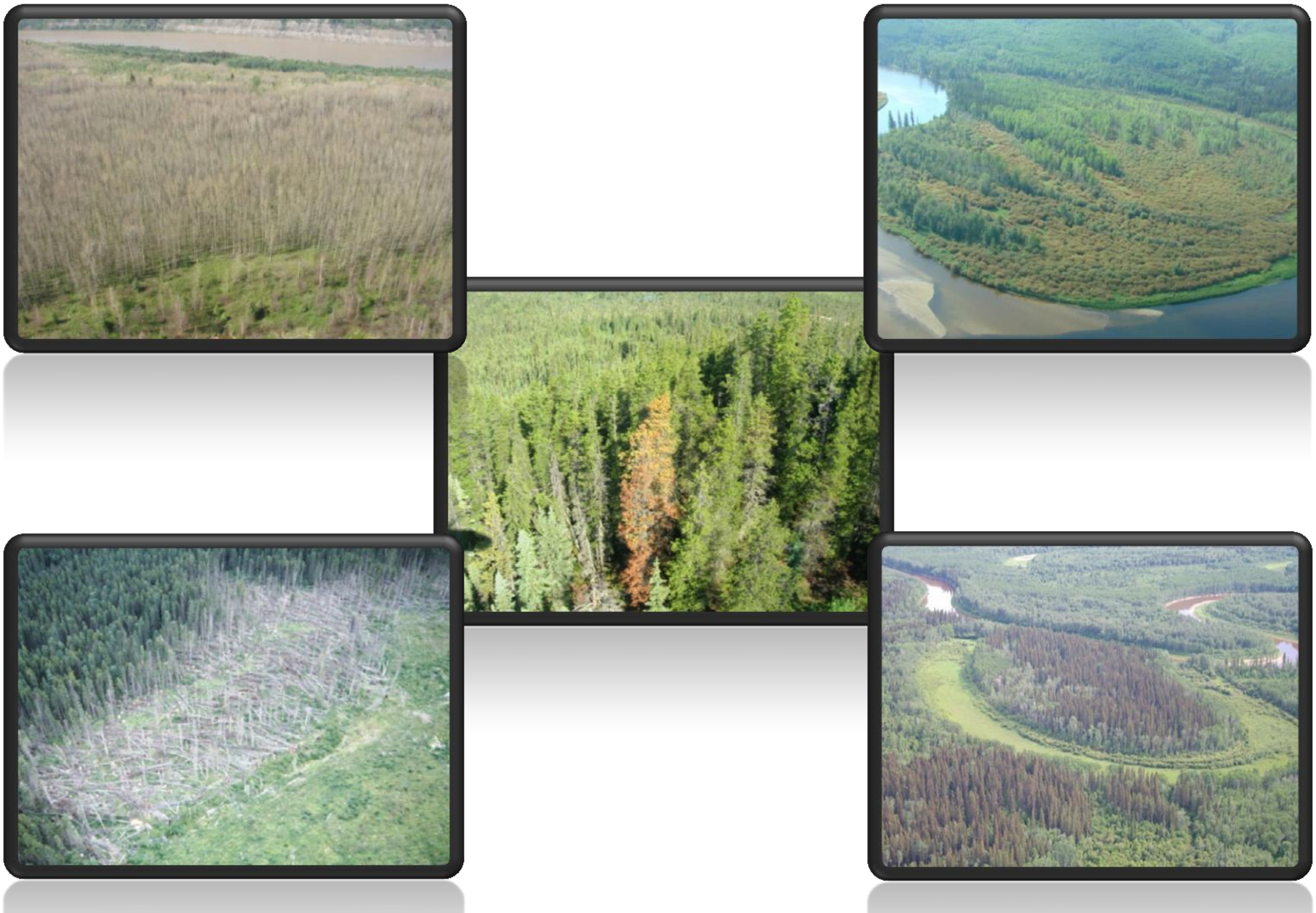

Forest Health Aerial Survey Manual

October 2012
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Section 1: Forest Health Surveys - Introduction

Overview aerial surveys are the most cost effective method to detect and monitor disturbances caused by Forest Health Damaging Agents (FHDA) on forested lands. Since 1998, routine overview aerial surveys of FHDA-caused disturbances in Alberta's forests have been carried out by Alberta Environment and Sustainable Resource Development (ESRD).

This manual on aerial surveys of forest pest damage was last updated in 2006. Traditionally, large-scale disturbances caused by FHDA such as defoliators and bark beetles have been surveyed in the past. With the anticipated global warming leading to climate change, forest composition as well as forest environment is expected to change. These changes in turn are expected to result in introduction of new FHDA and range expansions of current ones in Alberta. Climate change will also affect the frequency and severity of abiotic damaging agents. Thus, it has become imperative to update the manual to expand the scope of these surveys to cover more forest health damaging agents, especially the abiotic agents.

With the introduction of the use of tablet PCs and wider use of Global Positioning System (GPS) units for overview aerial surveys there is a need to update and expand the section on survey technology in this manual[1], as well.

Objectives

The main objectives of this manual are to:

- Ensure that aerial surveys carried out on forested lands in Alberta adequately record damage caused by a wide spectrum of damaging agents, by using current technology.

- Ensure that survey procedures carried out in different forest areas remain uniform and comparable. This is important in view of different levels of aerial survey expertise and experience available among the forest areas.

- To document timing, planning and procedures for carrying out of aerial surveys on FHDA-caused disturbances on forested land in the Green Area of the province.

1 *Disclaimer*: This manual is intended for use by the staff of ESRD. The digital survey methodology was built in house and accessible by ESRD staff only. Any external agency is welcome to use aerial survey methodologies described in this document, at their own risk and with no liability whatsoever to ESRD.

Contents

This manual is organized into several sections, with each section dealing with one main aspect of aerial surveys. Given below are the section headings with a brief description of the topics covered under each section.

Section 1: Forest Health Aerial Surveys - Introduction

Section 2: Aerial Surveys - General – outlines what aerial surveys are; why are aerial surveys carried out; who is responsible for aerial surveys; when and where these surveys are carried out; what to observe during aerial surveys; differences between overview and detailed aerial surveys; how to plan and carry out overview aerial surveys; safety measures to be taken during aerial surveys; and, performance measures.

Section 3: Surveying Disturbances Caused by Specific Forest Health Damaging Agents – describes optimum timing, symptoms to observe and rating severity of disturbances caused by damaging agents such as bark beetles, defoliators, diseases, wildlife, dwarf mistletoe, and abiotic agents.

Section 4: Forest Health Aerial Survey Techniques – Digital and manual techniques used in carrying out aerial surveys.

Appendix I: Arc Pad Quick Reference Guide

Appendix II: FHDA Codes

Appendix III: Timelines for data submission

Acknowledgements

This revised edition of the Alberta Forest Health Aerial Survey Manual was compiled by Sunil Ranasinghe (Forest Entomologist) with support provided by the following Forest Health staff of Environment and Sustainable Resource Development (ESRD): Daniel Lux (Senior Manager), Aaron McGill (Senior Information Management Technologist), and the following Forest Health Officers: Kris Heemeryck, Brooks Horne, Tom Hutchison and Dale Thomas.

Section 2: Aerial Surveys-General

Aerial surveys of forest health damaging agents (FHDA) are visual assessments made from the air of disturbances caused either by biotic and/or abiotic damaging agents.

Forest Health Damaging Agents are living (biotic) organisms such as pathogenic micro-organisms, tree damaging insects and related groups, vertebrates, parasitic plants and non-living (abiotic) climatic factors and elements found at levels that cause unacceptable degree of damage to forest trees.

These surveys are used to:

- detect the location of disturbance caused by the agent;
- record extent and severity of disturbance;
- identify possible damaging agent; and,
- identify host tree species affected by the damaging agent.

Aerial surveys of FHDA can be:

- overview aerial surveys
- detailed aerial surveys

Overview vs. Detailed Aerial Surveys

Overview aerial surveys:

- are carried out by observers in fixed-wing aircraft flying at appropriate safe heights above ground level (AGL) over the forest canopy;

- cover extensive areas to detect as many new FHDA-caused disturbances as possible;

- record locations, extent, severity, possible causative agent and host tree species involved in disturbances; and,

- pave the way to establish the need to carry out detailed aerial surveys leading to management actions.

Detailed aerial surveys are conducted over specific areas of concern to forest managers, identified during overview aerial surveys. These surveys provide details that are required to plan actions to manage disturbances.

Detailed aerial surveys:

- are carried out by observers in rotary wing aircraft flying, at relatively low but appropriate safe levels, over the forest canopy in selected areas;

- intensively cover specific areas with known FHDA disturbances where management action is contemplated;

- currently are used to survey known infestations of either mountain pine beetle or spruce budworm; can be used to get detailed information on dwarf mistletoe, hail damage or blowdowns to assess damage, reforestation needs and recovery of timber in affected areas.

- record locations and /or boundaries of disturbances by using tablet PCs connected to Global Positioning Systems (GPS).

Currently, detailed aerial surveys are limited to detecting potential mountain pine beetle-attacked pine trees. The detailed MPB surveys are not discussed further in this manual because heli-GPS surveys and aerial photography to detect MPB-infested trees are described in the "Mountain Pine Beetle Detection and Management in Alberta (Blue Book)."

Why are Aerial Surveys Carried Out?

Aerial surveys are cost-effective means of obtaining forest health damaging agent (FHDA) caused disturbance data at the landscape level. These surveys help to manage forests by providing early detection of FHDAs and once detected, by monitoring their trends. Aerial surveys are carried out to record:

- locations, extent and severity of new, FHDA-caused disturbances;

- changes to known FHDA disturbances for historical and evaluation purposes;

- background information needed for planning management actions; and,

- forest health data at the forest area, regional and provincial levels for reporting and inventory update.

Who is Responsible for Aerial Surveys?

The local Manager is responsible for ensuring that the necessary aerial surveys are carried out within the forest area. To accomplish this, the local Manager designates a person (usually the Forest Health Officer or Technician) who:

- identifies training needs at the forest area level and ensures that forest area staff are trained to carry out aerial surveys;
- requests funds for aerial surveys;
- makes sure that all the supplies needed are available for aerial surveys; and,
- ensures that surveys are completed and results are reported to the Forest Health Manager at the Headquarters and Forest Health Officer.

The Area Forest Health Officer (FHO) is responsible for:

- coordinating area budget involved in aerial surveys;
- coordinating training of forest area personnel involved in aerial surveys;
- providing technical expertise, where needed, to design and carry out surveys;
- coordinating aerial surveys with other forest areas;
- sending digital data (or hard copy of each survey map, in case maps were used) and metadata of surveys on time to the Information Management Technologist at the Provincial Headquarters for processing.

What Areas are Covered by Aerial Surveys?

Aerial surveys may be carried out over any forested land within the Green Area of the province. Note that prior permission from authorities is needed to survey the following areas:

- National Parks; and,
- Cold Lake Air Weapons Range, Department of National Defense.

Ideally, all the forested lands within the Forest Area have to be surveyed to detect and monitor all the FHDAs, abiotics in particular. However, the aerial surveyors have to operate within logistical constraints (funding, time and labour). To address this dilemma, carry out the regular annual survey flights over selected high priority forested lands within the Forest Area. In addition, cover a pre-determined percent of the ‘rest of the forested land’ in each Forest Area during aerial surveys, if logistics permit. Select this pre-determined area in such a way that the ‘rest of the forested land’ is completely surveyed over a rotation period (e.g., if 20 percent of the ‘rest of the forested land’ is covered per year, the rest of the forested land is completely surveyed over a rotation cycle of five years).

When are Aerial Surveys Carried Out?

The timing of aerial surveys normally depends on the pest species concerned. However, late June to early August, when many pest-caused disturbances are most visible from the air, is the best time to carry out most overview aerial surveys. This timing will also make aerial surveying more economical and survey maps from different forest areas comparable.

Current year symptoms of some pests, e.g., spruce beetle and needle diseases, may not be visible during the above period. These pests may have to be surveyed either earlier or later in the season. Check Table 1 in Section 3 to find the best time to carry out aerial surveys on that FHDA in Alberta.

What Observations are Recorded During Aerial Surveys?

Observe for the following symptoms in each forest disturbance during overview aerial surveys:

- either partial or complete defoliation;
- changing of foliage colour in part of the canopy;
- changing of foliage colour of the whole canopy;
- dying or dead trees standing;
- dying or dead trees fallen; and,
- swaths of blow downs or trees with broken tops

Record the location, type and extent of damage, causative damaging agent/s and host species affected by each forest disturbance. Determine and record severity categories only for those FHDA disturbances that are currently managed, e.g., mountain pine beetle, spruce budworm.

When Should Survey Data be Submitted?

The deadlines for submitting data vary depending on the damaging agent concerned. The survey data in the proper format should be submitted no later than the deadlines shown in Appendix III.

Overview Aerial Survey Procedures

Procedures used in carrying out an aerial overview survey are described below. An aerial overview survey is composed of three steps:

- planning;
- conducting the survey; and,
- data validation, processing and summarizing.

Planning

Follow the procedures given below to carry out an overview aerial survey as effectively as possible.

Determining the Survey Area

Make use of all existing information on pest conditions in planning an overview aerial survey. Use forest inventory maps to identify all the forested land and species composition within the Forest Area. This will show the areas that need not be surveyed due to landscape features, e.g., muskeg, large water bodies.

If you need historical data (prior to 1997) on pest incidence in the forested land, refer Forest Insect and Disease Survey (FIDS) reports by the Canadian Forest Service. Use Forest Health Annual Reports to find FHDA occurrences since 1997. Use previous year's FHDA survey maps to find the locations of disturbances that have to be monitored this year. In addition, investigate reports of current year's FHDA disturbances observed by other forestry personnel e.g., fire crews, timber cruising crews. This information is used to determine the 'priority forested land to survey during the regular flights.'

See under "What Areas are Covered by Aerial Surveys" above, for surveying the 'rest of the forested land.'

Preparing a Flight Plan

Once survey area has been identified, prepare a flight plan while paying attention to the following:

- topographical features that may impose limitations on flights, e.g., mountainous regions with deep valleys;
- areas where prior permission is needed to carry out aerial surveys, e.g., national parks;
- segments of survey area that can be flown comfortably within a day, i.e., within about five hours of flying;
- refuelling needs of the aircraft and locations available for refuelling;
- direction of the sun, i.e., avoid flying with sun shining into the eyes of the observers;
- need for adequate coverage, especially if there is only one aerial observer;
- any commitments to extend the surveys into adjoining jurisdictions, e.g., national parks, BC; and,
- funds available, i.e., if funds are limited, cover the most important areas first.

Reserving Aircraft

Go through the ESRD aircraft dispatch to reserve aircraft for aerial surveys. Send a request with the flight plan, names of the persons flying, and aircraft specifications (see below). Aircraft dispatch will reserve the aircraft and advise you.

Given below are fixed-wing aircraft specifications for aerial surveys:

- **type:** the aircraft must have a high wing configuration to allow an unobstructed view of the area below. A powerful aircraft such as a Cessna 210 is ideal for aerial surveys, especially to survey mountainous areas. If the terrain is flat a Cessna 180 or an equivalent may be used.
- **speed:** 100 to 130 knots depending on the aircraft, terrain and pest;

- **seating capacity:** at least three passenger seats;
- **maximum flight duration:** if refuelling facilities are not available, consider an aircraft with as long a flight duration as possible;
- **equipment:** global positioning system (GPS) capable of storing a large number of way points; radio headsets (intercom system is required) that could be used to communicate in flight with the pilot and with radio operators; portable transponder to keep in touch with radio operators if flight is to occur is an area beyond ESRD radio coverage, and,
- **pilot:** experienced pilot, preferably one familiar with aerial surveys and terrain.

Note: For safety reasons, a rotary wing aircraft may be better than a fixed wing aircraft for aerial surveys carried out in mountainous areas with deep valleys.

Aerial Observers

The aerial observers should be:

- trained on carrying out aerial surveys using Digital Sketch Mapping (DSM) as well as by using topographic maps, and be well versed with severity ratings of pest disturbances;
- familiar with the terrain of the survey area so as to navigate the aircraft;
- familiar with damage agent symptoms and tree species in the survey area; and,
- briefed on previous year's disturbances as well as the history of major pest occurrences in the survey area.

Ideally, from a safety point of view, there should be two aerial observers per aircraft. They should be given enough advanced notice to ensure their commitment to aerial surveys. It is advisable to have a stand-by aerial observer on a contingency basis.

Supplies

- DSM system with accessories programmed for aerial surveys (optional topographic maps as back-ups for surveying)
- binoculars;
- digital camera and batteries;
- sunglasses, preferably amber coloured, to minimize any distortions;

- colour pencils and fine tip pens, and mechanical pencils;
- notebook and a clipboard;
- aerial survey guide and field guides on pests (optional).

Conducting an Overview Aerial Survey

This section deals with procedures to follow before, during and after an aerial survey, to ensure its success.

Refer Section 4 of this manual for details on survey methodologies including digital sketch mapping using a tablet PC linked to a GPS unit, and use of either topographical maps or GPS units alone to carry out aerial surveys.

On the Day before the Aerial Survey:

- check the weather forecast to ensure that weather conditions are favourable for flying on the following day;
- if conditions are favourable, confirm the flight with the aircraft company;
- make sure that all the supplies are ready and equipment is functional;
- upload on to the tablet PC forest disturbances caused by abiotic damaging agents in the previous year so that the same disturbance is not double-counted during the current year survey; and,
- get enough rest.

On the Day of the Aerial Survey

Check the weather forecast and local conditions in the survey area, e.g., smoke, to ensure that conditions remain favorable for surveying. The favorable conditions include:

- minimum ceiling of 1000 metres;
- either clear, sunny day or at least solid high overcast conditions; and,
- wind speed acceptable to the pilot.

Broken cloudy conditions are less acceptable because these make it difficult to observe the disturbances. Normally, aerial survey flights should be carried out from mid-morning to mid-afternoon when sun is at a high angle, thus minimizing any shadows on the ground.

Safety

Safety is a prime concern in any aerial survey. Refer "*Sustainable Resource Development Aircraft*

Management Standard Operating Procedures (SOP)" for aircraft use and safety instructions during aerial operations. Please check the Forest Protection Division's internal website under "Manuals/Forms/Publications" to get copies.

Please note that notwithstanding the stated 500 feet altitude for "low and slow" flights in the above SOP, the minimum altitude of a fixed-wing aircraft used in any Forest Health-related survey is 1000 feet.

Given below are guidelines to follow to ensure safety:

- Use a company, pilot and an aircraft certified by Transport Canada for 702 Aerial Work.
- Flight crew are to be fully engaged in "flying the aircraft" and not to be distracted by other work.
- Wherever possible, there should be two aerial observers per survey flight. One observer (mapper) will concentrate on mapping the disturbance and the other observer will adjust flight lines (if necessary); watch out for other aircraft in the vicinity; operate radios, including telemetry receivers, on ESRD assigned frequencies; take notes and photos during the flight. The pilot may monitor radios if the cockpit workload permits.
- Except where specifically permitted in Sections 602.12 – 602.16 of Canadian Air Regulations, no flights over the built up area of a community shall be conducted at altitudes below 1000 feet above ground level (AGL).
- At the beginning of the project and at any time either the aircraft or pilot has been changed, have the pilot give all surveyors a safety briefing. The briefing should cover, but is not limited to: how to approach and leave the aircraft, opening and closing of doors, use of seat belts, head sets, emergency procedures including locations of safety/survival gear, proper storage of field gear and in-flight communications with the pilot;
- File a flight plan and estimated duration of the flight with the local ESRD radio operator;
- Use amber-tinted sunglasses for eye protection and to minimize distortion of the view below;
- Keep in touch with the radio operator as stipulated in the safety manual; and,
- Communicate with the pilot about any concerns during the flight.

Complete a passenger/cargo manifest and give a copy to the pilot and fax a copy to the Fire Centre Dispatch, if possible. If flying from an airstrip with no facsimile or scanning facility, relay this information over the radio and send it to the dispatch when possible.

Note: For safety reasons, the pilot of the aircraft has the final say in deciding whether to fly the aircraft.

During Flight

For safety reasons there should be two observers available; the observer who is familiar with the terrain occupies the front seat and the other observer occupies the back seat diagonally opposite to the observer in front. If no second observer is available, occupy the back seat with access to windows on both sides. Pay attention to the following:

- **altitude:** Minimum altitude is 1000 feet above ground level but select the best altitude to fly depending on the FHDA being surveyed. To cover an extensive disturbance, e.g., forest tent caterpillar defoliation, fly at a higher altitude (3000 feet above ground level (AGL) where it is easier to estimate the location and extent of disturbances. Low passes, within minimum altitude limits, may be required to identify the possible causative agents. For a fixed-wing flight the altitude should not be less than 1000 feet AGL, for safety reasons.

- **speed:** flying speed may vary between 100 to 130 knots. It depends on the aircraft, terrain, visibility and causative agent concerned;

- **direction:** transect flying over flat terrain is usually oriented either east-west or north-south with one or two parallel transects per township. Periodically, use landmarks, e.g., lake, to check whether the transects are reasonably spaced out. In mountain terrain, fly along the contours. In river valleys survey flights may be in a zigzag pattern to optimize coverage with a single pass.

- **photographs:** take photographs of the disturbance and make notes relating to each photograph.

Caution:

- It may not be possible to always accurately determine the causative agent of a disturbance, from the air. Aerial surveys should be followed up by ground surveys to confirm causative agents.

- The size of disturbances recorded invariably get overestimated when small scale maps, e.g., 1:250 000, are used and underestimated when large scale, e.g., 1:100 000 maps are used.

- Changes in lighting and stand densities can change the colour of the stands making it difficult to observe disturbances accurately.

- Do not ignore any unfamiliar disturbances; make a note and identify the area for ground checks.

Performance Measures

- Were surveys carried out within the windows specified for each damaging agent, as shown in Table 1, Section 3 of this manual;

- Did surveys cover 100% of the area affected by disturbances;

- Were survey ratings accurate within 10% of the severity category limitations;
- Was ground truthing carried out in a few accessible areas to confirm the causative agent, severity rating and the affected host species;
- Were survey data in proper format submitted to the Information Management Technologist at the Provincial Headquarters by the deadlines for data submission given in Appendix 3; and,
- Were submitted survey data complete and included relevant metadata.

Section 3: Aerial Surveying of Disturbances Caused by Specific Damaging Agents

Given below are guidelines for surveying disturbances caused by specific forest health damaging agents (FHDA). Depending on the agent, the ideal time for surveying may vary. For practical purposes, e.g., saving on expenditure, as many as possible forest health disturbances should be targeted during an overview aerial survey. Damage ratings vary for different agents. Damage rating categories are kept to a minimum because it is difficult to distinguish between finer categories of damage while flying over the forest canopy.

The ideal times for surveying specific FHDAs vary, as shown in Table 1 below. However, to have overview aerial survey data collected from different areas comparable, it is better if regular overview aerial surveys are carried out from late June to early August when many FHDA-caused disturbances occur.

During overview aerial surveys, record any FHDA-caused disturbance that is visible from the air. If the disturbance covers an area greater than 10 hectares, record that as a polygon; if the disturbance is within an area less than 10 hectares in extent, record it as a spot. If there are several such small groups scattered close to each other, group those in a polygon.

Table 1. Aerial survey windows for disturbances caused by Forest Health Damaging Agents

FHDA Category	FHDA and Field Codes	Disturbance	Survey Window
Bark Beetles	Mountain pine beetle (IBM)	Tree kill	Aug. 15 – Sept. 15
	Western balsam bark beetle (IBB)	Tree kill	Spring – summer
	Douglas-fir beetle (IBD)	Tree kill	Spring – summer
	Spruce beetle (IBS)	Tree kill	Winter
Defoliators, conifer	Eastern spruce budworm (IDE)	Defoliation, top-kill, tree kill	July 1 – Aug. 15

	Western spruce budworm (IDW)	Defoliation, top-kill, tree kill	July 15 – Sept. 15
Defoliators, broadleaf	Forest tent caterpillar (IDF) Large aspen tortrix (IDL) Bruce spanworm (IDB)	Defoliation; branch kill; aspen decline	June 15 – July 15
Diseases	Needle rust (DFC)	Loss of needles; growth loss	Spring, summer
	Armillaria root disease (DRA)	Tree kill; growth loss	Spring, summer
Abiotics	Drought (AD)	Tree stress; tree kill	Summer
	Frost (AF)	Foliage/ branch kill	Spring, summer
	Hail (AH)	Defoliation; branch kill; mechanical damage	12 months after the hailstorm
	Flooding (AO)	Tree kill	Spring, summer
	Redbelt (AR)	Tree kill; pre-dispose trees to other pests; increase wildfire hazard	Spring, early summer

Bark Beetles

The bark beetle species that could cause major disturbances in Alberta's forests are:

- Mountain pine beetle, *Dendroctonus ponderosae*
- Douglas-fir beetle, *D. pseudotsugae*
- Western balsam bark beetle, *Dryocoetes confusus*
- Spruce beetle, *D. rufipennis*

Early faders symptomatic of mountain pine beetle (MPB) infestations can be detected during overview aerial surveys. **However, either detailed heli-GPS aerial surveys or aerial photography are used to detect pine trees with red crowns symptomatic of MPB.** Please refer the ESRD blue book *"Mountain Pine Beetle: Detection and Management in Alberta"* for descriptions on MPB detection and surveys.

The Douglas-fir beetle, *D. pseudosugae* and western balsam bark beetle, *Dryocoetus confuses* are beetle species that have so far not caused major outbreaks in Alberta. However, these species have the potential to become important FHDA in the province, especially with the forecasted global warming and anticipated climate change.

Relatively large-scale outbreaks of the spruce beetle, *D. rufipennis*, have occurred in Alberta in the past. Blowdowns in spruce stands, leftover slash following harvesting operations and spruce budworm-weakened white spruce are potential triggers of spruce beetle outbreaks.

Douglas-fir Beetle, *Dendroctonus pseudotsugae*

Douglas–fir beetle usually has a one-year life cycle. Beetle-killed trees turn pale yellow-green to red in the spring of the year following beetle attacks (Figure 3-1). Red needles may remain on the beetle-attacked tree for up to two years. Sometimes needles may drop without discolouration. Record the location and the extent of Douglas-fir beetle infestation; if the attacked tree distribution fits into a polygon, estimate the cumulative percent tree kill in the stand.

Figure 3-1. Trees killed by Douglas-fir bark beetle (Source: William M. Ciesla, Forest Health Management International, Bugwood.org).

Western balsam bark beetle, *Dryocoetus confusus*

Normally the western balsam bark beetle requires two years to complete the life cycle although in drought years they may complete the life cycle in one year. The needles change from green to bright brick-red colour in the year following the attack (Figure 3-2). Record the location, extent and cumulative per cent tree kill in the stand with western balsam bark beetle infestations.

Figure 3-2. Western balsam bark beetle damage (Source: Kenneth E. Gibson, USDA Forest Service, forestryimages.org)

Spruce beetle, *Dendroctonus rufipennis*

The needles of spruce beetle-attacked trees normally do not change colour in the first year. In the second summer following attack, most needles in infested trees turn yellowish-green to orange red (Figure 3-3). However, some infested trees may not change their needle colour even in the second year. In some cases, different branches of the same tree change needle colour at different times. To make matters even more complicated, needles of some infested trees drop to the ground without changing colour, following heavy winds or thunderstorms (Figure 3-4). Needles of trees strip-attacked by the spruce beetle may not turn colour at all. Thus, it is important to note grey trees during spruce beetle surveys.

Spruce beetles normally attack white spruce and Englemann spruce. These disturbances are surveyed as and when needed. It may be advisable to survey for spruce beetle over large tracts of overmature white spruce stands repeatedly affected by spruce budworm infestations; similar stands may also be surveyed following large-scale blowdowns. Aerial surveys usually detect spruce beetle attacks in their second year or later (Figure 3-5). Ground surveys are needed to detect spruce beetle attacks in the first year of occurrence. Record locations of spruce trees symptomatic of spruce beetle attack from the air.

Use this information to carry out ground surveys to determine the true extent of spruce beetle infestation.

Figure 3-3. Aerial view of spruce killed by the spruce beetle (Source: William M. Ciesla, Plant Health Management International, Bugwood.org).

Figure 3-4. Spruce beetle-infested trees with premature needle drop (Source: Darren Blackford, USDA Forest Service, Bugwood.org).

Figure 3-5. White spruce infested with spruce beetle (Source: Dan Miller, USDA Forest service, Bugwood.org).

Defoliators

The major defoliators of Alberta's forests are:

- Conifer Defoliators:
    - Spruce budworm, *Choristoneura fumiferana*
    - Western spruce budworm, *C. occidentalis*
- Aspen Defoliators:
    - Forest tent caterpillar, *Malacosoma disstria*
    - Large aspen tortrix, *C. conflictana*
    - Bruce spanworm, *Operophtera bruceata*
    - Aspen serpentine leafminer, *Phyllocnistis populiella*

Defoliator infestations invariably are extensive. Check historical records and reports from other forestry crews before finalizing defoliator survey flight path. Defoliations caused by major conifer- and aspen defoliators are surveyed annually. Verify defoliator damage with ground surveys because agents other than major defoliators can cause similar symptoms.

Conifer Defoliators

Besides eastern – and western spruce budworms, the two-year cycle budworm, *C. biennis*, could potentially defoliate sub-alpine fir and white spruce/Englemann spruce complex at higher elevations. The crowns of damaged trees turn reddish-brown from June through August. Defoliation severity alternating between high and low in alternate years is a clue indicating presence of this pest in sub-alpine fir and white spruce/Englemann spruce stands. Record the geographical coordinates of the affected area, its extent and severity if this pest damage is suspected.

Jackpine budworm outbreaks have not occurred in Alberta in the recent past but potentially this pest can defoliate jackpine stands in the province. If large-scale defoliation of jackpine stands are observed from the air, record the coordinates and extent of defoliation; follow-up with ground truthing to verify presence of jackpine budworms in the affected stands.

Eastern Spruce Budworm, *Choristoneura fumiferana*

Aerial surveys on eastern spruce budworm defoliation are carried out annually over known outbreak areas, and over river valleys with overmature white spruce stands.

Conduct aerial surveys on spruce budworm disturbances as soon as the tree crowns turn red, usually in mid-July. Whenever possible, combine surveys on spruce budworm and aspen defoliator disturbances to save time and money. In this case, the combined surveys may be carried out in late June or early July before defoliated aspen has a second flush of foliage.

During spruce budworm surveys, look for change in spruce crown colour to a reddish tinge (Figure 3-6). Trees with severe and repeated budworm damage may appear grey due to heavy feeding on the upper crown. New cone crops may also impart a reddish tinge to the tree crowns. Make a low pass (not below 1000 feet AGL) over the canopy to check on this possibility. Record the location, extent and severity of defoliation of spruce budworm infestation.

Figure 3-6. Spruce stands defoliated by the spruce budworm (Note crowns with reddish colour).

Spruce budworm defoliation is rated as follows:

- Moderate, when there is a reddish tinge with <70% of new shoots, mostly in the upper crown, are defoliated (Figure 3-7);
- Severe, when trees appear reddish or grey with branches on the upper crown completely defoliated and over 70% of new shoots in the crown are defoliated (Figure 3-8).

Figure 3-7. White spruce stand moderately defoliated by the spruce budworm.

Figure 3-8. White spruce stand severely defoliated by the spruce budworm.

Note: Spruce budworm defoliation, when light (<35%), is normally not visible from a fixed-wing aircraft flying at a relatively high speed.

Western spruce budworm, *C. occidentalis*

The western spruce budworm primarily occurs on Douglas-fir, although white spruce, western larch and lodgepole pine are also attacked by this insect. The damage symptoms are similar to those of the eastern spruce budworm.

In Alberta, western spruce budworm defoliation is surveyed from mid-July through mid-August. In surveying the western spruce budworm defoliation, follow the same procedures and ratings as those used for surveying the eastern spruce budworm.

Figure 3-9. Douglas-fir stand defoliated by the western spruce budworm.

Budworm Tree Kill

In budworm-infested stands, the understorey host trees under stress begin to die after about five consecutive years of moderate to severe defoliation or equivalent. Dominant and co-dominant host trees begin to die after seven or more consecutive years of moderate to severe budworm defoliation (or equivalent). If host tree kill were observed from the air, record the location and estimated per cent of cumulative tree kill in the stand.

Figure 3-10. Spruce tree kill due to budworm damage.

Ground truthing is necessary to confirm tree kill because some host trees that from the air appear to have been killed by the budworm, may still be alive with dormant buds.

Aspen Defoliators

In Alberta, the major aspen defoliators include:

- Forest tent caterpillar, *Malacosoma disstria*
- Large aspen tortrix, *C. conflictana*
- Bruce spanworm, *Operophtera bruceata*
- Aspen serpentine leafminer, *Phyllonistis populiella*

Out of these, outbreaks of the forest tent caterpillar, large aspen tortrix and Bruce spanworm occur more commonly, compared to the other species listed. Other species occur occasionally as transient outbreaks. In some cases, more than one of these pest species may occur in a given outbreak making it more challenging to decide the causative FHDA of aspen defoliation.

Although it is not always possible to positively determine the cause of aspen defoliation during aerial surveys, the following clues help to find the likely cause. Forest tent caterpillar populations, when severe, completely defoliate branches of the tree canopy and understorey vegetation, as well. When completely defoliated, forest tent caterpillar damaged-trees may appear tan in colour (Figure 3-11). Aspen leaf rollers roll leaves. Defoliation due to severe outbreaks of aspen leaf roller may appear similar to that of forest tent caterpillar but aspen leaf rollers usually do not attack the understorey vegetation. The large aspen tortrix partially defoliates the canopy resulting in a ragged appearance of foliage and leaving clumped leaves on the crown (Figure 3-12). Bruce spanworm feeding leaves 'silk' on trees and ragged foliage with holes (Figure 3-13). Around June, aspen serpentine laefminers occasionally cause large-scale outbreaks. Foliage of heavily attacked aspen trees appear bleached (Figure 3-14). These attacks are short-lived. Record locations and extent of serpentine leafminer damage.

During overview aerial surveys record the location and extent of defoliation. Currently, none of these pest infestations is managed and recording severity categories of aspen defoliation is optional. However, ground truthing at a few accessible locations is needed to confirm the causative agent of defoliation.

Figure 3-11. Aspen trees may appear tan-coloured due to severe defoliation by the forest tent caterpillar.

Figure 3-12. Close-up of large aspen tortrix defoliation showing clumped leaves.

Figure 3-13. Aspen stand severely defoliated by the Bruce spanworm. Note copious silky webbing on understory.

Figure 3-14. Aspen stand damaged by the serpentine leafminer (Source: Ogden Archive, USDA Forest Service, Bugwood.org).

Ground surveys are needed to check the causative agent of aspen defoliation. If possible, collect larvae during the ground surveys to identify the causative agent because a number of other defoliator species attack aspen.

Damage Caused by Diseases and Other Agents

This section deals with agents other than bark beetles and defoliators, which may be encountered by aerial observers during overview aerial surveys. Note location and extent of area damaged by disease or other agent.

Diseases

Some diseases such as needle casts and needle rusts (figure 3-16) affecting conifers may be mapped during aerial surveys. These needle casts and rusts appear periodically but can be extensive. During overview aerial surveys record the host species and the extent of the area affected by these diseases.

Root disease centres can be mapped but are not easily identifiable from the air during overview aerial surveys. Root disease centres have trees fallen in a criss-cross fashion (Figure 3-17). However, a low pass (not below 1000 feet AGL) may be needed to identify disease centres.

Figure 3-16. Needle cast affected lodgepole pine stand (Jane Taylor, USDA Forest Service, Bugwood. Org.).

Figure 3-17. A root disease centre.

Wildlife Damage

Trees killed by porcupines (Figure 3-18) and bears may be visible from the air. These trees show mechanical damage caused by these damaging agents. But the cause of this damage cannot be ascertained without either a detailed survey or a ground survey. Record the location of trees that appear to have been killed by these damaging agents. Sometimes this damage may be confused with that of the mountain pine beetle.

Abiotic Agents

With impending climate change, incidence of abiotic damaging agents within the forest resource needs to be monitored. The following abiotic agents may cause disturbances visible during overview aerial surveys:

- Wind (blowdowns);
- Water in excess (flooding) ;
- Water in short supply (drought);
- Water in solid form (Hail) Lightning;
- Chemicals; and,
- Winter desiccation (red belt, winter kill).

Blowdowns, flood damage, drought and red belt may be identifiable from the air. The other disturbances may have to be ground truthed to confirm the causative agents. Mark the location and possible cause of disturbance to follow up with ground truthing.

Figure 3-18. Pine trees killed by porcupine damage.

Blowdowns and Wind Damage

The blowdowns can be recognized by the swaths of forest trees fallen in a unidirectional pattern. More than one tree species may be involved because strong winds indiscriminately affect trees in the path regardless of species involved.

Blowdowns can be recognized by trees either with broken tops or uprooted with large roots with soil still attached. The broken or uprooted stems lie parallel to each other facing the same direction. Damaged area can vary in extent. Most of the trees susceptible to wind damage are either stressed by root disease or with stand edge effect or with shallow roots. Unlike in root disease centres, uprooted trees lie parallel to each other in blowdowns (Figure 3-19).

With wind damage, the trees remain standing but the tops are broken (Figure 3-20).

Record locations, cause and extent of either blowdowns or wind-affected areas during overview aerial surveys.

Figure 3-19. Blowdown along the edge of a stand.

Figure 3-20. Wind damage (Note trees with broken tops).

Flooding

Waterlogging kills trees by depriving the root system of its oxygen supply. Usually, either standing water or evidence of standing water can be seen with a number of dead trees at flooded sites (Figure 3-21). Record the location, cause and extent of damage.

Drought

Persistent drought conditions can either cause tree stress or tree kill over large swaths of forest land. There may be a time lapse between occurrence of a severe drought and appearance of tree kill. Thus, it is important to check the historical records of precipitation at sites where drought is suspected to be the cause of tree kill. Usually, a large number of trees in a contiguous area are affected by drought conditions. Record the location, potential cause and extent of either tree decline or mortality in drought affected stands (Figure 3-22).

Figure 3-21. Large-scale tree kill due to flooding.

Figure 3-22. Drought-affected aspen stands.

Hail Damage

Hailstorms could cause extensive mechanical damage to forest stands. Sometimes hail damage can be quite extensive. Hail damages all tree species in the affected areas. The common hail symptoms visible from the air, soon after the damage occurrence, include tattered tree crowns and ground littered with broken branches and leaves; with time, hail-damaged trees show discolored, dying branches (Figure 3-23). Ground truthing shows stem lesions and scars that are aligned on one side of the stem.

Record the locations, cause and extent of damage.

Figure 3-23. Aerial view of hail-damaged forest stands.

Figure 3-24. Close-up view of a hail-damaged plantation of young spruce.

Chemicals, Pollution Damage

Forest trees could either get damaged or killed by chemicals such as roadside salt, soil sterilants or herbicides. All tree species are susceptible to this type of damage. Leaves of the affected trees develop unusual colours depending on the chemical compound involved.

During overview aerial surveys record the locations and extent of land affected.

Figure 3-25. Salt-killed spruce trees along a highway.

Lightning

Lightning strikes can initiate wildfires that burn and kill large tracts of forest land. Sometimes, lightning kills the tree directly struck and some surrounding trees creating “circular tree mortality.” These circular tree kills can be observed during overview aerial surveys (Figure 3-26). These patches usually contain a tree in the centre that has evidence of lightning strike such as burn marks or black streak, stem split and dead or dying trees around it. Eventually these circular tree kills may become as big as 0.2 ha with blackened and dead trees.

During overview aerial surveys, record the locations of circular tree kills.

Late Spring Frost

If frost occurs either in the late spring or early summer, the succulent current year growth of conifers as well as broadleaf trees wilt, droop or drop making the stands look patchy (Figure 3-27). This can reduce lateral and leader growth. Large tracts of young stands can get affected by late spring frost although they may recover later.

Figure 3-26. Lightning-killed conifer trees.

Figure 3-27. Frost-damaged aspen stand.

Red Belt

Usually in spring, foliage of conifers (particularly of lodgepole pine) along the eastern slopes turn reddish-brown making it appear as a well-defined horizontal band of red across the slope (Figure 3-28). This is the result of the occurrence of unseasonably warm dry air during the day followed by cold-air at night. The warm dry winds desiccate the needles but the lost moisture is not replaced because the ground is still frozen. The affected needles get dicoloured and shed. The reddish colour is more pronounced on the side of trees facing the prevailing wind. Unopened buds are not harmed by this phenomenon.

Record the locations and extents of red belt during overview aerial surveys.

Figure 3.28. Red belt on lodgepole pine along the eastern slopes of Rockies.

Section 4: Methodologies Available to Carry out Aerial Surveys

Overview aerial surveys can be carried out by using the following methodologies:

- Digital Sketch Mapping (DSM) System composed of ArcPad-installed tablet Personal Computer (PC) with touch screen capability, working in conjunction with a wireless Global Positioning System (GPS) unit

- Manual sketch mapping using small-scale (1: 250,000) topographic maps

- Tracking the disturbance boundaries by using a Global Positioning System (GPS) unit

For sake of accuracy, convenience and saving time, use of a DSM system for overview aerial surveys is recommended. However, it is advisable for the surveyors to be familiar with using topographic maps and GPS units as backups, in case digital system becomes dysfunctional.

Carrying Out Overview Aerial Surveys by Using a Digital Sketch Mapping (DSM) System

Introduction

Custom-made maps of intended survey areas are uploaded to the Digital Sketch Mapping (DSM) System in preparation for these surveys. An application has been built to allow data entry to these custom-made maps in the tablet PC during aerial overview surveys.

During the survey, the surveyors can see where they are in relation to the custom map of the survey area shown on the screen by a GPS position that is also displayed on the screen. The GPS position on the screen automatically updates as the aircraft moves. This allows the users to know where they are at any given time without having to compare landscape features on the ground to the map displayed on the screen.

The touch screen is combined with the ArcPad. A custom ArcPad application built in house allows the user to sketch map FHDA-caused disturbance visible on the ground directly on the screen. This sketch map is automatically saved as an ESRI shapefile, and related attributes, e.g., defoliation severity, can be added immediately.

Setting Up DSM System for a Day of Surveying

There are some file maintenance tasks and connections to be set up before the day of surveying. The tablet is set up with a folder structure and **it is important that some file maintenance is done to prevent either loss of survey data or overwriting on previous survey files.**

Two **VERY** important steps have to be carried out before undertaking a new survey:

Step 1. If you haven't done so already, back up the previous survey to the *CompleteSurveyShapefiles* folder. Store the files in the proper location, i.e. region and year folder, and create a folder for the date, backup number, etc.

- There is no standard here, but keep in mind that if you try and back up twice to the same folder the files will be overwritten because all working shapefiles have the same name regardless of the date, survey, etc.

Step 2. Make a copy of the original shapefiles in the *OriginalShapefiles* folder and place the copy in the *WorkingShapefiles* folder. This will replace the working shapefiles in the *WorkingShapefiles* folder with clean ones. When doing this it is assumed that you have already backed up your survey data from the previous survey.

DSM System Survey Folder Structure

```
Folder Structure
|-------- C:\ForestH
|         |-------- AerialSurveyWorking
|         |         |-------- CompleteSurveyShapefiles
|         |         |         |-------- Year (2004)
|         |         |         |         |-------- NEB
|         |         |         |         |         |-------- Asdef
|         |         |         |         |         |-------- General
|         |         |         |         |         |-------- MPB
|         |         |         |         |         |-------- SBW
|         |         |         |         |
|         |         |         |         |-------- NES
|         |         |         |         |         |-------- Asdef
|         |         |         |         |         |-------- General
|         |         |         |         |         |-------- MPB
|         |         |         |         |         |-------- SBW
|         |         |         |         |
|         |         |         |         |-------- NWB
|         |         |         |         |         |-------- Asdef
|         |         |         |         |         |-------- General
|         |         |         |         |         |-------- MPB
|         |         |         |         |         |-------- SBW
|         |         |         |         |
|         |         |         |         |-------- SES
|         |         |         |                   |-------- Asdef
|         |         |         |                   |-------- General
|         |         |         |                   |-------- MPB
|         |         |         |                   |-------- SBW
|         |         |         |
|         |         |         |-------- Year (2005)
|         |         |
|         |         |--------           OriginalShapefiles
|         |         |
|         |         |--------           WorkingShapefiles
|         |
```

- **AerialSurveyWorking Folder** - The *AerialSurveyWorking* folder contains three subfolders for aerial survey data. These subfolders contain everything needed to conduct the survey and back up data.

- **CompleteSurveyShapefiles** – this folder contains subfolders used to store shapefiles for the completed surveys. Surveys can be backed up here either at the end of the day or at the end of a particular survey.

- **OriginalShapefiles** – this folder contains the original shapefiles and applets that can be copied to start a new survey. These are backups of the original shapefiles and should not be edited.

- **WorkingShapefiles** – this folder contains the shapefiles that you would edit during a survey. These files should be backed up and renamed after the survey and replaced with clean files from the *OriginalShapefiles* folder before starting a new survey.

Conducting Surveys

A project has been set up in ArcPad to conduct aerial surveys and save the data to shapefile.
This project has:

- the data loaded,
- been configured with the GPS, and
- editable shapefiles associated with it.

Open the **"File Survey.apm"** on the Desktop:

- There will be 2 toolbars available, the main toolbar and the aerial survey toolbar.

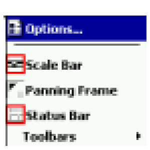
- The Aerial survey toolbar should be the only one you require.

- There may be a third toolbar available depending on the ArcPad configuration (Browser Toolbar). This toolbar can be removed to maximize the viewing area.

- To remove it click the **Tools** dropdown  and go to **Toolbars**, **Tools|Toolbars**.

- A fly out will appear and you can remove the check mark next to the browser toolbar by clicking it.

Options Dropdown



Open the Aerial Survey Document]

There is a shortcut on the desktop called **"SURVEY.APM"** this is an ArcPad working document for aerial surveys. Double click this shortcut to open the document.

For help in using ArcPad refer to the *"ArcPad Quick Reference Guide"* in Appendix 1.

Initialize the GPS

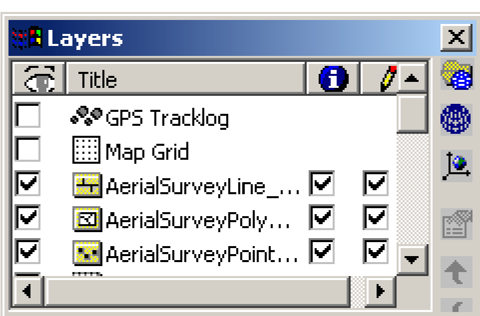
- Click **Tools|Find GPS**. This will search the com ports for incoming signals from a GPS.
- If no GPS is found check the GPS to ensure that it is receiving data from satellites.
- If the GPS is receiving data from satellites and these is still no connection refer to the **"GPS Setup"** section of this manual.

When ArcPad finds a signal there will be a popup with the heading *"Device Found"* that gives information about the device.

- Click yes to update GPS preferences
- On the **"Aerial Survey Toolbar"** click the first button, **GPS Active** .
- Also, click the second button to activate the **GPS Position Window**. This shows the GPS status and location information.
- Once the GPS is activated you will see a target in the centre of the screen with one pointed side. This is the GPS location and the pointed side is the direction of travel.

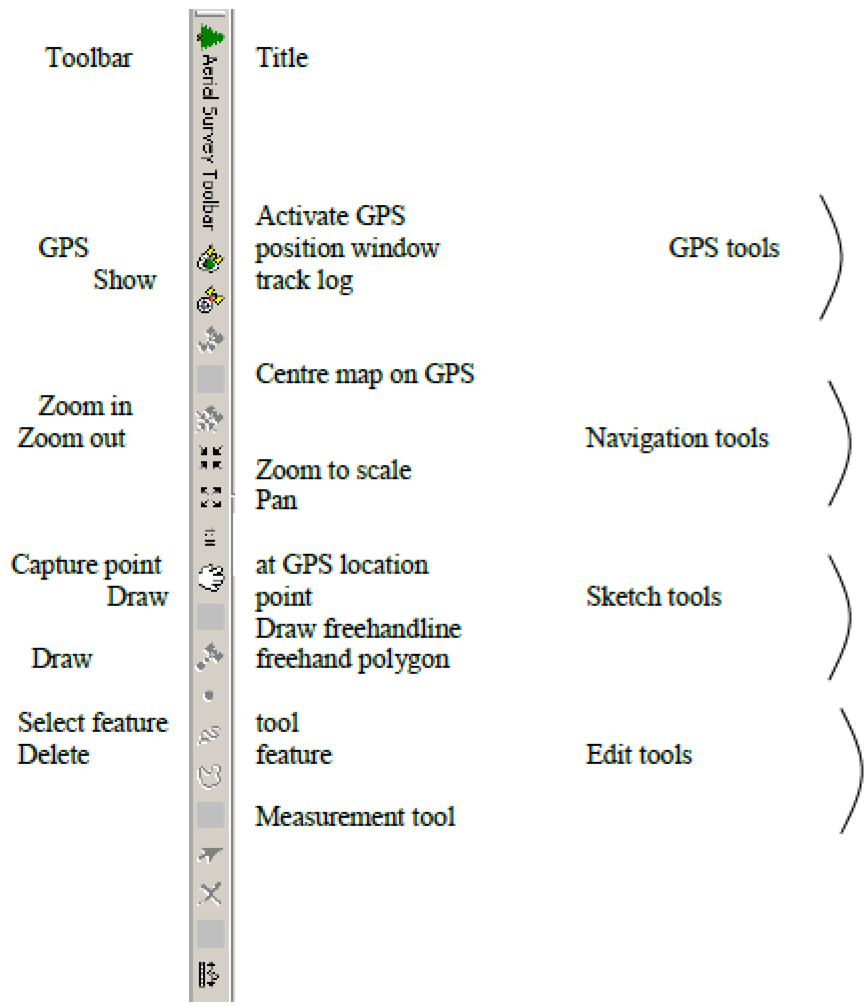
Initialize the Shapefiles to Edit

- Click the **Layer** button on the "**Main Toolbar"** to open the layer dialog.



- The pencil symbol shows that the file is in editing mode. Ensure that all three files (point, lone, and poly) have checkmarks next to them to show that they are in editing mode.

Forest Health Aerial Survey Toolbar



Note: On your tablet screen this toolbar appears horizontally.

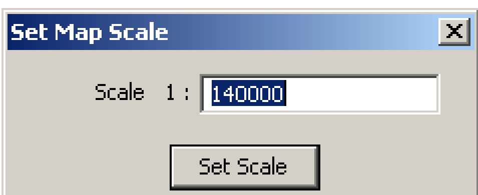
Set the Scale for the Survey

The system works well at a scale of between **1:250,000 and 1:80,000**. At a smaller scale the base map looks grainy and at a larger scale the image gets pixelated.

To set the scale:

- Click the **1:N** button . A popup like the one below will appear asking for a number to be input for the scale of the map.
- Use the **tablet's writing pad** to enter a number for the scale. Just enter the number after the colon, i.e. for 1:100,000 enter 100000.

Set Map Scale Popup



- The **Zoom In** and **Zoom Out** tools can also be used to change the scale quickly. Keep in mind that the Zoom In tool divides the scale number in half and zooms in to that number, and the Zoom Out tool multiplies the number by 2. This can make a significant difference to the scale that you are working with.

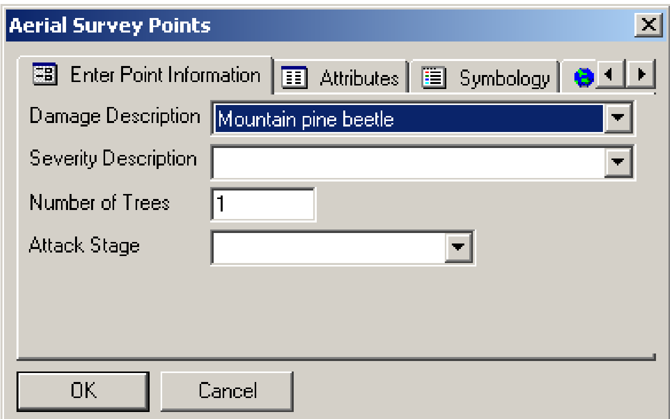
Sketching Disturbance

The main tools that are used to sketch disturbances are the capture point from GPS tool, the draw point tool, and the freehand polygon tool.

- **Capture Point From GPS** - This tool will only be active if the GPS is active and transmitting data to the tablet. Click this button to capture a point at the location of the GPS. This works well if you are in a helicopter hovering over either an infested tree or a group of infested trees.
- **Draw Point** - The Draw Point tool allows the surveyor to draw a point anywhere on the screen. To draw a point use the pen to activate the button, and with the button active touch the map area of the screen with the pen.

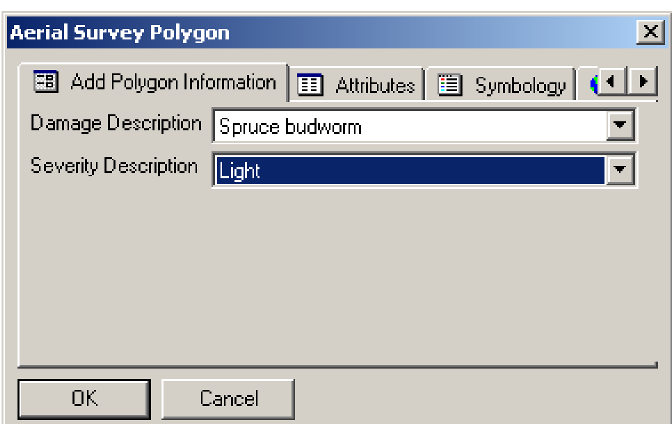
- With the **Capture Point From GPS** and the **Draw Point** tool the following screen will pop up asking for input. Enter the relevant information and click **OK**, or click **Cancel** if the point was placed in error.

- Use the dropdown menu for Damage Description, Severity Description, and Attack stage, and use the tablet's writing pad to enter the Number of Infested Trees. Make sure to have the cursor in the number field to enter the number.



- **Freehand Polygon tool** - use this tool to sketch around a defoliated stand or area. The polygon will close itself off so there is no need to either double tap or return to the starting point to close the polygon. When the pen is lifted from the screen the polygon is closed.

- After the pen is lifted the following screen will appear. Use the dropdown menu to pick the required attributes and click OK when done. Click cancel if you are not happy with the polygon, and retrace it.



Hints for sketching large polygons – It is recommended to try and sketch polygons with areas smaller than area covered by the map shown on the screen. At a scale of 1: 150,000 the screen shows almost 40 kilometres west to east, and almost 30 kilometres south to north. This is farther than FHDA-caused disturbance that can be seen by the surveyor in most cases.

- **Zoom out** – The zoom out tool can be used to double the scale of a large area that is required to be sketched. Depending on the working scale, this could bring the scale to a much as 1:300,000, in most cases. This should be adequate for sketching very large polygons.

- **Panning -** Pan so that the area that requires sketching is in the centre of the screen before sketching. This gives more room to work with on the screen.

- **Centre On GPS** – Use the Centre on GPS tool before sketching if the position indicator is close to the edge of the screen, and you would like to sketch a large polygon. This gives adequate time to sketch before the screen refreshes. If the screen refreshes while sketching, the pen may jump across the map and cause undesired results to the sketch.

- **Double up** – To sketch really large areas two or more polygons can be sketched adjacent to each other and given the same attributes. If possible, overlap the polygons to show that they should be adjacent. They can be easily joined in the post processing phase.

Deleting Points, Lines or Polygons

The last feature drawn is already selected if you have not hit any more buttons since sketching the feature. To delete it hit the **Delete Feature** button .

If no feature is selected, activate the **Select Feature** tool , select the feature with the pen, and hit the delete button. When a feature is selected a black dashed line will be drawn around it. This line is difficult to see, an alternate way of knowing that a feature is selected is that the delete button will be inactive if no feature in selected.

Saving Data

Anything that is sketched while in editing mode is **automatically saved** to the proper shapefile. Points are saved to the point shapefile, polygons to the polygon shapefile, and lines to the line shapefile. Be sure to back up the data when the survey is complete.

Taking Notes during the Survey

Notes can be taken during the survey using the **Notepad** application.

- Open Notepad and Save a file in the folder where you intend to back up the survey data at the end of the day.

- To write into notepad, activate notepad with the pen and use the tablet PC writing pad to print text into notepad.

- After making a note on the writing pad, press enter and the text will be entered into notepad.
- Alternately, a pencil and paper could be used to take down the notes as long as those are referenced properly to the data collected on the tablet PC.

Submitting Data

The tablet PC can be plugged into the network and it automatically connects to the network.

- After plugging into the network click on the desktop shortcut named **"Transfer Survey data To Here"**.
- This will open up a connection to the Cygnus FTP server LFSxchange folder.
- To transfer data you can make a folder for your data and copy it into the folder. Do not overwrite any data on the site as it may not be your data.
- After transferring the data to the FTP server send an email to the Forest Health Section data management person notifying the data submission.

Bluetooth GPS Setup

The system is equipped with a wireless **Bluetooth GPS**. The bluetooth device should be connected to the computer; however, the connection can be lost and has to be reconfigured.

Before trying to reconfigure the Bluetooth device ensure that Wireless is turned on.

- To turn on wireless click the Q button at the top of the tablet PC.
- The Q menu will appear.
- If Wireless Off is showing that means that wireless has been turned on. If Wireless On is showing click that button to activate wireless.

The following steps show how to reconfigure the Bluetooth device if the preceding steps did not work.

- Double click on **My Bluetooth Places** on the Desktop.
- Double click on **Bluetooth Setup Wizard**
- Select **Option 2** "find a specific bluetooth device and configure"
- Click **Next**
- Windows will search for devices
- Select **BT-GPS-xxxx**
- Enter the **PIN code** written on the device
- Click **Initiate Paring**
- Select the device in the menu and select **Configure**

- Select a Communications port…use the highest number available com. 5 or com. 6
- Make sure **Secure connection** is selected
- Select **Finish**

Use of Topographic Maps to Survey FHDA-Caused Disturbances

Maps

- Use small scale topographic maps (1: 250 000) in colour to record the FHDA-caused disturbances. Have maps for the areas adjoining the planned survey area to record any unexpected expansions of the infestation.

- 1: 250 000 provincial base topographic maps are recommended. This will ensure consistency for an observer who is familiar with the maps.

- If provincial base maps are not used, use maps that meet the following standards:

    - colours and symbols consistent with provincial base maps

    - ensure rivers, lakes, contours, settlements, and roads are on the map and names are easily readable while flying

    - labelled coordinate reference, especially at the corners of the map, either geographic (latitude and longitude), or UTM

    - maximum map size 30 x 36 inches (67.5 x 81 cm)

    - monochromatic (greyscale) imagery can be used as a background

    - do not either use colour imagery (may obscure polygon boundaries) or replace contour lines with a digital elevation model (DEM)

- Have one copy of each map per observer to record the details about the disturbance, while flying;

- If space permits, staple a copy of the previous year's disturbances on to the working map; and,

- Fold the maps for easy reference while on flight.

The aerial observers are responsible for the following information during overview aerial survey flights where maps are used:

Note: Altitude, visibility, and flight lines may be used to delineate an approximation of the areas surveyed.

- **Flight paths:** record the flight path using a GPS track. Start the track as soon as you start surveying for disturbance, and stop it when breaking for lunch/ refuelling, if possible. Flight lines should also be sketched on the map as a backup and to assist in orienting yourself during a survey.

- **Altitude and visibility:** record the altitude of the aircraft or record a mark with a GPS unit periodically if in a mountainous area. If you are working in a relatively flat area, periodically check and record the estimated visibility on the map.

- **Detection:** look out for new disturbances and for changes in disturbances recorded during the previous years.

- **Delineation:** once detected, delineate the disturbance on the survey map. Use the landscape features to map the limits showing the extent and shape of the disturbance. If it covers less than ten ha of land, use a dot to mark it on a 1: 250 000 scale map. If it is bigger than the area represented by a dot, then use a polygon to show the shape and the size of the disturbance. If no prominent landscape features are available, note the GPS coordinates for the peripheral limits of the disturbance.

- **Disturbance:** depending on the damaging agent, note severity of the disturbance on the map. For damage severity ratings on infestations caused by a given pest species, look under the description of that pest in Section 3.

- **Causative agent and host trees:** record the possible causative agent of the disturbance and host tree species affected, on the map. Use the binoculars and get the pilot to make a safe low level pass (minimum altitude 1000 feet AGL), if necessary. Use the pest survey codes (Appendix II) to record this information. Note whether ground truthing is needed.

After the Flight

- Review the maps and notes while the details are still fresh in your mind; ensure that each polygon or dot is marked with a damage severity code, causative agent code, and flight lines have been recorded. Add a detailed legend to the map to show the following:

    - date/s of survey;
    - name/s of observer/s;
    - type of aircraft used;
    - weather conditions and flight conditions that may have influenced the observations;
    - pest code and damage severity code;

Data Summary

Summarise the data to produce a final map for digitizing or photocopying. To do this:

1. Compare the working maps, if two aerial observers were involved in the survey. Combine the information from both working maps on to a clean map showing the pest disturbance. Use in-flight notes, as well.

If only one aerial observer was involved, use the working map to produce a clean map of the pest disturbance.

2. The final map has to be approved by the Forest Health Officer and contain the following required information:

    - date/s of survey
    - name/s of observer/s
    - type of aircraft used
    - map certified by weather conditions and flight conditions that may have influenced the observations and,
    - pest severity descriptions/codes

3. Download the flight lines from the GPS and prepare them for submission to the data administrator.

Follow-up Action

Once the final map is prepared, revise it by taking the following steps:

1. Label the photographs taken during the survey with relevant information; use them to revise the map, if necessary, e.g., severity ratings.
2. Carry out ground surveys to verify the causative agent, especially in any doubtful areas.
3. Use any other new information to revise the map, if necessary.
4. Forward the completed maps and GPS data, including flight lines, to your assigned data administrator.

Use of a GPS Unit to Survey

If a GPS unit is used during aerial surveys follow the guidelines below:

1. Ensure that your GPS unit is set up correctly:

    - Location (degrees-minutes-decimals (dmd)
    - Datum (NAD83) Units (Metres)
    - Time (Set correctly to 24 hour Mountain Standard Time)
    - Date (Ensure correct date)

2. A GPS unit could be used to record either points or polygons with FHDA disturbance. If it were a point, record the coordinates of that point. If it were a polygon, fly the periphery of the disturbance

on a rotary-wing aircraft, starting at a good landmark. Use the GPS unit to record the location of the aircraft every 2-3 seconds as it follows the disturbance.

3. At the end of the survey, submit the GPS points together with pest code, damage severity code and required metadata to the Senior Information Management Technologist at the Provincial Headquarters who will create a map delineating the points/polygons of FHDA infested areas of interest.

Detailed Survey Procedures

The purpose of a detailed aerial survey is to get more accurate and detailed information about pest-caused disturbances recorded during an overview aerial survey. The detailed aerial surveys are carried out in areas where management activities, e.g., mountain pine beetle control, aerial spraying programs, are planned.

Detailed aerial surveys on mountain pine beetle (MPB) infestations are different from detailed aerial surveys on other disturbances such as spruce budworm defoliation, hail damage or blowdowns. Thus the MPB heli-GPS survey procedures are described below, separately from other detailed aerial survey procedures.

The main objectives of the MPB heli-GPS surveys are to record locations of new fading/red trees killed by MPB in the past summer. These survey results are used for:

- Priority setting for ground survey and control programs
- Information for planning management actions
- Evaluating effectiveness of management operations
- Evaluating changes to previous infestations for historical and evaluation purposes
- Data reporting and inventory update at the forest area, regional and provincial levels

Types of MPB aerial surveys

Detailed Heli-GPS surveys

These are conducted throughout the Leading Edge Zone and the Active Holding Zone. These surveys provide information that is necessary to plan ground surveys and control programs. These are usually carried out by surveyors in rotary wing aircraft flying at low levels (300 feet AGL).

Detailed Full Color Aerial Photography

Aerial photography is used in areas where no direct control work will be conducted by the Department. Photographs taken of the specified areas are interpreted to map the locations of the pine trees with red crowns. These photographs are useful in determining the change in mortality rates and in developing either salvage or rehabilitation strategies.

Timing of Surveys

Heli-GPS surveys begin no earlier than August 15 and must be completed by September 15. Data must be delivered to the Information Management Specialist in Edmonton by September 20.

Aerial photography timelines vary because the information generated is not used to develop survey and control operational plans. Photographs must be taken between August 15 and September 15. Aerial photo interpretation deadlines are set on a project by project basis.

Planning an MPB Heli-GPS Aerial Survey

When planning a detailed aerial survey, the following should be considered in order for the survey to be cost effective, time efficient and reliable.

Survey Area

Area covered during a detailed aerial survey is limited and defined. If maps generated during an aerial overview survey are available, use those to identify the location of disturbances to be mapped during a detailed aerial survey. In the case of mountain pine beetle (MPB) heli-GPS surveys, follow the pre-approved survey plan to find the areas to be surveyed in detail.

Flight Plan

Plan the flight so that the travel distance between the blocks to be surveyed is kept to a minimum. In carrying out Heli-GPS surveys on MPB, follow the pre-approved survey plan regarding the areas to be surveyed in detail. In planning the flight, pay attention to the refuelling needs and locations of fuel caches.

Funds

Request and commit funds as soon as detailed survey plan is in place. Keep in mind that detailed aerial surveys are more expensive than the aerial overview surveys.

Aircraft

Use a rotary wing aircraft. Use of a relatively smaller rotary wing aircraft can save on charter cost and fuel usage but **choose an aircraft that does not compromise on safety**. Use an aircraft with as long a flight duration as possible. The pilot should preferably have aerial mapping experience. If flying time is more than a couple of hours long, contract out the aircraft to get a better rate; otherwise, use an aircraft on casual charter with ESRD.

Aerial Observers

The aerial observers should be familiar with the terrain and the pest that is being surveyed. For safety and wider coverage, two aerial observers per aircraft are preferable. In addition to recording the locations of MPB-symptomatic trees on tablet PC, the observer seated in front seat should be able to guide the pilot to fly the aircraft along the periphery of the survey area.

Maps

Use the pre-approved survey plan (MPB) as a guide to locate the disturbance that is to be surveyed in detail. During the flight, make appropriate corrections to the survey plan, if necessary.

Specialized Equipment

A hand-held GPS unit with enough memory capacity to store a large number of waypoints and an external antenna are required for a detailed aerial survey. This GPS unit is used as a back-up in case there are technical difficulties in using the tablet PC.

Flight Safety

Safety during the flight is the most important consideration. Follow these important guidelines:

- Ensure that all staff review the Hazard and Risk Assessment for Heli-GPS Surveys.

- At the beginning of the project and any time either the helicopter or pilot is changed, have the pilot give all surveyors a safety briefing. The briefing should cover, but is not limited to:

    - Safe entering to and exiting form the aircraft
    - Proper seatbelt use
    - Location of safety/survival gear
    - Proper storage of field gear
    - Emergency procedures

- Fly at 300 feet AGL. Only go below 300 feet AGL if mortality agent or patch size cannot be determined from the current height. Return to 300 feet AGL as soon as possible.

- Review SRD Aircraft Management SOP 6.13 Low Level Operations

ESRD Aircraft Management SOP 6.13 Low Level Operations (<500 feet above ground level (AGL)

The following are operating procedures for activities which do not have a specific set of procedures similar to those developed for Fire Bombing, Rappel, Aerial Ignition and Hover Exit.

- Use a company, pilot and aircraft qualified by Transport Canada for 702 Aerial Work.

- Flight crew are to be fully engaged in “flying the aircraft” and not be distracted by other work being done.

- Wherever possible, ESRD staff should operate radios on ESRD assigned frequencies, including telemetry receivers. The pilot can monitor these radios if the cockpit workload permits.

- Except where specifically permitted in Canadian Air Regulations sections 602.12 – 602.16, no flights over the built up area of a community shall be conducted at altitudes below 1000 feet above ground level (AGL).

- A Hazard and Risk Assessment is to be done for the specific task undertaken requiring low level operations including the need for the flight and alternate means of accomplishing the task identified.

Rotor Wing

- The flight profile should remain at an altitude of at least 300 feet above ground level (AGL) and remain in the safe operating areas of the Height Velocity (HV) chart specific to the rotor wing in use.

- If the mission requires the flight profile to go below 300 feet AGL or into the “unsafe” portion of the Height Velocity (HV) curve:

    - The exposure time is to be minimized and:
    - Only essential crew are allowed on the aircraft.

If working over open water, the pilot must brief SRD personnel on the specific emergency procedures to follow, including ditching procedures and egress from the aircraft.

A Hazard and Risk Assessment shall be completed to identify any extra safety equipment and/or training required by ESRD staff or contractors (e.g. flight helmets and flotation devices, water egress training, etc.).

Winds must be less than 75 km/hr or wind gusts less than 30 km/hr.

A power check must be done prior to entering the HV curve. There shall be sufficient torque to maintain the aircraft in a hover for 5 minutes without exceeding the manufacturer’s temperature or torque limits and have full tail rotor authority.

Conducting an MPB Heli-GPS Survey

Procedures

1. Check the weather forecast. Flying in strong wind, rain or snow reduces effectiveness of the survey. Discuss any concerns with the pilot before take-off.

2. Provide pilot with either a map indicating the area to be surveyed or GPS locations delineating edges/corners of the site.

3. Prior to the flight, discuss with the pilot a flight plan covering:

    i. Route for flying to the area to be surveyed;
    ii. How to fly grid pattern, considering the direction of the sun, wind, and terrain;
    iii. Where to land for fuel and breaks; and
    iv. Roles of surveyors and the pilot

4. Fasten external antenna of a handheld GPS on a window of the helicopter by using a suction cup; else, fasten wireless Bluetooth GPS for tablet PC with Velcro (or masking tape) either onto the dashboard of the helicopter or next to a window.

5. Fly to the survey area and review grid pattern according to light conditions, weather conditions and terrain.

6. Fly the grid at a safe altitude and speed. A safe height for detailed aerial surveying is approximately 300 feet above the ground level. Stay above this height as much as possible, during the flights.

7. Look out the window of the helicopter (left, right and front) and search either for red or fading trees.

8. Direct pilot to hover above each discoloured tree and determine the damage agent. If a closer look is required to determine causal agent, direct the pilot to reduce the altitude only for the time required to look at the trees. Regain a safe altitude as soon as possible.

9. If the tree has died due to MPB, mark it as a waypoint on your handheld GPS or tablet PC. If using a handheld GPS,

   i. Ensure you have adequate satellite coverage (signals from at least 3 satellites)

   ii. Record site number, as well as the causal agent of mortality and the number of infested trees at that location on a sheet of paper. If the causal agent cannot be accurately attributed, record notes describing the observed damaging agent).

10. If marking a larger area of infested trees, draw a polygon either on satellite image of the tablet PC at the correct location or by using a handheld GPS:

   i. Slowly fly around periphery of patch, recording a waypoint every 1-2 seconds.

   ii. Write down the waypoint numbers delineating the polygon and note the percentage of total stems that are infested, in 10% increments. Surveyors should take into account non-host areas and stand openings.

11. If the cause of mortality is unclear and ground truthing is required but the tree is difficult to access from the ground by vehicle, direct the pilot to land at a close by spot within walking distance, if feasible and time permits. Use recorded GPS location to find the tree and search for signs/symptoms from the ground to determine the cause of mortality.

12. Continue surveying along the grid.

13. If you record a tree damaged by an agent other than MPB (Figures 4-1, 4-2), record it with the appropriate FHDA code provided in Appendix II.

14. Each site (waypoint) should have a unique number. Label the sites consecutively, without missing any numbers.

15. Take breaks, land at least every couple of hours to maintain productivity.

Figure 4-1. Pine trees killed by porcupine damage.

Figure 4-2. Lightning-killed conifer trees.

Flying Patterns

Depending on the topography, either grid pattern or contour pattern flights are used to carry out detailed aerial surveys.

A grid or parallel-line flight pattern is a series of equally spaced, straight flight lines where the helicopter flies back-and-forth to achieve optimal survey coverage of an area. The pattern can be flown either with one surveyor or two surveyors in a team.

In flat areas with poorly defined terrain, parallel-line flight patterns are usually flown straight in cardinal directions in a back- and-forth pattern. Figure 3-1 shows a grid pattern flown with two surveyors. In mountainous areas orientation of straight lines depend on topography, angle of the sun and wind direction. In these areas it is best to fly along contour lines so that the pilot does not have to constantly climb and descend in altitude.

If the wind is strong, the pilot may advise a direction for the flight lines. Angle of the sun is another consideration in setting the flight lines to avoid having to look straight in the direction of the sun which could be hard on the observer.

Visibility is greatest in the front seat of the helicopter. The surveyor in the front should look to the front and perpendicular to the helicopter on the side of greatest visibility, i.e. away from the pilot. The second surveyor should sit on the pilot's side at the back, looking half-way to the next flight line. The surveyor in the back should be recording the information on the tablet PC. When the helicopter reaches the edge of the survey area it turns to fly the next flight line in the opposite direction. The flight lines will vary based on a variety of factors discussed later.

If there is only one surveyor in the helicopter, flight lines need to be closer together since the view on the side of the helicopter opposite the surveyor will be restricted.

The surveyor is responsible for identifying the tree species and the cause of mortality. If the pilot spots a discoloured tree he/she should fly beside it to let the surveyor identify its cause of mortality. Some pilots help find discoloured trees, however, the surveyor should not rely on the pilot for detecting infested trees. The pilot may be distracted by watching for other aircraft, keeping the helicopter on line or reporting to flight tracking personnel.

Figure 4-3. Aerial view of a lodgepole pine stand showing mountain pine beetle-killed trees with symptomatic red crowns (Photo courtesy of Devin Letourneau)

Other causes of symptoms that resemble mountain pine beetle attack are:

- Lodgepole pine beetle attack on declining pine;
- Porcupine or bear girdling pine trees; and,
- Lightning damage

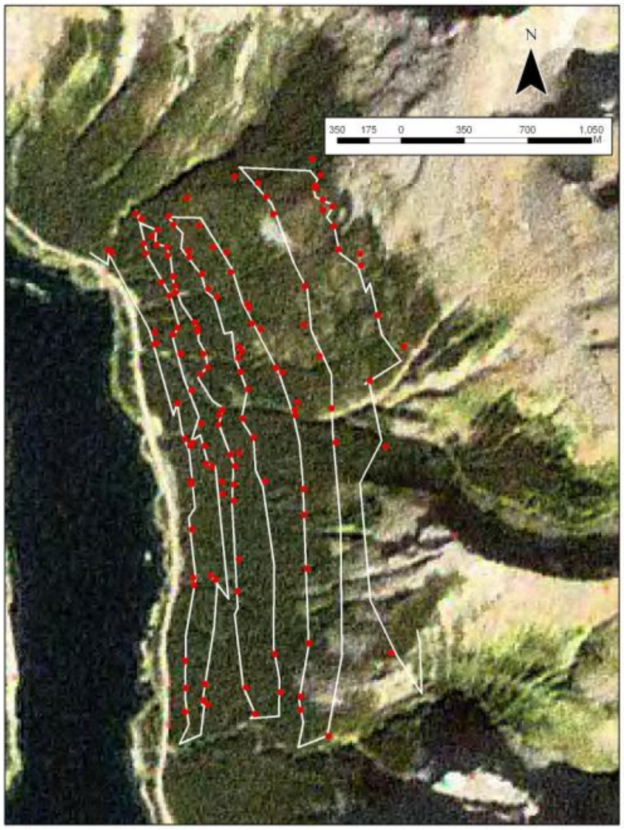


Figure . Flight lines flown in grid pattern

Line spacing and flight altitude

The distance between the flight lines is directly related to the altitude of the helicopter. The greater the distance between flight lines, the higher you'll need to fly to see farther. The more closely spaced the flight lines the lower the helicopter can be. Other factors in choosing the flight line spacing are the amount of pine in the survey area, the amount of faders to be marked and the surveyor's skill level. Usually, 300 – 500 m spacing provides enough room for the helicopter to manoeuvre and observe enough detail for surveying.

The most important factor for determining the altitude of the helicopter is safety. Helicopters must stay above 300 feet AGL as much as possible. Safety and flight altitude is discussed in Section 2.

Staying on line

The pilot should take the responsibility of keeping the helicopter on line so that the surveyors can concentrate on scanning the forest canopy. Provide assistance to the pilot in keeping the helicopter on line, especially if you have flight lines on your GPS or tablet.

The pilot needs to constantly correct for being displaced by crosswinds or leaving the straight flight line to hover above an infested tree. The pilot may advise to change the flight pattern if winds are strong. It is therefore important that the surveyor discusses the flight pattern with the pilot.

Speed

If you fly too fast, you may miss trees. If you cannot scan the entire area between flight lines ask the pilot either to fly slower or to decrease the distance between the flight lines. If there is little activity on the ground to record, it is cost-effective to increase the speed. However, the slower the helicopter flies, the more time the observers has to look at the ground covered and better the level of accuracy and details of coverage.

Ensure you hover above the infested tree when marking its location with a handheld GPS. A novice surveyor should not try to save time by passing a tree that does not appear infested by the agent of interest from a distance, thereby compromising the accuracy of data. Also, do not take a GPS point 'on-the-go' with a handheld GPS unit or with the tablet.

Factors affecting aerial survey accuracy

Many factors contribute or detract from the quality of the data collected during an aerial survey. The difference between a quality aerial survey and an inadequate aerial survey is determined by the management of the following factors.

Aviation factors

- *Visibility:* Visibility is greatest from the front seat of the helicopter. Look to the front and perpendicular to both sides. If two surveyors work as a team the second surveyor should sit on the pilots side at the back, as the lead surveyor in the front can see least on the pilot's side. Some pilots help find discoloured trees but the surveyor is still responsible to identify the tree species and the cause of mortality. Don't rely on the pilot for detecting infested trees.

- *Weather:* Bright sunlight provides the best conditions for detecting subtle colour differences in the foliage. Terrain may determine the timing of the flight as east facing slopes are best to be flown earlier in the morning because they face the morning sun and west facing slopes are better for flying later in the day. The best time to fly is during the three to four hours before and after noon.

- *Cloud cover:* Clouds may reduce the amount of sunlight, but a high cloud layer may diffuse the sunlight, thus reducing shadow and creating even lighting on the ground. However, clouds that cause dark shadows contrasting with brightly lit adjacent areas can make detection of colour changes difficult.

- *Winds and turbulence:* High winds can cause anxiety and motion sickness, particularly in mountainous terrain. This may affect the surveyor's ability to concentrate and compromise data accuracy. Strong turbulence can also make hovering difficult, such that the surveyor may not accurately identify the cause of mortality. Severely strong winds can make flying dangerous and the pilot may advise you not to fly. Always respect the pilot's safety considerations.

- *Precipitation:* It is possible to conduct aerial surveys either in rain or in snow. This may occur for a short time of the day and it may be better to take a break until the weather improves. Rain on the windscreen reduces visibility as does the darkness of the rain clouds. Never fly near a hail or lightning storm because of downdrafts, potential hail damage and possible direct lightning strikes.

- *Haze:* Haze can be caused by smoke, smog, dust or moisture. It may be possible to make up for such limiting visual conditions either by decreasing the distance between flight lines or by choosing a different area that is not affected by haze, if the skipped area can be surveyed on another day.

- *Human factors:* Once trained, it is the responsibility of the individual surveyor to recognize and manage the factors that determine the accuracy of the survey.

Helpful tips for surveyors

- Maximize the time you spend looking out the window and minimize the time you spend looking at the tablet PC or notes. Watch the drainage patterns or other predictable features to orient yourself.

- To minimize fatigue, use all possible ventilation devices in the helicopter, drink enough water, wear sunglasses and a baseball cap. Endurance levels vary amongst surveyors; realize when your attentiveness declines. Take breaks to stretch your legs and change your activity.

- Rose or amber-colored sunglasses are a great assistance when surveying for red and fading trees. The color of the lenses highlights the difference in the color of the healthy versus the dead/dying trees.

- When taking pictures, try doing so through an open window to prevent glare.

Green to Red Ratio Surveys (Current Attack to Old Attack)

Green to Red Ratios (G: R) are completed on aerial survey sites either during or after the aerial surveys are completed. G: R surveys are carried out from September 1-15. The Forest Health Officer will inform the surveyors if G: R ratios are to be collected.

G: R surveys are completed in a grid pattern with a minimum of one site per four townships. Choose a site with 3 or more trees, if possible. Sites with 1 or 2 trees can be used, if no others are available. Choose sites that are in the centre of the four townships and within approximately 250 metres of a landing site.

Equipment

- GPS, compass and map
- Knife, hatchet
- DBH tape
- Red Pest Management flagging tape
- Black permanent marker and pencil
- Data sheet

Procedure

- Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101'longitude

- A minimum of one (1) site must be surveyed for each four (4) township blocks. Choose a survey site close to the centre of the township block.

- Choose a survey site within 250 m of a landing site, if possible.

- Survey sites should have 3 or more fading/red trees. If sites with only 1 or 2 trees are available, still conduct a survey.

- Walk into site and find fading/red trees. Choose a fading/red tree to be the Plot Centre and flag the tree with red Pest Management tape.

- Label the flagging with the beetle year, site number (The Project Manager will give instructions on numbering sites), and the words "PLOT CENTRE".

- On the Concentric Ground Survey/Control Form record in the "Survey Comments" section that this is a G:R survey. Record plot centre location.

- Measure 50 m in all cardinal directions from the plot centre hanging a red Pest Management flag at 50 meters. Label each red flag with the beetle year, the site number, direction and distance from the plot centre (e.g. 2009 G:R 26 S 50m). The Project Manager may instruct surveyors to flag at 25 m as well. Label the 25 m flag in the same manner as the 50 m flag (e.g. 2009 G:R 26 S 25m)

- Survey all pine trees within the 50m radius concentric plot around plot centre.

- Count and record the number of currently infested and previously (old) infested trees within the concentric plot.

- Mark the location of each tallied tree on the crosshair map. Use unique symbols to identify current vs. old attack. (e.g. using a · and an 'x' or 'C' and 'O'.)

- A Tree must have at least 40 hits before it can be considered a successfully attacked tree and counted in tally.
- Up to a maximum of 10 trees, of the successfully attacked trees must be examined for beetle presence, life stages present, and to define the year of attack.

Performance Measures

For all aerial surveys conducted the following performance measures apply:

- Surveys to be completed by September 15th
- Data must be submitted to the Senior Information Management Technologist of the Forest Health Section at the Provincial Headquarters by September 20th
- Total (100%) area identified for survey by the Project Manager must be surveyed
- GPS locations of points must be within +/- 30 metres
- Polygon boundaries must encompass all fading/red trees
- Polygon infestation severity estimated must be within +/- 10%
- If surveys are completed after September 1, G:R surveys may need to be conducted as per direction of the Project Manager

The Province will be divided into 2 Areas for the purpose of performance measures on aerial surveys. The standards for each Area follow.

Primary Area

- Tree counts must be within:
    - 1 or 2 trees - +/- 0 trees
    - 3 - 10 trees - +/- 1 tree
    - 11 - 24 trees - +/- 4 trees
    - 25+ - +/- 10 trees
- Only patches with 3 or more infested trees are to be GPSed unless Program Manager directs surveyor to GPS 1 or 2 red or fading trees
- Detect 100% of patches of >3 trees within 5% ??
- No less than 2% and no more than 20% of the sites must be ground truthed. The Project Manager will determine (? determine what?) prior to beginning of survey.

Secondary Area

- Tree counts must be within:
  - +/- 5 trees for a patch of 5 - 25 trees
  - +/- 10 trees for a patch of 25+ trees
- Patches of 5 or more trees only are to be GPSed unless Program Manager directs surveyor to GPS sites with less red or fading trees
- Detect 100% of patches of >25 trees within the identified areas within 5% ??
- Detect 100% of >5 trees within the identified areas within 20%??
- A minimum of 1% up to a maximum of 5% must be ground truthed. The Project Manager will determine prior to beginning of survey.

Quality Inspection procedures for Aerial Surveys

- 100% of the area identified for survey by the Project Manager must be surveyed. If the extent surveyed is found to be insufficient, those areas missed must be surveyed.
- In the Primary and Secondary Areas 10% and 5% of the sites/area respectively will be surveyed for quality.
- If deficiencies are found, 5–10 additional sites of that surveyor's sites will be audited. If all additional sites fail, that surveyor will be removed from the survey project and lose certification. That surveyor must be replaced with another certified surveyor. If less than all the sites fail, corrective action or removal from the project will be at the discretion of the Project Manager.
- The Quality Inspector will record missed patches of red and/or fading trees. If deficiencies are found, either corrective action or removal from the project will be at the discretion of the Project Manager.

Collecting Quality Inspection Data

- Data can be collected using a tablet or a handheld GPS
- If wanted, load survey data from area to be QI'ed into tablet or GPS
- Create a new working shapefile if using the tablet. Name the shapefile "QI_name of original shapefile". For example if the original shapefile was 'Woodlands Aerial Survey August 20' the QI shapefile will be 'QI Woodlands Aerial Survey August 20'
- Re-survey the area to be QI'ed.

- Do not change the original survey shapefile. Correction of the data, if needed, should be completed when data is being compiled prior to sending to Edmonton.

Conducting Detailed Aerial Surveys on Other FHDA

Detailed aerial surveys are carried out for planning management of spruce budworm infestations. Similarly, detailed aerial surveys may be carried out to evaluate damage caused by blowdowns or hail damage. The procedures used for such detailed aerial surveys are described below.

Once the block earmarked for detailed surveys is located, guide the pilot to fly along the periphery of the disturbance. Start recording waypoints with the calibrated GPS unit at an easily identifiable landmark of the infestation, e.g., stream crossing the edge of the infestation, and fly along the periphery recording the GPS coordinates every one or two seconds until you return to the starting point.

> **Note:** The same GIS coverage should not contain both detailed survey data and overview survey data. These should be kept as separate files because of the difference in accuracy and intended purpose.

Following the survey, the data should be differentially corrected if you are using a compatible GPS and converted to an ArcInfo export file or ArcView shape file. Once this is done, an ArcInfo coverage needs to be created. The data can then be used to generate maps of the disturbed blocks. These maps can be overlaid with other topographical features and attributes that would help in designing the management plan. A copy of the final map can be supplied to the contractor hired to carry out the management plan.

Setting Up a GPS and Submitting Data

If a GPS unit is used during aerial surveys follow the guidelines below:

- Ensure that your GPS unit is set up correctly:
  - Location (decimal degrees – ddd.dddd);
  - Datum (NAD83) ; Units (Metres)
  - Time (Set correctly to 24 hour Mountain time)
  - Date (Ensure correct date)

- Since selective availability has been removed cheaper GPS units such as the common Garmin units can achieve accuracy as low as 15-20 metres without differential correction. This is considered adequate for detailed aerial surveys. Keep in mind that many of these units may only hold one track and limited number of waypoints.

- GPS information can be submitted as a shapefile in the proper UTM projection or in geographic coordinates, or a text file, excel spreadsheet, or dbase file containing decimal degrees.

Conducting Detailed Surveys without a GPS

When sketching a disturbance on 1: 50 000 or larger scale maps the survey is considered a detailed survey. Accuracy for 1: 50 000 sketch maps will be considered to be accurate within 50 metres (1mm on the map). This is comparable to GPS information collected by using a rotary wing aircraft.

The survey and data submission is to be conducted in the same manner as in an overview survey, but the observer should take extra care in sketching the disturbance to ensure accuracy of the information.
When submitting the maps to the data administrator state that it is a detailed survey. Detailed and overview survey data should not be mixed on the same maps or in the same coverage

Appendix I: Arc Pad Quick Reference Guide

NAVIGATION INFORMATION
SOG: Speed Over Ground
Tap and hold the COG display to change the reference.
TCOG: True North Course Over Ground
MCOG: Magnetic North Course Over Ground
DST: Distance to destination
BRG: Bearing to destination

POSITION MEASURE OF QUALITY
Tap and hold the display to change the measure.
PDOP: Position Dilution of Precision
HDOP: Horizontal Dilution of Precision
VDOP: Vertical Dilution of Precision
TDOP: Time Dilution of Precision
HPE: Estimated Horizontal Position Error
VPE: Estimated Vertical Position Error
EPE: Estimated Position Error
SATS: Satellites used in solution
DAGE: Differential data age
DSID: Differential reference station ID

SIGNAL CHART
Shows a bar chart of the relative signal strength of the satellites in the almanac. A red bar indicates the satellite is unavailable.
Tap the Signal Chart to display the Compass.

COMPASS
Shows the GPS direction with a black arrow and direction to destination in red.

MAIN TOOLBAR

Open Map	Open an ArcPad map (a file with an .apm extension).
Save Map	Save the current ArcPad map.
Add Layer	Add one or more layers to the current map.
Layers	Open the Layers dialog box.
GPS Position Window	Open or close the GPS Position Window.
Tools	Open the ArcPad Options dialog box.
Help	Open the online help.

OPEN MAP DROPDOWN LIST

New Map	Close the current map and create a new map.
New Layer	Create a new shapefile and load it into the current map.
Open Map	Open an ArcPad map (a file with an .apm extension).
Save Map	Save the current ArcPad map.
Save Map As	Save the current ArcPad map with a new name and/or in a different folder.
Map Properties	Enter the title of the current map.
Recent Maps	Display the nine most recently opened maps.
Recent Layers	Display the nine most recently added layers.
Exit	Close ArcPad.

ADD LAYER DROPDOWN LIST

Add Layer	Add one or more layers to the current map.
Add Internet Server	Add an ArcIMS® image service as a layer to the current map.
Geography Network	Go to the www.geographynetwork.com Web site, using the default Internet browser.

GPS POSITION WINDOW DROPDOWN LIST

GPS Position Window	Open or close the GPS Position Window.
GPS Active	Activate or deactivate the GPS.
GPS Tracklog	Start or stop storing GPS points in the tracklog shapefile.
GPS Debug	Open or close the GPS Debug window.

TOOLS DROPDOWN LIST

Options	Open the ArcPad Options dialog box.
Scale Bar	Display or hide the scale bar.
Panning Frame	Display or hide the map panning frame.
Status Bar	Display or hide the status bar.
Toolbars	Display a submenu containing all the toolbars in ArcPad.

HELP DROPDOWN LIST

Help Topics	Open the online help.
About ArcPad	Open the About ArcPad dialog box.
About Extension	Display a submenu listing all loaded ArcPad extensions.

BROWSE TOOLBAR

Zoom In	Zoom in on the map using the pen.
Zoom to Full Extent	Zoom to the full extent of the map.
Go Back to Previous Extent	Zoom back to the previous extent you were using.
Identify	Activate the Identify tool.
Find	Open the Find tool.
Clear Selected	Unselect the selected feature.
Refresh	Redraw the map.

ZOOM IN DROPDOWN LIST

Zoom In	Zoom in on map using the pen.
Zoom Out	Zoom out on map using the pen.
Pan	Pan the map using the pen.

ZOOM FULL EXTENT DROPDOWN LIST

Fixed Zoom In	Zoom in on the center of the map by 25%.
Fixed Zoom Out	Zoom out on the center of the map by 25%.
Zoom to Selected	Zoom to the extent of the selected feature.
Center on GPS	Center the map on the current GPS position.
Zoom to Full Extent	Zoom to the full extent of the map.
Zoom to Layer	Zoom to the extent of a particular layer in the map.

GO BACK TO PREVIOUS EXTENT DROPDOWN LIST

Go Back to Previous Extent	Zoom back to the previous extent you were using.
Go to Next Extent	Zoom forward to the next extent in the extent history.
Set View Coordinates	Set the map extent or center the map at specified coordinates.
Set Map Scale	Set the map scale.
Create Bookmark	Create a spatial bookmark.
Manage Bookmarks	Edit or delete existing spatial bookmarks.
Zoom to Bookmark	Zoom to an existing spatial bookmark.

IDENTIFY DROPDOWN LIST

Identify	Activate the Identify tool.
Measure	Measure distances in the map view in "point mode".
Radial Measure	Measure radial distances in the map view using the pen.
Freehand Measure	Measure distances in the map view in "freehand mode".
Hyperlink	Activate the Hyperlink tool.
Go To	Activate the Go To tool.
Advanced Select	Activate the Advanced Select tool.

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EDIT/DRAWING TOOLBAR

Select	Activate the Select tool.
Vertex Edit	Activate vertex display and editing for the selected feature.
Point	Activate the point feature type for data capture.
Capture Point Using GPS	Capture a point feature in the editable point layer using the current GPS position.
Add GPS Vertex	Capture a single vertex in the current line or polygon feature using the current GPS position.
Add GPS Vertices Continuously	Continuously capture vertices in the current line or polygon feature using the current GPS position.
Feature Properties	Open the Feature Properties dialog box (or custom edit form) for the selected feature.

SELECT DROPDOWN LIST

Select	Activate the Select tool.
Select at GPS Position	Select the feature at the current GPS position.

POINT DROPDOWN LIST

Point	Activate the point feature type for data capture.
Line	Capture a straight line feature using the pen.
Polyline	Activate the polyline feature type for data capture and start a new line feature.
Freehand Line	Capture a freehand line feature using the pen.
Rectangle	Capture a rectangle polygon feature using the pen.
Polygon	Activate the polygon feature type for data capture and start a new polygon feature.
Ellipse	Capture an ellipse polygon feature using the pen.
Circle	Capture a circle polygon feature using the pen.
Freehand Polygon	Capture a freehand polygon feature using the pen.

FEATURE PROPERTIES DROPDOWN LIST

Feature Properties	Open the Feature Properties dialog box (or custom edit form) for the selected feature.
Zoom to Selected Feature	Zoom to the selected feature.
Center on Selected Feature	Center the map on the selected feature without changing the current map scale.
Go to Selected Feature	Set the selected feature to be the current destination for navigation.
Delete Feature	Delete the selected feature.

ArcPad Resources
Visit www.esri.com/arcpad for
- The latest information on ArcPad.
- Updates and downloads.
- Technical Support Knowledge Base.
- ArcPad Discussion Forum.

ArcGIS Quick Reference

GPS POSITION WINDOW

SATELLITE SKYPLOT
Shows the almanac of which satellites should be available.
Black: available and used for calculating the GPS position
Blue: available but not used
Red: unavailable
Tap the Satellite Skyplot to display the Signal Chart

GPS POSITION COORDINATES
Tap and hold the coordinate display to change coordinate system.
Map Projection
DMS (ddd°mm'ss.sss")
DMM (ddd°mm.mmmm')
DD (dd.dddddddd°)
UTM (Universal Transverse Mercator)
WGS84 DMS (ddd°mm'ss.sss")
WGS84 DMM (ddd°mm.mmmm')
WGS84 DD (dd.dddddddd°)
MGRS (Military Grid Reference System)

GPS MODE
NOFIX: no position
2D: x,y position
3D: x,y,z position
DGPS 2D/3D: real-time Differential GPS
RTK flt/fit: Real-Time Kinematic fixed or float solution
PPS 2D/3D: Precise Positioning Service

ELEVATION
Tap and hold the elevation display to change units.
Altitude (meters or feet)
Depth (meters or feet)

Appendix II: Forest Health Damaging Agent Codes

Abiotics	
Drought	AD
Frost	AF
Hail	AH
Flooding	AO
Redbelt	AR
Windthrow	AW
Chemical	AC
Lightning	AL
Diseases	
Spruce needle rust	DFC
Pine needle cast	DFL
Lodgepole pine dwarf mistletoe	DMP
Armillaria root disease	DRA
Tomentosus root rot	DRT
Insects	
Western balsam bark beetle	IBB
Douglas-fir beetle	IBD
Mountain pine beetle	IBM
Spruce beetle	IBS
Spruce budworm	IDC
Western spruce budworm	IDW
Forest tent caterpillar	IDF
Large aspen tortrix	IDL
Bruce spanworm	IDB
Linden looper	IDE
Serpentine leafminer	IDP
Wildlife Damage	
Bear	WB
Porcupine	WP

Appendix III: Timelines for Forest Health Surveys

Pest	Survey	Timelines	
		Complete	Submit Data
Eastern Spruce Budworm	Defoliation and tree kill	Jul 1 - Aug 15	Sep 1
Western Spruce Budworm	Defoliation and tree kill	Jul 15 – Sep 15	Nov 1
Major Aspen Defoliators	Defoliation	Jun 20 – Jul 15	Aug 1
Bark Beetles (except MPB)	Incidence and per cent tree kill	Sep 15	Nov 1
Abiotics	Extent and per cent tree kill	Sep 15	Nov 1
Diseases	Extent and per cent tree kill	Sep 15	Nov 1

APPENDIX III.

HAZARD ASSESSMENT & CONTROL REPORT

Ministry: Environment and Sustainable Resource Development

Work Site: Airport/Helibase / Heliport / Wildland Areas

Type of Work: Insect and Disease Rotor Wing Surveys **Completed by:** Erica Lee, Mathew Christie **Date:** July 22, 2009

Work-Related Activities	Environmental Factors and Equipment, Tools, Materials, Machinery, Chemicals, etc. used in each activity	Potential Hazards in each activity	Risk Analysis (Rating of 1 to 4 – see Guide)			Degree of Risk	Risk Classification High, Medium, Low	Review Date: ___July 2010___				
			Frequency of Exposure	Incident Probability	Potential Consequence			Engineering Controls	Administrative Controls	Personal Protective Equipment	Status	Completion Date
Approaching Helicopter	Engine	Noise	4	2	3	24	Medium			Hearing Protection		
	Main Rotor Blades	Rotor Blade Contact	4	1	4	16	High		Pilot Briefing to cover methods for pickup, approaching helicopter, storing gear in side compartments or tail boom			
	Tail Rotor Blades	Rotor Blade Contact	4	1	4	16	High					
Entering / Exiting Helicopter	Skid Gear, Doors	Slips, Trips, Falls, Strain	4	1	2	8	Low		Ergonomic Practices Pilot Briefing	Footwear		
	Loading/unloading equipment and gear	Pinch fingers	4	3	2	24	Medium		Routine inspection of basket Proper training/briefing on basket operations			
		Strains	4	3	2	24	Medium		Proper lifting techniques			
		Exposure to exhaust	4	4	1	8	Low		Mitigate exposure			
		Downwash – main rotor	4	4	2	16	Medium		Crew to wait for downwash to subside			
Helicopter Flight	Seats, Fumes, Machine motion Turbulence	Air/Motion Sickness	3	3	1	9	Low		Staff and Pilot Briefing	Personal Medication		
	Turbulence	Hitting head	3	3	1	9	Low	Seatbelts	Pilot briefing to cover proper use of seatbelts. Seatbelts must be worn at all times when in helicopter.			

Work-Related Activities	Environmental Factors and Equipment, Tools, Materials, Machinery, Chemicals, etc. used in each activity	Potential Hazards in each activity	Risk Analysis (Rating of 1 to 4 – see Guide)			Degree of Risk	Risk Classification High, Medium, Low	Review Date: ___July 2010___				
			Frequency of Exposure	Incident Probability	Potential Consequence			Engineering Controls	Administrative Controls	Personal Protective Equipment	Status	Completion Date
	Engine	Noise	4	2	3	24	Medium	DOT approved head sets		Hearing Protection		
	Flight Components	Component Failure	4	2	4	32	High		Pilot Briefing	Appropriate clothing		
	Survey operations	Glare/eye strain Headaches	4	3	1	12	Low		Staff briefing	Polarized sunglasses; Peaked hat		
	Operations in remote areas	Forced Landing, crash; Equipment failure; Forced to overnight in remote areas	4	2	4	32	High	Appropriate survival kit in machine (DOT regulations); Appropriate radio gear in machine	Pilot briefing to cover emergency procedures. SRD-approved flight watch Staff to have personal survival gear appropriate for the weather conditions	Personal survival kit worn at all times; appropriate clothing and foot gear		
	Low level work	Ground Hazards (e.g. towers, power lines)	4	3	4	48	High	Appropriate survival kit in machine (DOT regulations); Appropriate radio gear in machine	Staff and pilot briefings SRD-approved flight watch; Advance scouting of area to identify hazards	worn at all times; appropriate clothing and foot gear, Personal survival kit		
		Mechanical failure	4	2	4	32	High	Appropriate survival kit in machine (DOT regulations); Appropriate radio gear in machine	Pilot to perform routine and scheduled maintenance on time			
		Chip lights, warning horn	4	3	1	12	Medium	Appropriate survival kit in machine (DOT regulations); Appropriate radio gear in machine	Pilot to take appropriate action according to operations manuals			
		Motion sickness	4	4	2	32	High	Leak proof containers/bags	Properly brief crews on avoiding motion sickness			
		Loss of situational awareness	4	4	4	64	High		Job Sharing – at least one member of crew watching outside of aircraft			
Fueling aircraft	Rolling drums	Strains/muscle pulls	1	1	1	1	Low		Refer to SRD Aircraft Management Section SOP 14			
	Aviation Fuel Contact	Chemical Hazard	1	1	1	1	Low		Refer to SRD Aircraft Management Section SOP 14			
		Fire Hazard	1	1	1	1	Low		Refer to SRD Aircraft Management Section SOP 14			