0 | | | | |
| IDU - Satin Moth | Polygon | Boundary | 4 | P | 20 | 30 | 0,168,255 | 0 | 0 | | | | |
| IDW - Western Spruce Budworm | Polygon | Boundary | 4 | P | 20 | 34 | 168,0,255 | 0 | 0 | | | | |
| IDZ - Western False Hemlock Looper | Polygon | Boundary | 4 | P | 20 | 176 | | 0 | 0 | | | | |

| | | |
|---|---|---|
| Water | 104 | 0,0,168 |
| District/Region Boundaries | 0 | 255,255,255 |
| Adjacent District Shapes | 9 | 204,204,204 |

NOTE: Pest Spot Infestation cell to be named 'pest'

## Metadata

In addition to the attributes listed above, all mapping data must be accompanied with it's own metadata (associated information), which describes in detail :

- Map projection (Lambert, UTM, Polyclinic, etc.)
- Projection parameters (numerical data describing the units, origin, false easting and northing, central meridian, etc.)
- Accuracy limitations (scale the data was created at, speed at which data was gathered, level of accuracy desired, i.e. overview or operational)
- Description of each item in the database and the values for each
- Method of data collection (detailed aerial survey, overview quick sketchmapping, ground survey, transfer of data from air photos)
- Scale data was originally collected at
- Purpose of data collection - what the data is intended for (collected
- as secondary data while conducting other surveys, detailed operational procedures, overview survey, rough location information only)
- Contact names and location for future reference
- Permission or restrictions on redistribution of data

**Minimum Metadata Specifications for Provincial Aerial Survey Data**

All IGDS and Arc/Info data will be in the following format:

| | |
|---|---|
| Projection: | Mercator |
| Datum: | NAD 83 |
| Units: | Metres |
| Spheroid: | GRS 1980 |
| Longitude of central meridian: | -129 0 0.00 |
| Latitude of true scale: | 45 0 0.000 |
| False easting (metres): | 1000000.00000 |
| False northing (metres): | 0.00000 |

The IGDS textnode on levels 20 or 21 (polygonal or spot data), tie to the first field in the Access Database (e.g:, the textnodes on level 20 (polygonal data) for Arrow IBM (PDAR_IBM.DGN) ties to the field DAR_IBM_ID in the Access Database (PDAR_IBM.MDB)).

## Data Transfer

**Providing Data to the Ministry of Forests:**

Electronic data prepared by contractors may be transferred by ftp or CD to the administrating district or regional office for review for errors and omissions. Hard copy maps may be required to facilitate the data review process. Once the data quality has been checked against the original

overview maps, map files are transferred to the Forest Practices Branch or directly to the Provincial GIS contractor.

The preferred method of digital data to the Forest Practices Branch is through the Ministry of Forests' FTP site at:

ftp.for.gov.bc.ca/branches/forest_practices/external/incoming/aerial_overview/

The output from the digital roll-up of all provincial data will be in the form of:

1. IGDS (.dgn) and ArcExport (.00e) files for polygonal and spot data for each district and the entire province;
2. Attributes summarized in both an MS Access database (template.mdb) and in an MS Excel spreadsheet (fhsurvey.xls)(templates posted on the ftp site at: ftp.for.gov.bc.ca/branches/forest_practices/external/!publish/Aerial_Overview/); and,
3. Adobe Acrobat portable document format (pdf) versions of each of the following mapsheets:
    - Provincial (4), regional (4 x 7 = 28) and district (4 x ~40 = 160) summary maps for mountain pine beetle (IBM), spruce beetle (IBS), Douglas-fir beetle and western balsam bark beetle (IBD and IBB), All defoliators and other disturbances (other IB, diseases, abiotics and animal damage).
    - Only district mapsheets will require attribute labels (i.e., severity and unique label)

Each mapsheet will have a title, legend, and points and polygons with appropriate annotation and/or color theme depicting pest code as needed for interpretation. Hard copies are not required.

Output will be distributed via the Ministry of Forests' web site at http://www.for.gov.bc.ca/hfp/forsite/forsite.htm

# Accuracy

Aerial surveying is not an exact science, but an observer should do everything to ensure the best calls are made. No matter what type of aircraft, the flying height, the weather, the survey map base, or the biological window, the survey is always going to be less than perfect. Credibility comes from following established criteria:

- not missing extensive damage
- getting the polygon or dot in the right geographic location
- drawing polygons to accurately reflect infested areas on the ground
- correctly calling the tree (host) species
- knowing and calling the pest damage correctly
- accurately estimating defoliation or damage intensity and numbers of trees

Aerial sketch-mapping can be enhanced with the use of aerial photographs, especially in areas of extensive pest damage on even terrain with few geographical features. Up-to-date aerial photos can be useful in showing logging, burns and other details that observers can delineate from infested timber. If available, custom drawn GIS maps that highlight cutblocks, roads, water bodies and other landmarks greatly improve the observer's ability to orient themselves quickly and thus enhance the accuracy of pest polygon placement.

Studies have shown (J.W.E. Harris et al. 1979, 1982, and Gimbarzevsky et al.1992) that defoliation estimates are frequently exaggerated during sketch mapping, while counts of bark beetle-killed trees are low when compared to aerial photographs, ground plots and some remote sensing techniques. For a given area, assessment of aerial survey accuracy and presence of bias are best determined using a multistage sampling procedure, comparing sketch mapping, aerial photography and ground plot data.

## Check Flights

Periodic check flights of overview surveys should be done by experienced observers to maintain accuracy and precision of pest assessments within acceptable parameters such as the qualitative and quantitative criteria listed above. The recommended process is as follows:

A flight audit should be made no more than two weeks after the initial survey and remain within the biological window of the pests mapped.

1. Identify the pests to be assessed from the map legend.
2. Use same map scale and any previous data.
3. Randomly select sample polygons or dots representing 5 to 10% of the total area mapped. This can be done by plotting transects through infestations and mapping only intersected polygons. Normally, this should not amount to more than the equivalent of a weeks flying for all of B.C. and the Yukon.
4. Analyze and compare both maps against established criteria such as pest and host identification, damage intensity levels etc.
5. It is suggested that the level of accuracy be proportional to the degree of mapping difficulty, i.e., scattered occasional defoliation or bark beetle kill, versus extensive defoliation or large

scale beetle outbreak mapping. However, acceptable limits of accuracy are expected to be within 30% plus or minus the check flight assessment. When those limits are exceeded the observer should be re-assessed to determine the source of discrepancy.

# Conclusions

While improvements and efficiencies will continue to be sought after, annual aerial surveys are expected to remain a basic method for contributing to the national and provincial annual summary of forest health conditions. It is hoped that this standards manual will aid in providing consistency and accuracy to aerial sketch mapping.

For further information or comment please contact:

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Pacific Forestry Centre
Forest Health Network
506 West Burnside Rd
Victoria, B.C. V8Z 1M5

Phone (250) 363-0600 or e-mail - Pkoot@pfc.forestry.ca

Forest Site Management Section
Forest Practices Branch
B.C. Ministry of Forests
P.O.Box 9578 Stn. Prov Govt.
Victoria, B.C. V8W 9C2

Phone (250) 387-8739 or e-mail - Tim.Ebata@gems8.gov.bc.ca

# References

British Columbia Forest Service 1997. Aviation Safety Manual, Aviation Management, Protection Program, Ministry of Forests. 58 pp.

British Columbia Forest Practices Code. Operational Planning Regulation.

Gimbarzevsky, P., A.F. Dawson and G.A. Van Sickle 1992. Assessment of aerial photograph and multi-spectral scanner imagery for measuring mountain pine beetle damage. Pacific Forestry Centre. Information Report BC-X-333. 31 pp.

Hamm, M. 1991. Aerial Pest Survey Procedures. Sketch-Mapping of Pest Damage and Compilation of Losses. B.C. Forest Service, Cariboo Forest Region, Williams Lake , B.C. Unpublished report.

Harris, J.W.E. and A.F. Dawson 1979. Evaluation of Aerial Forest Pest Damage Survey Techniques in British Columbia. Pacific Forest Research Centre Report BC-X-198, 22 pp.

Harris, J.W.E., A.F. Dawson and R.G. Brown 1982. Evaluation of Mountain Pine Beetle Damage Using Aerial Photography, Flathead River, B.C. 1980. Pacific Forest Research Centre. Report BC-X-228, 10 pp.

McConnell, J (editor) 1995. Proceedings Aerial Pest Detection and Monitoring Workshop. Las Vegas, Nevada.. U.S. Dept. of Agriculture. Report 95-4.

Shore, T.L. (Compiler) 1984. General Instructions Manual. Pacific Forest Research Centre, Victoria, B.C. Working Draft.

Taylor, S.P. 1982. Procedures For Aerial Sketch Mapping and Volume Determination of Forest Insect Infestations. B.C.Forest Service, Protection Branch, Internal Report PM-PB-4.

# Appendix I

**COLOR PHOTOS OF PEST DAMAGE**

Bark Beetles


**Figure 1 Enlargement of 1:100 000 NTS map showing polygons of mountain pine beetle-killed lodgepole pine and the original 70 mm photo, Flathead Valley, Nelson Forest Region.**

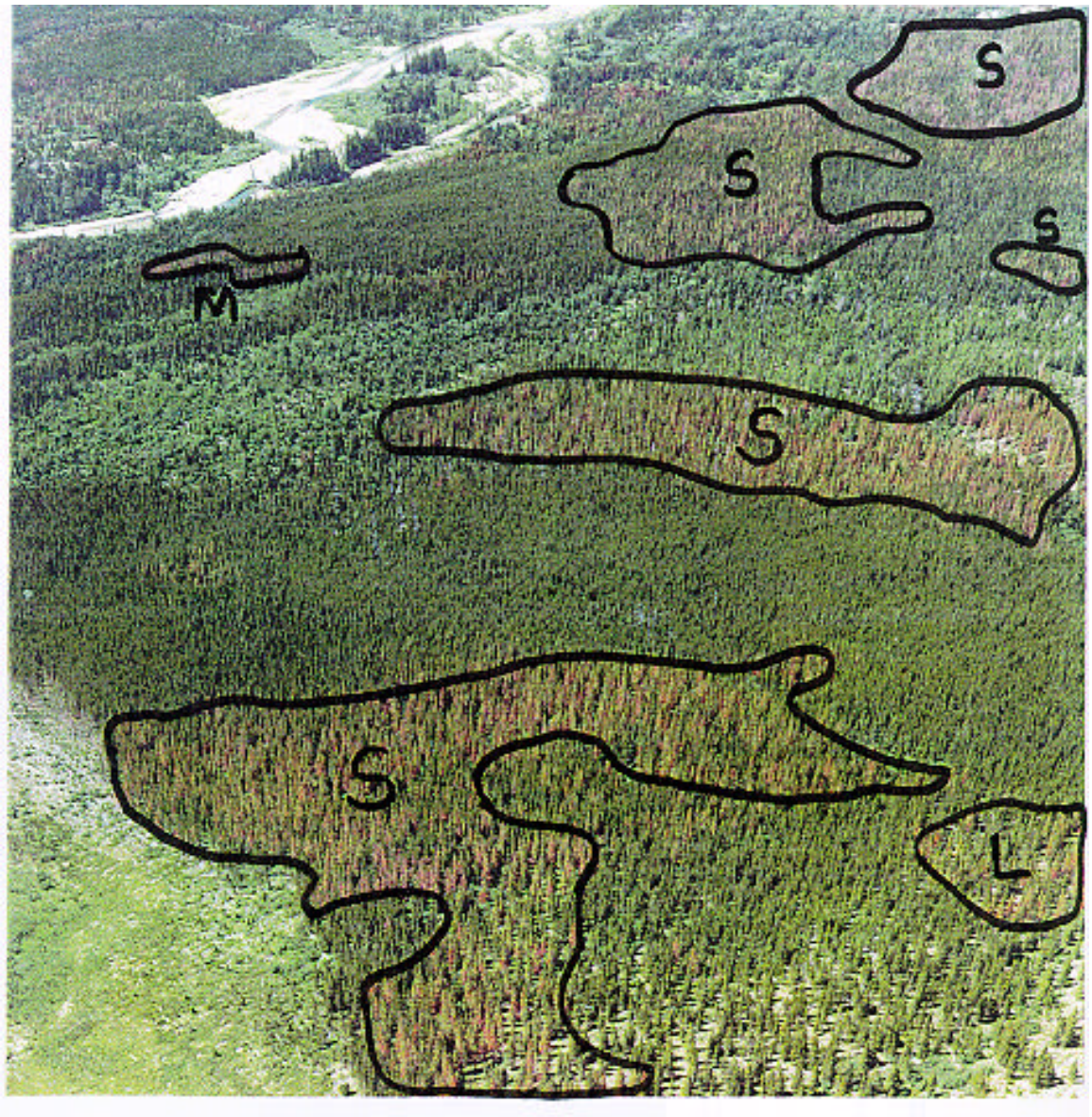


**Figure 2 Enlargement of original 70 mm photo with examples of LIGHT, MODERATE and SEVERE mortality of lodgepole pine caused by mountain pine beetle.**

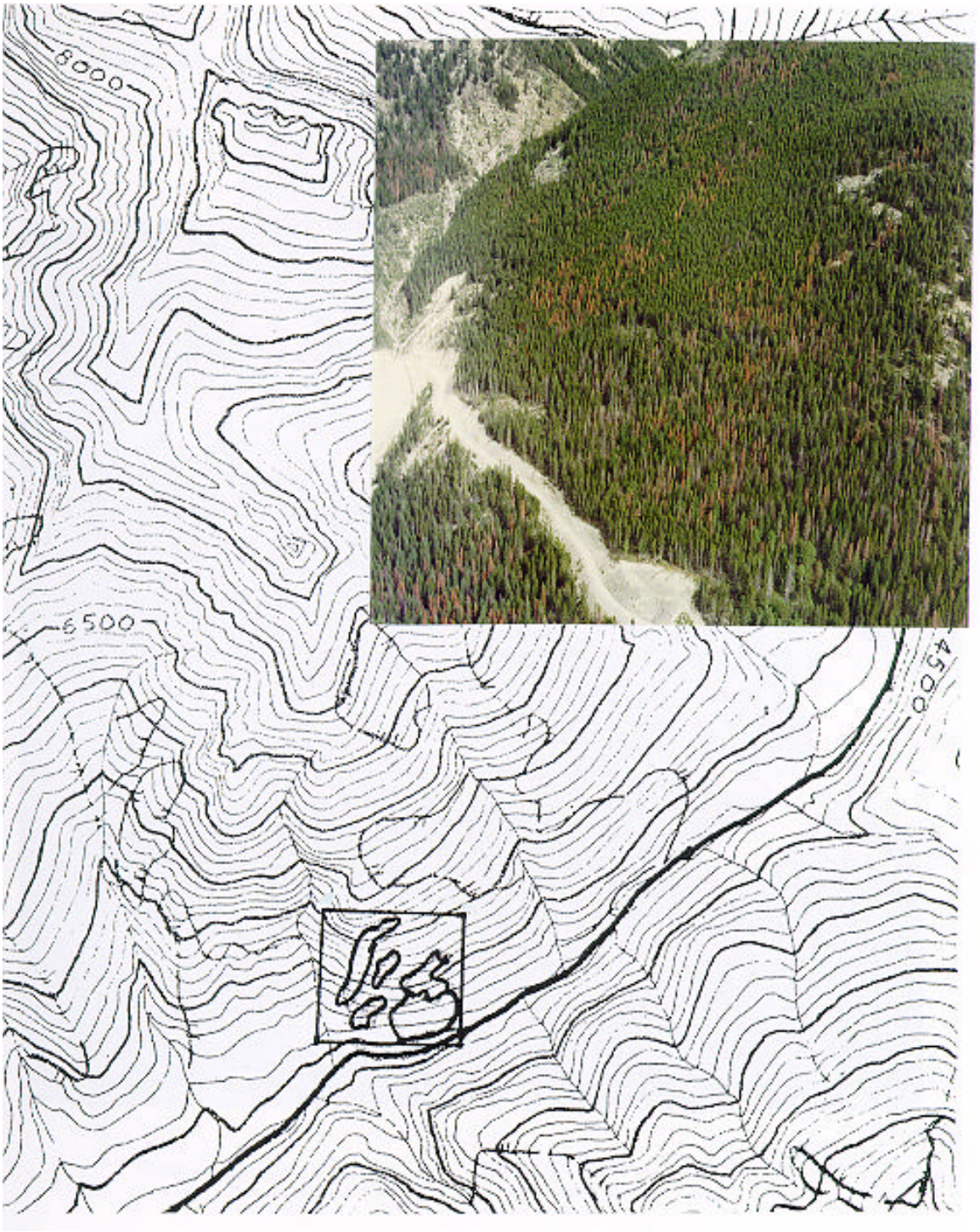


**Figure 3 Enlargement of 1:100 000 NTS map showing polygons of mountain pine beetle-killed lodgepole pine and the original 70 mm photo, Elk Creek, Nelson Forest Region.**

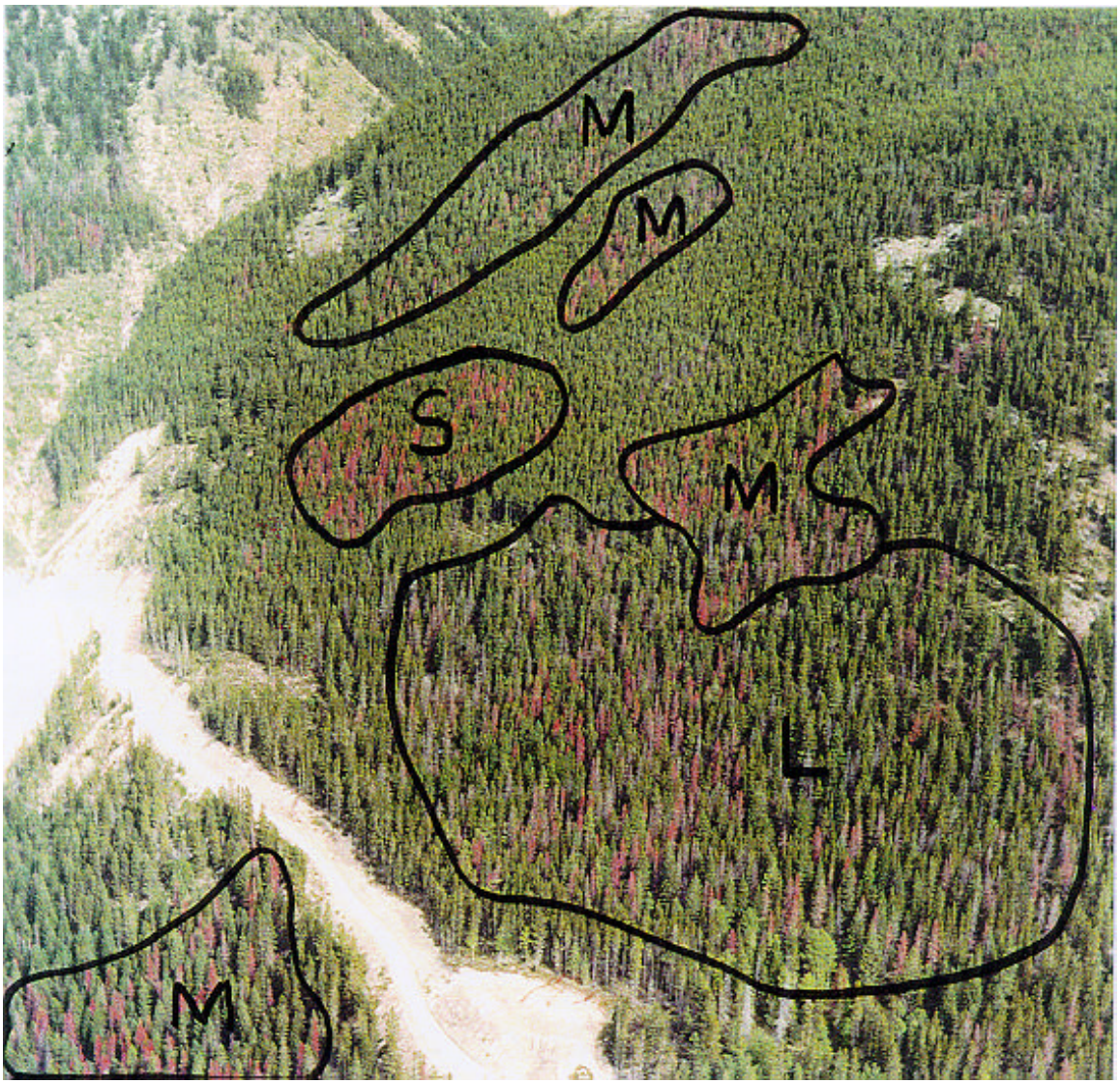


**Figure 4 Enlargement of original 70 mm photo with examples of LIGHT, MODERATE and SEVERE mortality of lodgepole pine caused by mountain pine beetle.**

Light -

Moderate

(prob. 5-10%)

Moderate

Severe

**Figure 5 Examples of LIGHT, MODERATE AND SEVERE classification of mountain pine beetle infestation (from FIDS General Instructions Manual).**

Defoliators

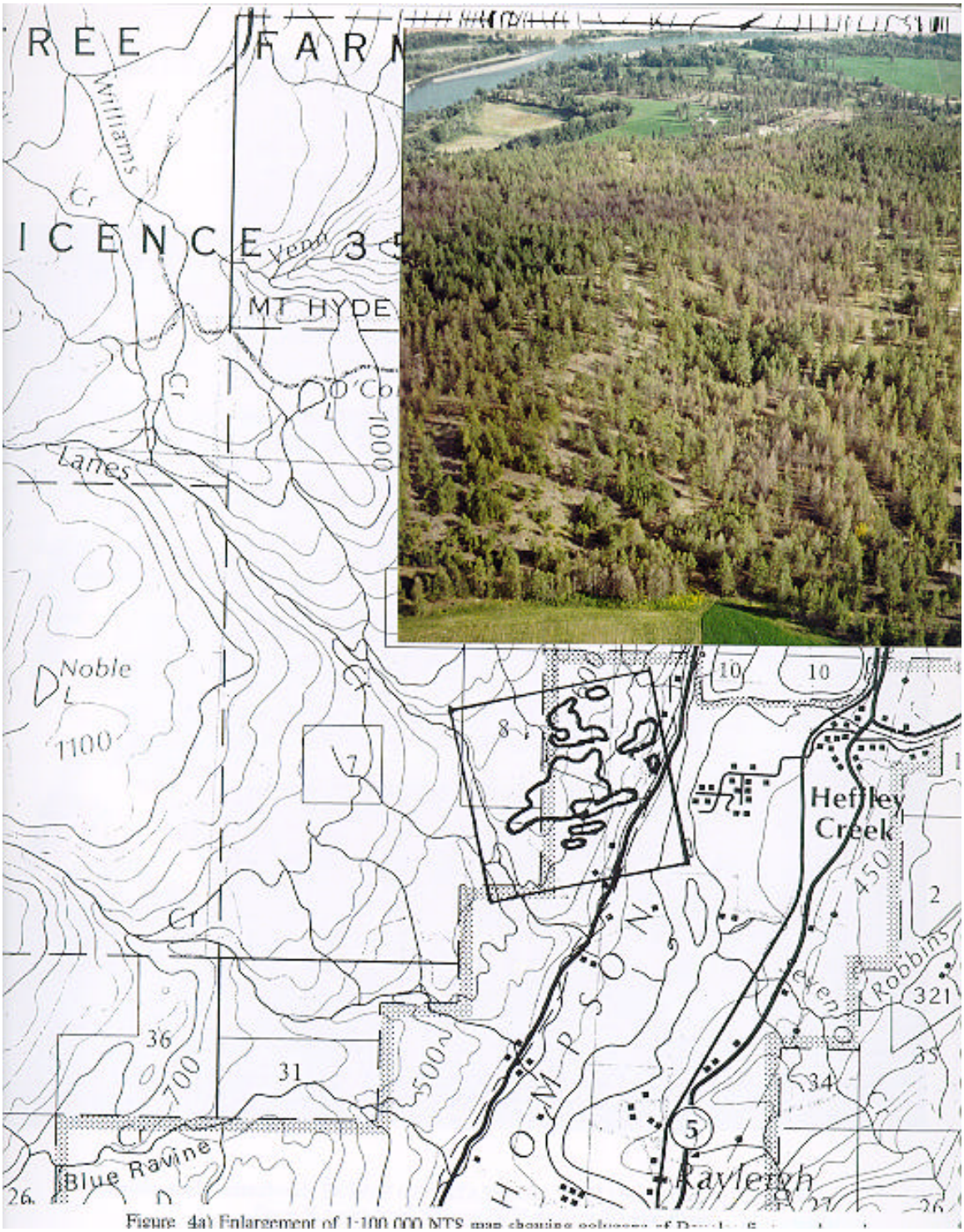


**Figure 6 Enlargement of 1:100 000 NTS map showing polygons of Douglas-fir tussock moth defoliation of Douglas-fir and the original 70 mm photo, Lanes Creek, Kamloops Forest Region.**


**Figure 7 Enlargement of original 70 mm photo with examples of MODERATE, SEVERE and GREY categories of defoliation of Douglas-fir by Douglas-fir tussock moth, Lanes Creek, Kamloops Forest Region.**


**Figure 8 Enlargement of 1:100 000 NTS map showing polygons of western spruce budworm defoliation of Douglas-fir and the original 70 mm photo, Boston Bar, Vancouver Forest Region.**

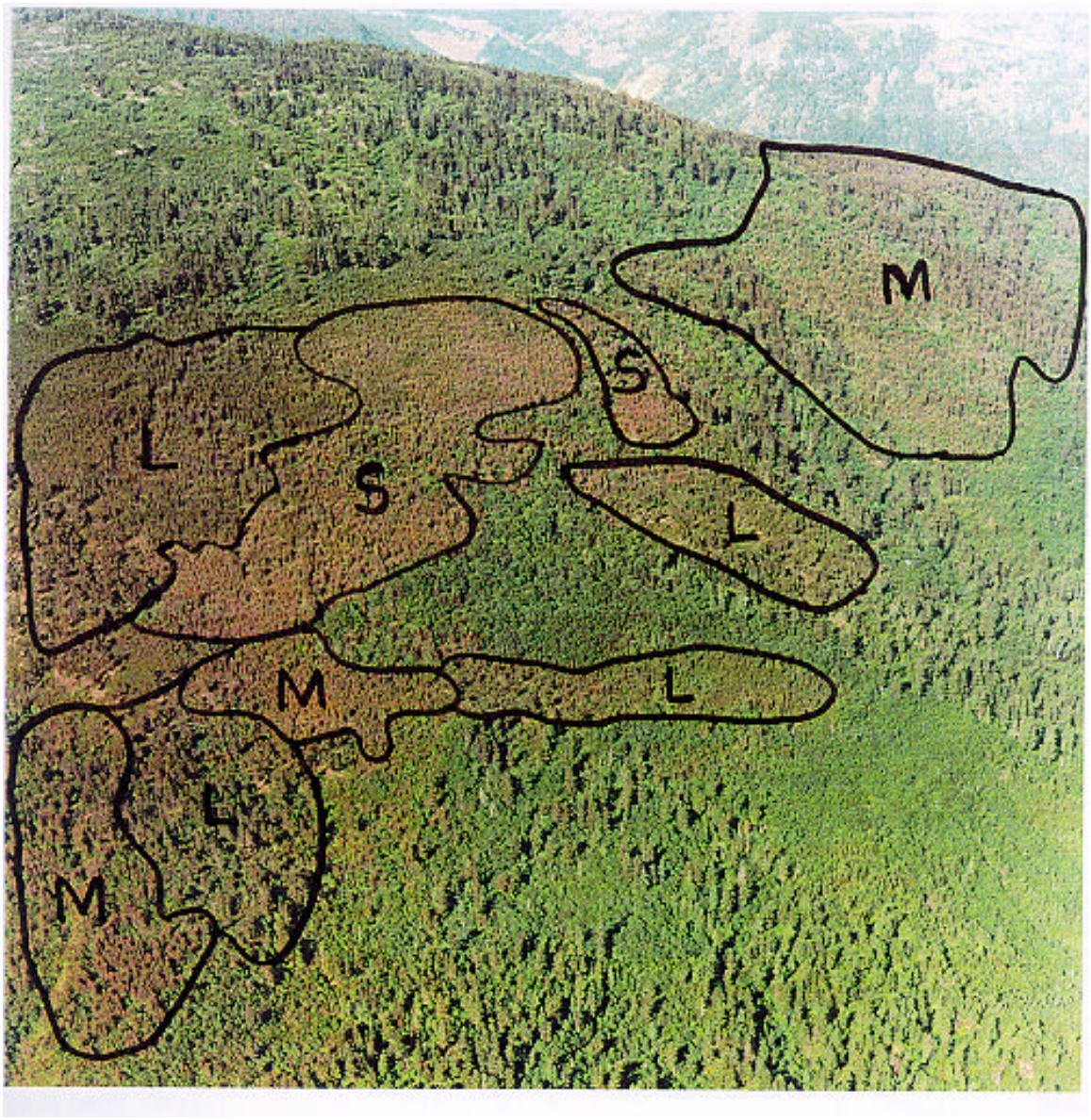


**Figure 9 Enlargement of original 70 mm photo with examples of LIGHT, MODERATE and SEVERE categories of defoliation of Douglas-fir by western spruce budworm, Boston Bar, Vancouver Forest Region.**


**Figure 10 Examples of LIGHT, MODERATE and SEVERE defoliation of Douglas-fir by the western spruce budworm (from FIDS General Instructions Manual).**

AERIAL SURVEY MAPS

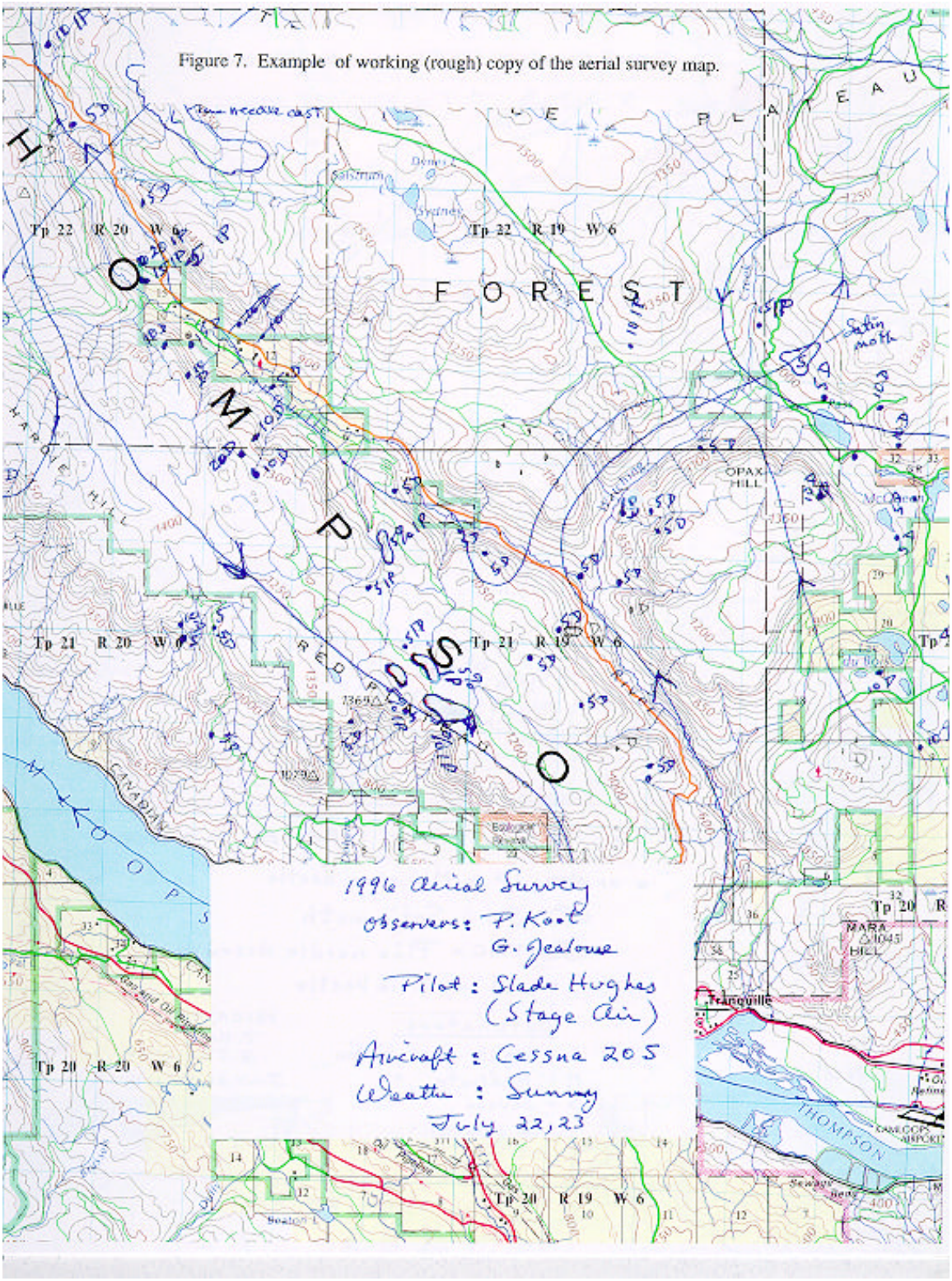


**Figure 11 Example of a working (rough) copy of the aerial survey map**

.

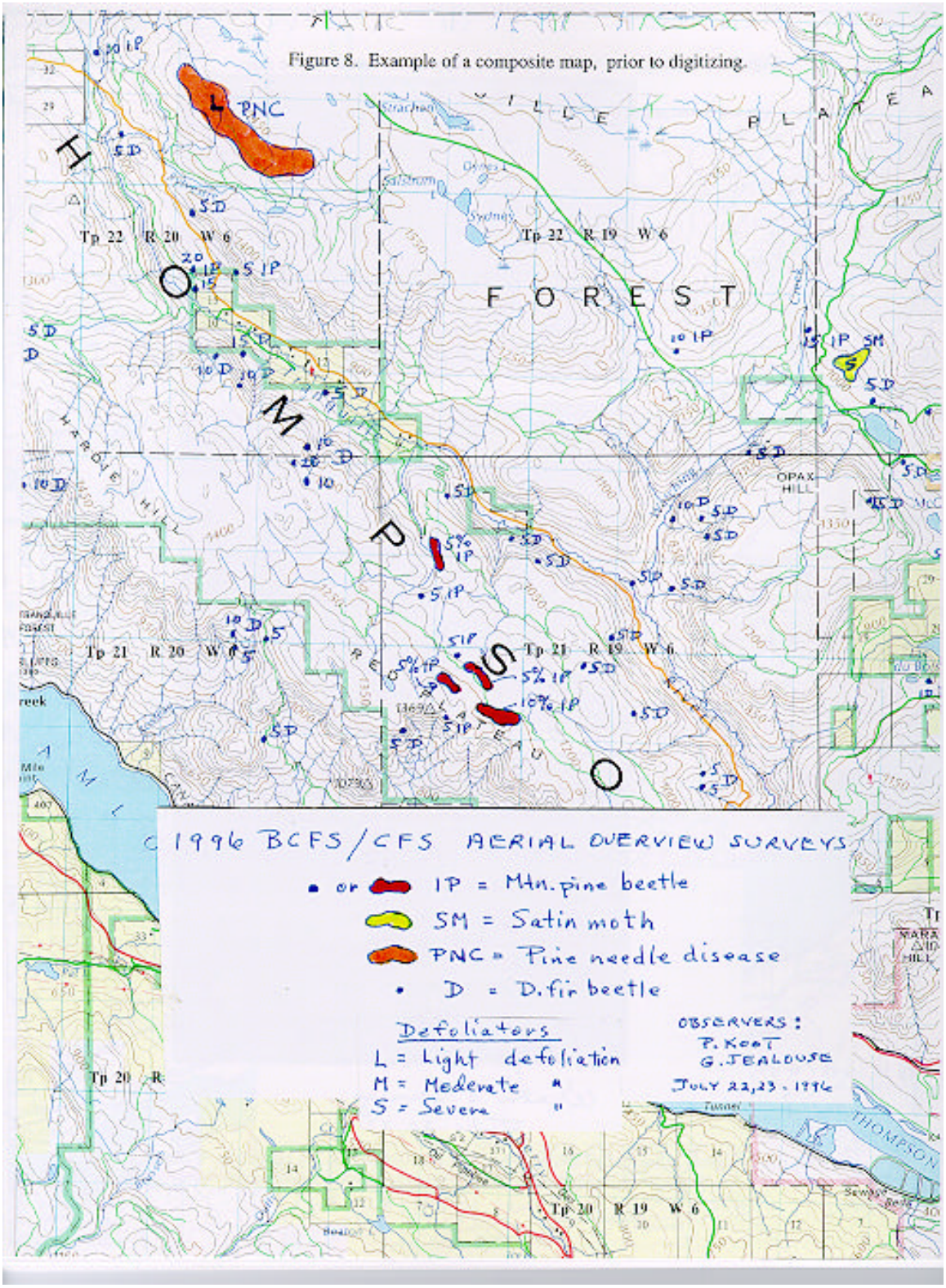


**Figure 12 Example of a composite map, prior to digitizing.**

# Appendix II

Three letter field codes denoted with an asterisk are proposed standards. Standardized codes are from Ministry of Forests form FS747 96/11.

| Field Code | | Description |
|---|---|---|
| **A: Animal Injuries** | | |
| **AB** | | Bear |
| **AO** | | Cattle |
| **AD** | | Deer |
| **AP** | | Porcupine |
| **N: Abiotic Injuries** | | |
| **NB** | | Fire |
| **NK** | | Fume Kill |
| **NF** | | Flooding |
| | NGK | Frost |
| **NL** | | Lightning |
| **NR** | | Red Belt |
| **NW** | | Windthrow/Blowdown |
| **D: Diseases** | | |
| **DF** | | FOLIAGE DISEASES |
| | DFH | Larch Needle Cast |
| | DFL | Pine Needle Cast |
| **DM** | | DWARF MISTLETOES |
| | DMP | Lodgepole pine dwarf mistletoe |
| **DR** | | ROOT DISEASES |
| | DRA | Armillaria root disease |
| **DS** | | STEM DISEASES (bark cankers and rusts) |
| | DSB | White pine blister rust |
| **I: Insects** | | |
| **IA** | | APHIDS |
| | IAB | Balsam Woolly Adelgid |
| | IAS | Spruce aphid |
| **IB** | | BARK BEETLES |
| | IBB | Western balsam bark beetle |

| Field Code | | Description |
|---|---|---|
| | IBD | Douglas-fir beetle |
| | IBM | Mountain pine beetle |
| | IBS | Spruce beetle |
| | IBI | Engraver (Ips) beetle |
| | IBW | Western Pine Beetle |
| **ID** | | DEFOLIATORS |
| | IDB | Two-year budworm |
| | IDC | Larch casebearer |
| | IDD | Western winter moth |
| **I: Insects** | | |
| | IDE | Eastern spruce budworm |
| | IDF | Forest tent caterpillar |
| | IDG | Green-striped forest looper |
| | IDH | Western blackheaded budworm |
| | IDI | Pine needle sheath miner |
| | IDK | Northern tent caterpillar |
| | IDL | Western hemlock looper |
| | IDN | Birch leaf miner |
| | IDP | Larch sawfly |
| | IDR | Alder sawfly |
| | IDS | Conifer sawfly |
| | IDT | Douglas-fir tussock moth |
| | IDU | Satin moth |
| | IDW | Western spruce budworm |
| | IDX | Large aspen tortrix |
| | IDZ | Western false hemlock looper |