

**Alberta Agriculture and Forestry
Forest Health Aerial Survey Guide
2020**

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Section 1: Introduction to Forest Health Aerial Surveys

Aerial surveys are a very cost effective method to detect and monitor disturbances caused by forest health damage agents (FHDA) on forested lands. Since 1998, routine overview aerial surveys of FHDA-caused disturbances in Alberta's forests have been carried out by the Province.

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 that these surveys are undertaken to document potential changes.

1.1 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 that may be among 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.

1.2 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; and safety measures to be taken during aerial surveys.

Section 3: Overview Aerial Survey Procedures

Outlines data collection methods; how to determine the survey area, how to prepare a flight plan; aerial observer experience requirements; equipment/supplies list; pre- and during flight procedures; and safety.

Section 4: Detailed Aerial Survey Procedures

Information provided in this section is similar to that in section 3, although it is specific to performing detailed survey.

Section 5: Data Collection Methodologies for Aerial Surveys

Digital and manual techniques used in carrying out detailed aerial surveys.

Section 6: Aerial Surveying of Disturbances Caused by Specific Forest Health Damage Agents

Describes optimum timing, symptoms to observe, and rating severity of disturbances caused by damaging agents (e.g. bark beetles, defoliators, and diseases).

Section 7: MPB Heli-GPS Aerial Survey Methodology

Provides specifics on methodologies to perform detailed surveys for mountain pine beetle.

1.3 Acknowledgements

The Alberta Forest Health Aerial Survey Manual was developed through contributions from the following past and present Forest Health and Adaptation staff: Sunil Ranasinghe, Daniel Lux, Aaron McGill, Kris Heemeryck, Brooks Horne, Tom Hutchison, Dale Thomas, Pam Melnick, Mike Undershultz, Devin Letourneau, Devin Belanger, Ryan Hermanutz, Caroline Whitehouse, David Tellier, Fraser Mckee, Jennifer MacCormick, Allison Brown, Andrea Sharpe, Louis Price, and Bart McAnally.

Section 2: Aerial Surveys - General

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

Forest health damage 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 agents; and,
- identify host tree species affected by the damaging agent.

Survey information is commonly used for:

- planning pest management actions;
- forest management planning (e.g. harvest sequencing, timber supply);
- national and provincial forest pest reporting; and
- research related to changes in pest population dynamics.

2.1 Overview vs. Detailed Aerial Surveys

Aerial survey of FHDA can be overview aerial surveys, or detailed aerial surveys.

Overview aerial surveys:

- cover extensive areas to detect as many FHDA-caused disturbances as possible;
- are carried out by observers typically in fixed-wing aircraft flying at appropriate safe heights above ground level over the forest canopy;
- record locations, extent, severity, possible causative agent and host tree species involved in disturbances; and,
- establish the need to carry out detailed aerial surveys where more accurate information is required.

Detailed aerial surveys:

- intensively cover specific areas of concern with known FHDA disturbances where management action is contemplated;
- are carried out by observers in rotary wing aircraft flying, at relatively low but appropriate safe levels, over the forest canopy in selected areas;
- provide an accurate assessment of the locations and/or boundaries of disturbances and the severity of damage; and
- are the foundation for planning potential management actions.

2.2 Rational for Aerial Surveying

Aerial surveys are cost-effective means of obtaining forest health damage 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;
- forest health data at the forest area, regional and provincial levels for reporting and inventory update.

2.3 Roles & Responsibilities

The Forest Health & Adaptation Program is responsible for ensuring that the necessary aerial surveys are carried out within the Province.

The Forest Health Officer (FHO) is responsible for:

- requesting/obtaining funds and monitoring budget;
- 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;
- ensure that surveys are completed, data is accurate, and results are reported to Forest Health & Adaptation's Information Management Technologist.

The Forest Health & Adaptation Section is responsible for:

- reviewing aerial survey plan and providing budgets;
- coordinating mentoring/training for Forest Health Officers;
- provide technology support;
- producing final map products.

2.4 Coverage

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

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

Although permission is not required to survey Provincial Parks and Protected Areas (authorized by Memorandum of Understanding), communication with Parks staff is essential to identify issues that may impact survey coverage or timing.

Ideally, all the forested lands within the Forest Area have to be overview surveyed to detect and monitor all the FHDAs, abiotics in particular. However, the aerial surveyors have to operate

within logistical constraints (funding, time and labor). To address this dilemma, two options can be considered.

One option is to carry out the regular annual overview survey flights over selected high priority forested lands within the Forest Area. In addition, cover a pre-determined percent of the secondary priority area. Select the secondary priority area coverage in such a way that it is completely surveyed over a rotation period (e.g., if 50 percent of the secondary area is covered per year, it is completely surveyed over a rotation cycle of 2 years).

Alternatively, to address logistical constraints, a coarser survey (e.g. wider flight lines) could be used in some secondary priority areas to ensure some level of coverage over the entire forest area each year. In this scenario the coarser survey should not be undertaken over the same area each year, but rather rotated to ensure subsequent standard coverage. This option may be superior to that in the previous paragraph as there is a higher chance of recording significant events that may only be evident in one year.

2.5 Timing

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, may not be visible during the above period. These pests may have to be surveyed either earlier or later in the season. Refer to Table 1 in Section 6 for optimal aerial surveying timeframes when pest-specific damage is most evident in Alberta.

Time of day is also critical. 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.

2.6 What to Observe

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

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

For each disturbance polygon, record the symptom, agent, severity and tree species affected.

Section 3: Overview Aerial Survey Procedures

Procedures used in carrying out an aerial overview survey are described below.

3.1 Selecting Data Collection Method

Refer Section 5 for details on survey data collection 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.

Refer to Section 5 for details on data submission standards specific to each data collection method.

3.2 Determining the Survey Area

Make use of all existing information on pest conditions in planning an overview aerial survey. Use forest inventory information 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 or access restrictions (e.g. muskeg, large water bodies, recent large wildfires, weapons range).

Use previous year's FHDA survey data to find the locations of disturbances that have to be monitored this year. Use Forest Health & Adaptation Annual Reports to find FHDA occurrences since 1997. In addition, investigate reports of current year's FHDA disturbances observed by other forestry personnel e.g., fire crews, timber cruising crews, forest industry etc. This information is used to determine the priority forested land to survey during the regular flights.

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.

3.3 Preparing a Flight Plan

Once survey area has been identified, prepare a flight plan while considering the following:

- Topographical features that may impose limitations on flights, e.g., mountainous regions with deep valleys.
- Flight line widths should be close enough together to allow the observer to see partial coverage of the precious flight line. Generally flight lines are 1 township (6 miles) apart at a maximum. May vary depending on resource availability/time restrictions/visibility etc.
- Flight lines may be staggered between years to position the observer in a slightly different geographic location than the previous year while still maintaining complete coverage.

- Note areas where prior permission is needed to carry out aerial surveys, e.g., national parks.
- Compartmentalize the survey area into zones that can be flown comfortably within a day, i.e., within about five hours of flying.
- Refueling needs of the aircraft and locations available for refueling.
- 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;
- 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.

3.4 Reserving Aircraft

Go through the Provincial aircraft dispatch to reserve aircraft for aerial surveys. Aircraft options include those already on contract with the Department (e.g. Bird Dog) or casual charter. 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.

If aircraft are not available through dispatch, alternative Contract options must be explored.

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 206 or 210 are ideal for aerial surveys, especially to survey mountainous or large 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; move to procedure speed dependent on surveyor ability to keep up, pest types, area to be covered etc.
- **Seating capacity:** at least three passenger seats;
- **Maximum flight duration:** if refueling 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; communication system to allow flight following by dispatch; portable transponder to keep in touch with dispatch if flight is to occur in an area beyond 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 or windy areas.

3.5 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.

3.6 Supplies

- DSM system with accessories programmed for aerial surveys
- Maps as back-ups for surveying
- GPS as back-up for surveying
- binoculars;
- digital camera and batteries;
- sunglasses, preferably amber colored, to minimize any distortions; color pencils and fine tip pens, and mechanical pencils;
- notebook and a clip board; and
- aerial survey guide and field guides on pests (optional).

3.7 Pre-flight Procedures

On the days leading up to the Aerial Survey:

- check the weather forecast to ensure that weather conditions are favorable for flying on the following day;
- if conditions are favorable, confirm the flight with the aircraft company;
- provide digital flight lines to the pilot (example formats include .gpx files, .kml files, avenza maps, .pdf maps, or an excel file with all the turning point locations);
- 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(s) to assist with mapping;
- 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 meters;
 - either clear, sunny day or at least solid high overcast conditions as broken cloudy conditions make it difficult to observe the disturbances; and
 - wind speed acceptable to the pilot.
- Begin survey as early as possible. The morning is often less turbulent and lighting is optimal for detection.

3.8 Safety

Safety is a prime concern in any aerial survey. Refer to the most current version of the *Agriculture and Forestry Aircraft Management Standard Operating Procedures* for aircraft use and safety instructions during aerial operations. The Procedures can be accessed at:

<https://forestry.sp.alberta.ca/forestry/forestprotection/SOP%20Manual/Forms/public.aspx>

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 some general guidelines to follow to ensure safety during low level fixed-wing operations:

- The company, pilot and aircraft must be 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, Agriculture and Forestry employees should operate radios on Agriculture and Forestry assigned frequencies, including telemetry receivers. The pilot can monitor these radios if the cockpit workload permits.
- Except where specifically permitted in Canadian Aviation 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.
- A hazard and risk assessment must be undertaken for low-level operations including the need for the flight and alternate means of accomplishing the task identified.
- 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 assigned frequencies; take notes and photos during the flight. The pilot may monitor radios if the cockpit workload permits.
- 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 area 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
- 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.

3.9 During Flight Activities

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. 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 must 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 color 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.

3.10 Ground Truthing

Ground truthing is the process of verifying the accuracy of aerial calls with ground visits to damage agent polygons recorded during the survey. The primary purposes of this activity is to verify the damage agent call made from the air, or attribute a damage agent to polygons with “unknown” damage agents. Where possible, 10% of polygons should be ground truthed.

Use the “Flag for Follow-up” check box during the survey (or other appropriate method) to identify polygons for ground truthing. Selection of the 10% of ground truth check locations should be based on:

- good ground accessibility;
- goal of attributing damage agent to polygons with “unknown” agent(s);
- geographic distribution across forest area;
- attempt to visit at least one polygon of every individual damage agent recorded in the survey; and
- coordination with adjacent Forest Area ground truthing checks.

3.11 Post-flight Data Management

Prior to submitting the aerial overview survey data to the Information Management Technologist, it is necessary to review it in ArcMap for errors and completeness.

Geometry Errors

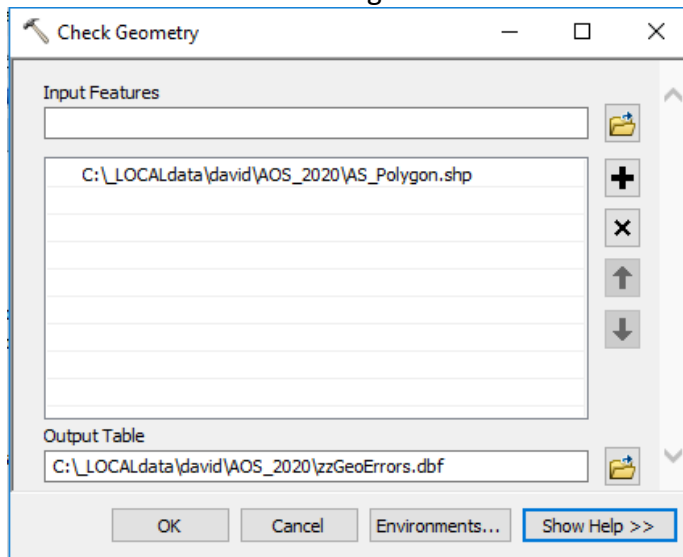
ArcPad allows the creation of invalid polygon geometry. This is important to fix, since features with geometry errors cannot be reported properly (corrupt area), nor analyzed with geoprocessing tools in ArcMap. It is important to fix these errors first, since geometry errors can cause ArcMap to crash.

Digitizing these patterns result in geometry errors (note how the digitizing line crosses itself):



To determine if there are polygons with geometry errors, execute this ArcToolbox tool

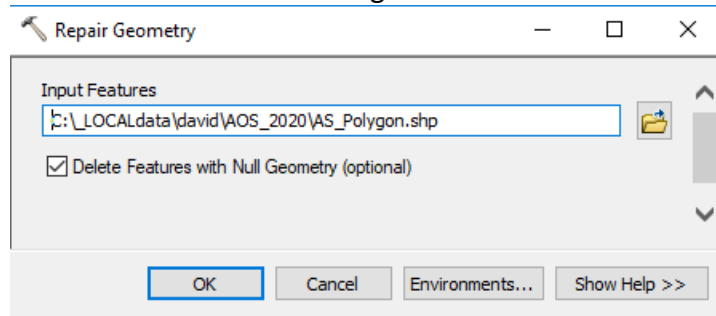
>> ArcToolbox > Data Management Tools > Features > **Check Geometry**



Check: If your output table is empty, then there is nothing to fix.

To automatically fix polygons with geometry errors, you may run this ArcToolbox tool

>> ArcToolbox > Data Management Tools > Features > **Repair Geometry**



Repairing the geometry results in these shapes:



Further manual edits may be required, if you wish to delete the “fish-tail” or add to the “interior” of the polygon.

Polygon-By-Polygon Check

Review each polygon in ArcMap to confirm attributes and shape.

Setup ArcMap

- in “Data View” mode
- Setup background layers as required
- Setup background imagery
- Setup the draw-symbol for the AOS polygons
 - Thin black outline
 - Solid fill, light red, 80% transparent
- Setup labelling the AOS polygons
 - Label with this “advanced” expression

Function FindLabel ([DMG_DESC], [SEVDESC], [SYMPTOM], [SPECIES], [COMMENT])

FindLabel = [DMG_DESC] & vbNewLine & [SEVDESC] & "-" & [SYMPTOM] & vbNewLine & [SPECIES] & vbNewLine & [COMMENT]

End Function

- Click on the “Editor” pulldown, and click “Start Editing”

To review each polygon, double-click on each record

- Double-click on the far-left box to zoom to next polygon

OBJECTID *	DMG_DESC	SEVDESC	SYMPTOM	SPECIES	COMMENT	Shape_Area
1	Pine needle cast	DMD	Foliar damage	Pine, lodgepole		108499687.134955
2	Unknown	SMD	Mortality	Fir		42883077.076508
3	Unknown	SMD	Mortality	Fir		3495024.651574
4	Unknown	SMD	Mortality	Fir		9944227.655374
5	Unknown	SMD	Mortality	Fir		4161550.484393
6	Unknown	SMD	Mortality	Fir		11846368.332203
7	Unknown	SMD	Mortality	Fir		4959404.622104
8	Unknown	SMD	Mortality	Fir		1321754.771158
9	Unknown	SMD	Mortality	Fir		5428232.285124
10	Pine needle cast	DSV	Foliar damage	Pine, lodgepole		14930462.894782
11	Douglas-fir beetle	SMD	Mortality	Fir, Douglas		523900.620161
12	Douglas-fir beetle	SMD	Mortality	Fir, Douglas		486055.559699

Check if the polygon accurately depicts the damage agent extent?

- Cleanup as required

Check for overlapping polygons?

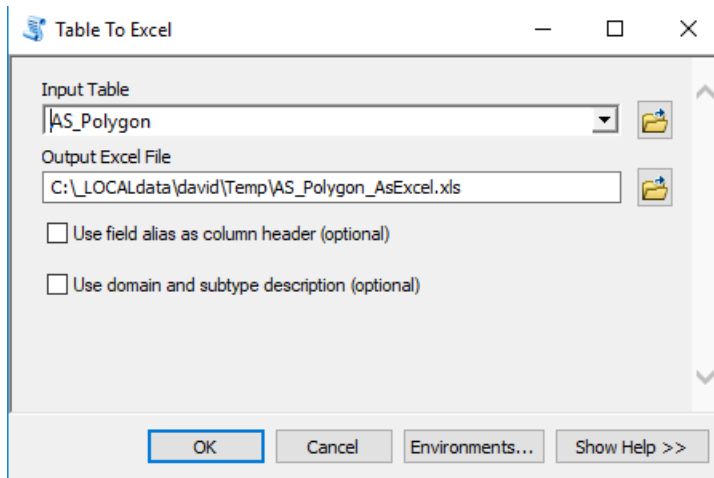
- Overlapping polygons are usually *not* an error.
- It can be an error when the polygons have all the same attributes, with the exception of “SEVDESC” or “COMMENT”. In this case, the overlapping area must be erased from the polygon that is either less severe or has no comment.
 - Select the polygon with greater “SEVDESC” or has a “COMMENT”
 - Click the “Editor” pulldown, then click the “Clip...” button
 - Ensure you select the option to discard the overlapping area.

Attribute Checks

Once GIS checks are complete, the attributes must be checked. Ensure that DAMAGE AGENT, SEVDESC, SYMPTOM, and SPECIES are the correct combination, and can be double-checked against the data dictionary is the aerial survey manual. Check that any manually entered attributes are spelled and capitalized correctly. The easiest method to do this is to export the attributes table to Excel and create a pivot table to identify outlier codes.

To export the shapefile to Excel, bring the *AS_Polygon.shp* file into ArcMap, and ensure you have “cleared” selection features . Use this ArcToolbox tool to export to Excel:

ArcToolbox > Conversion Tools > Excel > **Table To Excel**



Create a series of pivot tables to double check the combinations of damage agents, symptoms, severities and tree species. Below are a couple of examples:

2						
3	Sum of Hectares	Column Labels				
4	Row Labels	Defoliation	Dieback	Foliar damage	Mechanical	Mortality
5	Armillaria root disease					81516.23311
6	Aspen serpentine leafminer	8419.556889				
7	Aspen twoleaf tier	130775.6879				
8	Douglas-fir beetle					2829.0927
9	Drought			31545.3584		
10	Eastern larch beetle					10186.8842
11	Flooding				15777.15531	186.6625787
12	Forest tent caterpillar	127285.8822				
13	Gray willow leaf beetle	2705.241633				
14	Hail				7439.522048	
15	Larch sawfly	2.849980191				
16	Large aspen tortrix	1769.855371				

Section 4: Detailed Aerial Survey Procedures

Procedures used in carrying out a detailed aerial survey are similar in many respects to those related to overview aerial surveys. Refer to Section 3 for information on the following topics:

- Selecting data collection method
- Preparing a flight plan
- Reserving an aircraft (similar process as overview surveys although rotary wing aircraft are used for detailed surveys)
- Aerial observers
- Supplies
- Pre-flight Procedures
- Safety
- During Flight Activities
- Post-flight data management

Refer to Section 7 for mountain pine beetle heli-GPS survey procedures.

4.1 Determining the Survey Area

Detailed aerial survey areas are often determined by the location of disturbances detected during overview aerial surveys that require a more accurate assessment of extent and/or severity. Detailed survey areas may also be determined by disturbances detected on the ground, forest inventory/stand susceptibility, and/or past climate/weather.

4.2 Safety

Safety is a prime concern in any aerial survey. Refer to the most current version of the *Agriculture and Forestry Aircraft Management Standard Operating Procedures* for aircraft use and safety instructions during aerial operations. The Procedures can be accessed at: <https://forestry.sp.alberta.ca/forestry/forestprotection/SOP%20Manual/Forms/public.aspx>

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 some general guidelines to follow to ensure safety during low level rotor-wing operations:

- The company, pilot and aircraft must be 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, Agriculture and Forestry employees should operate radios on Agriculture and Forestry assigned frequencies, including telemetry receivers. The pilot can monitor these radios if the cockpit workload permits.
- Except where specifically permitted in Canadian Aviation 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.

- A hazard and risk assessment must be undertaken for low-level operations including the need for the flight and alternate means of accomplishing the task identified.
- 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 assigned frequencies; take notes and photos during the flight. The pilot may monitor radios if the cockpit workload permits.
- 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 area 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
- 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.
- The flight profile should remain at an altitude of at least 300 feet above ground level and remain in the safe operating areas of the Height Velocity chart specific to the rotor wing in use.
- If the mission requires the flight profile to go below 300 feet above ground level or into the unsafe portion of the Height Velocity curve, the exposure time must be minimized and:
 - Only essential crews are allowed on the aircraft.
 - If working over open water, the pilot must brief Agriculture and Forestry 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 Agriculture and Forestry employees or contractors (e.g., flight helmets and flotation devices, water egress training, etc.).
 - Winds must be less than 75 km/hr sustained or wind gusts less than 30 km/hr above the sustained wind speed.
 - A power check must be done prior to entering the Height Velocity curve. There shall be sufficient torque to maintain the aircraft in a hover position for five minutes without exceeding the manufacturer's temperature or torque limits and have full tail rotor authority.

Section 5: Data Collection Methodologies

Aerial survey data collection 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 Global Positioning System (GPS) unit (Section 5.2).
- Manual sketch mapping using small-scale (1:250,000) topographic maps (Section 5.3).
- Tracking the disturbance boundaries by using a Global Positioning System (GPS) unit (Section 5.4).

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.

5.1 Data Collection Standards

For all 3 methods of data collection, survey information is collected using a similar and hierarchical method (Table 1). For every point or polygon the following is recorded:

- 1) Symptom – defoliation, dieback, foliar damage, mechanical or mortality.
- 2) Agent – name of the known or suspected forest health damage agent. Use ‘unknown’ when agent is not known, or ‘multiple agents’ if symptom is a result of damage agent complexes.
- 3) Severity – depending on the symptom, the severity is recorded as either:
 - a. Per cent crown affected (mod 35-70%, severe <70%) or
 - b. host stems affected (very light 1-10%, mod 11-29%, severe 30-49, very severe <50%)
- 4) Tree species – record individual, multiple or unknown species affected by the damage agent.
- 5) Comments – include any information that provides context to the polygon (e.g. suspected agent(s) when recorded as “unknown” or “multiple”).
- 6) Flag for Follow-up – use this check box to identify accessible sites for ground truthing, or for disturbances that may require a follow-up detailed aerial survey

Table 1. Indicates five symptom categories, the damage agents that are associated with each symptom, the type of severity recorded for each symptom, and the tree species affected.

Symptom	Agent	Severity	Tree species
Defoliation	Aspen twoleaf tier Aspen serpentine leafminer Bruce spanworm Forest tent caterpillar Gray willow leaf beetle Jackpine budworm Larch sawfly Large aspen tortrix Linden Looper Spruce budworm Two-year cycle budworm Wester spruce budworm Willow leafminer Unknown	Per cent crown affected <ul style="list-style-type: none"> • Moderate 35- 70% • Severe 70 - 100% 	Aspen Birch Fir Larch Pine Poplar Spruce Willow Mixed Unknown Fir balsam Fir Douglas Fir subalpine Pine Jack Pine lodgepole Spruce black Spruce Englemann Spruce white
Dieback	Multiple agents Unknown Lodgepole pine dwarf mistletoe	Host stems affected <ul style="list-style-type: none"> • very light 1-10% • mod 11-29% • severe 30-49 • very severe <50% 	
Foliar Damage	Leaf scorch Frost Hail Pine needle cast Redbelt/winter desiccation Spruce needle rust Unknown	Per cent crown affected <ul style="list-style-type: none"> • Moderate 35- 70% • Severe 70 - 100% 	
Mechanical	Animal Chemical Lightning Snow damage Windthrow/blowdown Unknown	Host stems affected <ul style="list-style-type: none"> • very light 1-10% • mod 11-29% • severe 30-49 • very severe <50% 	
Mortality	Armillaria root disease Douglas fir beetle Eastern larch beetle Fire Flooding Mountain pine beetle Spruce beetle Tomentosus root rot Western balsam bark beetle Multiple agents Unknown	Host stems affected <ul style="list-style-type: none"> • very light 1-10% • mod 11-29% • severe 30-49 • very severe <50% 	

Data collection tips

Unknown agent

- To be used when damage agent cannot be determined with 100% confidence.
- Use comment field to include likely agent if applicable.
- Use “flag for follow-up” to assist with subsequent ground reconnaissance where appropriate (i.e. polygon with good ground access).

Dieback and Mortality

- Dieback is the partial mortality of a single tree’s crown. Despite this, dieback is measured in per cent of stems exhibiting dieback, not the average per cent of individual crown dieback of trees contained within the polygon. It is recognized that a dieback polygon will contain trees with variable amounts of individual crown dieback.
- It is often not possible to accurately attribute dieback to a single agent at the time of survey due to proximity and the likelihood of contributing factors. For this reason the agent list for dieback is limited to “unknown” or “multiple agents”.
- Mortality is the death of a single tree and is measured in per cent of stems affected within the polygon.
- Often, it is not possible to accurately attribute mortality to a single agent at the time of survey due to proximity and the likelihood of contributing factors. For this reason the agent list for dieback and mortality are limited to those that have characteristic signs/symptoms and/or patterns allowing positive identification from the air. Alternatively the surveyor may indicate damage agent as “unknown” or “multiple agents”
- If more than one species is affected when mapping dieback or mortality, select “mixed species” and estimate the per cent of all species stems affected.
- If selecting “multiple agents” it is mandatory that the agents are included in the comments field (this does not have to be done at the time of survey for each polygon and could be done more effectively in the database post-survey).
- Because normal levels of aspen dieback and mortality are in the range of the very light host stems affected (1-10%), this severity category is only applicable to conifer.
- It is possible that a dieback polygon would overlap or intersect with another type of damage polygon. For example, in a spruce stand with both SBW defoliation and dieback (top-kill), two polygons will need to be drawn; one encompassing the defoliated area with SBW noted as the defoliating agent, and the second polygon outlining only the extent of the dieback. In this example the dieback agent would be “multiple agents” and SBW would be noted in the comments as a contributing factor.
- Dieback and mortality should be mapped cumulatively to document the state of the forest each year. For example, if the area of mortality expands from 10 to 20 hectares between survey years, the new polygon will encompass all 20 hectares (not just the additional 10 ha). If the area affected has remained constant it still must be mapped (with severity adjusted appropriately if required). As areas green up they can be dropped from the polygon area.

Drought

- Drought should be included in comments field if suspected as a contributing factor when mapping dieback or defoliation.
- Drought-induced browning of leaves in the summer is to be called leaf scorch under the foliar damage symptom category.

Lodgepole pine dwarf mistletoe

- Dwarf mistletoe is a difficult pest to categorize and arguably could fall into a number of symptom categories. Although for consistency, dwarf mistletoe is categorized as dieback and is recorded as the number of host stems affected.

5.2 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 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 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 Folder Structure

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.

C:_Localdata\ForestH\AerialSurveyWorking

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.

C:_Localdata\ForestH\AerialSurveyWorking\CompleteSurveyShapefiles

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.

C:_Localdata\ForestH\AerialSurveyWorking\OriginalShapefiles


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.

C:_Localdata\ForestH\AerialSurveyWorking\WorkingShapefiles

Open the Aerial Survey Project

There is a shortcut on the desktop called “**SURVEY.APM**” plus other survey projects for specific surveys such as aspen overview surveys. This is an ArcPad working document for aerial surveys. Double click this shortcut to open the document.

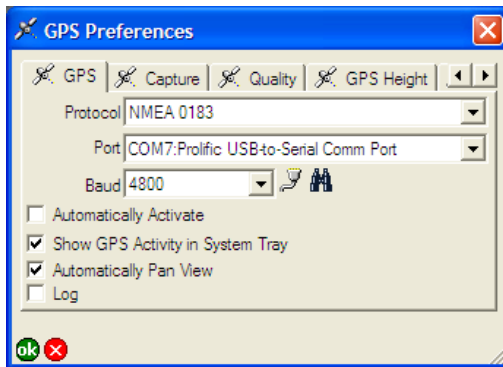
Open the “File Survey.apm” on the Desktop;

- 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.

GPS Setup

The system is equipped with a wired USB GPS and the option of a wireless Bluetooth GPS. The wired GPS is the easiest and most reliable to use.

To configure the USB GPS, plug it into a USB port and open arcpad. Once your arcpad project is open, pick GPS Preferences from the drop down menu. Once it opens, click the binoculars. Arcpad will automatically search for the GPS unit. It should look something like the results below. Actual COM port usage may be different though. From this point, all you have to do is turn on your GPS (Activate GPS Button) and then you are ready to start your survey. It is best to use a GPS unit such as a Garmin Map 62 to collect your tracklog. Arcpad doesn't always collect tracklogs properly.



Optional: Bluetooth GPS Setup

The optional bluetooth device can be connected to the computer; however, the connection can be lost and then has to be reconfigured.

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

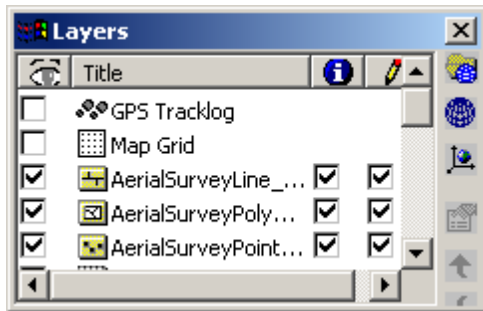
- To turn on wireless click the Q button at the top of the tablet PC.
- The Q menu will appear.
- If Wireless Off is showing that means that wireless has been turned on.
- If Wireless On is showing click that button to activate wireless.

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, and click **Initiate Pairing**
- 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**

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.

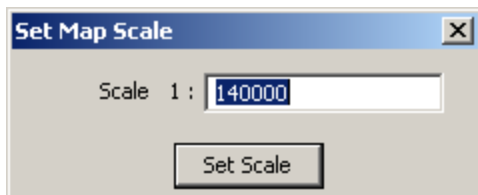
Set the Scale for the Survey

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

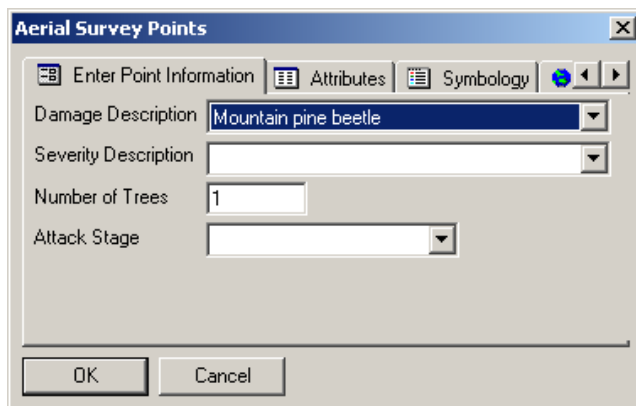


- The Zoom In and Zoom Out tools can also be used to change the scale quickly. Keep in mind that the Zoom In tool divides the scale number in half and zooms in to that number, and the Zoom Out tool multiplies the number by 2. This can make a significant difference to the scale that you are working with.


Sketching Disturbance

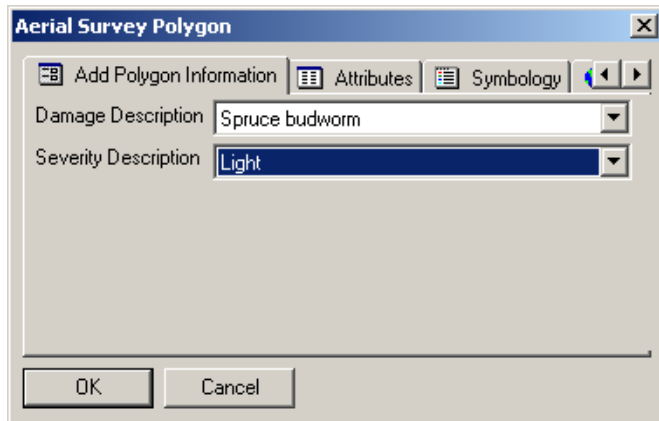
The main tools that are used to sketch disturbances are the capture point from GPS tool, the draw point tool, and the freehand polygon tool.

- **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.




The screenshot shows a dialog box titled "Aerial Survey Points". It has three tabs: "Enter Point Information", "Attributes", and "Symbology". The "Enter Point Information" tab is active. It contains four input fields: "Damage Description" (a dropdown menu with "Mountain pine beetle" selected), "Severity Description" (a dropdown menu), "Number of Trees" (a text input field with "1" entered), and "Attack Stage" (a dropdown menu). At the bottom of the dialog are "OK" and "Cancel" buttons.

- **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 kilometers west to east, and almost 30 kilometers 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 as 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 center 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 is selected.

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.

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.

Extracting 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.

5.3 Use of Topographic Maps

Introduction

- Use small scale topographic maps (1: 250 000) in color 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:
 - colors 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 color 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:

- **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/ refueling, 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. Altitude, visibility, and flight lines may be used to delineate an approximation of the areas surveyed
- **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 6.
- **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. 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

Summarize the data to produce a final map for digitizing. To do this if two aerial observers were involved in the survey, compare the working maps and 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.

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.

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.

5.4 Use of a GPS Unit to Survey

If a GPS unit is used during aerial surveys, ensure the unit is set up correctly:

- Location (decimal degrees – ddd.dddd);
- Datum (NAD83);
- Units (Meters)
- Time (Set correctly to 24 hour Mountain time)
- Date (Ensure correct date)

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.

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 in Edmonton who will create a map delineating the points/polygons of FHDA infested areas of interest.

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.

Section 6: Aerial Surveying of Disturbances Caused by Specific Damage Agents

This section provides guidelines for surveying disturbances caused by specific forest health damage agents (FHDA).

6.1 Survey Timing

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.

The ideal times for surveying specific FHDAs vary, as shown in Table 1 below. These survey windows are critical for detailed aerial surveys. However, overview surveys are best undertaken from late June to early August when the majority of FHDA-caused disturbances are visible.

Table 1. Aerial survey windows for disturbances caused by forest health damage agents.

Agent	Survey Window
Aspen twoleaf tier	June 15 – July 15
Animal	Year round
Armillaria root disease	Year round (ground truth Spring – Fall)
Aspen sperpentine leafminer	June 15 – July 15
Bruce spanworm	June 15 – July 15
Chemical	Summer
Douglas-fir beetle	June 15 – July 15
Drought	Summer
Eastern larch beetle	Fall
Fire	Spring - Fall
Flooding	Spring - Summer
Forest tent caterpillar	June 15 – July 15
Frost	Spring - Summer
Gray willow leaf beetle	June 15 – July 15
Hail	12 months after hailstorm
Jack pine budworm	July 1 – Aug 15
Larch sawfly	July 1 – Aug 15
Large aspen tortrix	June 15 – July 15
Lightning	Summer
Lodgepole pine dwarf mistletoe	Year round
Mountain pine beetle	Aug 15 – Sept 15

Pine needle cast	Spring - Summer
Red belt/Winter desiccation	Spring - Early Summer
Spruce beetle	Summer - Fall
Spruce budworm	July 1 – Aug. 15
Spruce needle rust	June 15 – July 15
Tomentosus root rot	Year round (ground truth Spring – Fall)
two-year-cycle budworm	July 1 – Aug 15
Western balsam bark beetle	Aug. 15 – Sept 15 (if it's in AB at all)
Windthrow/Blowdown	Year round

6.2 Bark Beetles

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

- Mountain pine beetle, *Dendroctonus ponderosae* (see Chapter 7)
- Douglas-fir beetle, *D. pseudotsugae*
- Western balsam bark beetle, *Dryocoetes confusus*
- Spruce beetle, *D. rufipennis*

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 6-1). Red needles may remain on the beetle-attacked tree for up to two years. Sometimes needles may drop without discoloration. 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 6-1. Trees killed by Douglas-fir bark beetle (Source: William M. Ciesla, Forest Health Management International, Bugwood.org).

Western balsam bark beetle, *Dryocoetes 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 color 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 6-2. 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 color in the first year. In the second summer following attack, most needles in infested trees turn yellowish-green to orange red (Figure 6-3). However, some infested trees may not change their needle color even in the second year. In some cases, different branches of the same tree change needle color at different times. To make matters even more complicated, needles of some infested trees drop to the ground without changing color, following heavy winds or thunderstorms (Figure 6-4). Needles of trees strip-attacked by the spruce beetle may not turn color at all. Thus, it is important to note grey trees during spruce beetle surveys.

Spruce beetles normally attack white spruce and Engelmann spruce. Blowdowns, leftover slash following harvesting operations and spruce budworm- weakened spruce are potential triggers of spruce beetle outbreaks. Aerial surveys usually detect spruce beetle attacks in their second year or later (Figure 6-5). 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 6-3. Aerial view of spruce killed by the spruce beetle (Source: William M. Ciesla, Plant Health Management International, Bugwood.org).



Figure 6-4. Spruce beetle-infested trees with premature needle drop (Source: Darren Blackford, USDA Forest Service, Bugwood.org).

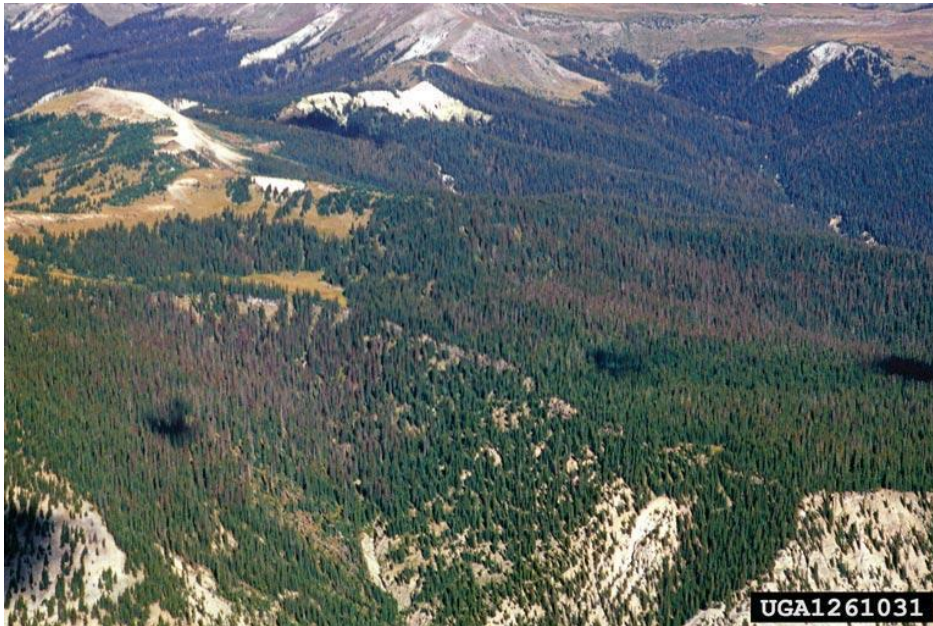


Figure 6-5. White spruce infested with spruce beetle (Source: Dan Miller, USDA Forest service, Bugwood.org).

6.3 Defoliators

The major coniferous defoliators of Alberta's forests are:

- Spruce budworm, *Choristoneura fumiferana*

- Western spruce budworm, *C. occidentalis*

The major aspen defoliators of Alberta's forests are:

- 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.

6.4 Conifer Defoliators

Besides eastern – and western spruce budworms, the two-year cycle budworm, *C. biennis*, could potentially defoliate sub-alpine fir and white spruce/Engelmann 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/Engelmann 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 over-mature 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 color to a reddish tinge (Figure 6-6). 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.

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 6-7);

- 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 6-8).

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



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



Figure 6-7. White spruce stand moderately defoliated by the spruce budworm.



Figure 6-8. White spruce stand severely defoliated by the spruce budworm.

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 6-9. Douglas-fir stand defoliated by the western spruce budworm.

Budworm Tree Kill

In budworm-infested stands, the understory 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.

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.



Figure 6-10. Spruce tree kill due to budworm damage.

6.5 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 understory vegetation, as well. When completely defoliated, forest tent caterpillar damaged-trees may

appear tan in color (Figure 6-11). 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 understory vegetation. The large aspen tortrix partially defoliates the canopy resulting in a ragged appearance of foliage and leaving clumped leaves on the crown (Figure 6-12). Bruce spanworm feeding leaves 'silk' on trees and ragged foliage with holes (Figure 6-13). Around June, aspen serpentine leafminer occasionally cause large-scale outbreaks. Foliage of heavily attacked aspen trees appear bleached (Figure 6-14). 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 6-11. Aspen trees may appear tan-colored due to severe defoliation by the forest tent caterpillar.



Figure 6-12. Close-up of large aspen tortrix defoliation showing clumped leaves.



Figure 6-13. Aspen stand severely defoliated by the Bruce spanworm. Note copious silky webbing on understory.



Figure 6-14. 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.

6.6 Diseases

Some diseases such as needle casts and needle rusts (figure 6-16) 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 centers can be mapped but are not easily identifiable from the air during overview aerial surveys. Root disease centers have trees fallen in a criss-cross fashion (Figure 6-17). However, a low pass (not below 1000 feet AGL) may be needed to identify disease centers.



Figure 6-16. Needle cast affected lodgepole pine stand (Jane Taylor, USDA Forest Service, Bugwood. Org.).



Figure 6-17. A root disease center.

6.7 Wildlife Damage

Trees killed by porcupines (Figure 6-18) 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.



Figure 6-18. Pine trees killed by porcupine damage.

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

Blowdown, 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.

Blowdown and Wind Damage

Blowdown 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.

Blowdown can be recognized by trees either with broken tops or uprooted with large roots with soil still attached. 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 centers, uprooted, blowdown trees lie parallel to each other facing the same direction. (Figure 6-19).

With wind damage, the trees remain standing but the tops are broken (Figure 6-20).

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



Figure 6-19. Blowdown along the edge of a stand.



Figure 6-20. 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 6-21).

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 6-22).



Figure 6-21. Large-scale tree kill due to flooding.



Figure 6-22. 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 6-23). 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 6-23. Aerial view of hail-damaged forest stands.



Figure 6-24. 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 colors depending on the chemical compound involved. During overview aerial surveys record the locations and extent of land affected.



Figure. 6-25. 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 6- 26). These patches usually contain a tree in the center 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.



Figure 6-26. Lightning-killed conifer trees.

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 6- 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 6-27. 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 6-28). 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 discolored and shed. The reddish color 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 6.28. Red belt on lodgepole pine along the eastern slopes of Rockies.

Section 7: Heli-GPS Aerial Survey Methodology

Heli-GPS aerial surveying for mountain pine beetle (MPB) infestations are different from detailed aerial surveys of other disturbances such as spruce budworm defoliation, hail damage or blowdown. Thus the MPB heli-GPS survey procedures are described 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

7.1 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.

7.2 Planning a MPB Heli-GPS Survey

When planning a heli-GPS 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 heli-GPS 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 heli-GPS 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 for MPB, follow the pre-approved survey plan regarding the areas to be surveyed in detail. In planning the flight, pay attention to the refueling needs and locations of fuel caches.

Funds

Request and commit funds as soon as heli-GPS survey plan is in place. Keep in mind that heli-GPS 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 the Province.

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 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 heli-GPS survey. This GPS unit is used as a back-up in case there are technical difficulties in using the tablet PC.

7.3 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 from the aircraft, proper seatbelt use, location of safety/survival gear, proper storage of field gear, and 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 Aircraft Management SOP 6.13 Low Level Operations

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 is to be fully engaged in “flying the aircraft” and not be distracted by other work being done.
- Wherever possible, Provincial staff should operate radios on 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 allowed on the aircraft.
 - If working over open water, the pilot must brief 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 Provincial 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.

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 7.4 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 discolored tree he/she should fly beside it to let the surveyor identify its cause of mortality. Some pilots help find discolored 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 7.3 Aerial view of a lodgepole pine stand showing mountain pine beetle-killed trees with symptomatic red crowns (Photo courtesy of Devin Letourneau)

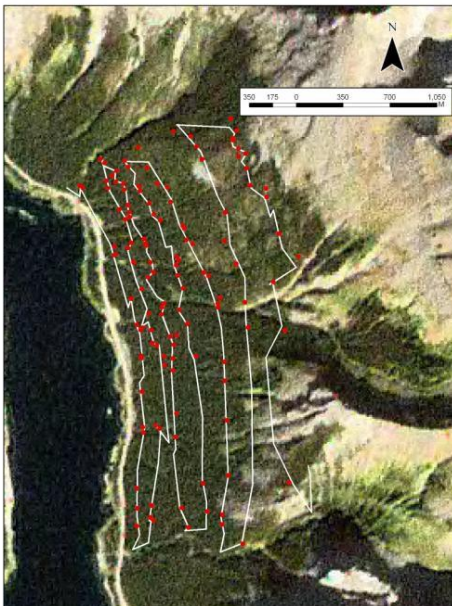


Figure 7.4 Flight lines flown in grid pattern

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 maneuver 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.

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.

7.4 Factors Affecting Aerial Survey Accuracy

Many factors contribute or detract from the quality of the data collected during a heli-GPS 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 discolored 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 color 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 color 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.

7.5 Conducting a MPB Heli-GPS Survey

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 discolored 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 required number of trees in a patch has died pursuant to Zone and Area due to MPB, mark the patch as a waypoint on your handheld GPS or tablet PC (see A below for further details). 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 (see A below for further details).

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. Each site (waypoint) should have a unique number. Label the sites consecutively, without missing any numbers.
14. Take breaks, land at least every couple of hours to maintain productivity.

Note: “Red” trees means any trees of any color that were attacked and killed by MPB in the summer prior to survey. This means reds, oranges or yellows. These trees will be recorded as red trees in tablet. The exceptions are trees attacked during same year of survey which have begun to change color (early faders). These will be recorded as green trees on tablet.

Spot Infestations - Discrete and Clustered

A **discrete spot infestation** is defined as a discrete location of 3 or more red trees which can be captured inside a 50m radius circular plot and is located more than 200 meters from another spot infestation. In essence, a spot infestation can easily be replicated by quality inspectors due to its discrete nature. See Figure 7.5.

- Heli-GPS location will be centered on red trees (Figure 7.6).
- Do not place the GPS coordinate in between patches where no red trees exist (Figure 7.7).
- There may be multiple trees or patches within the 50m radius circle. Centre the plot on largest patch when at all possible. GPS'd center points cannot be less than 50m apart.
- Spot infestation locations will be collected as point features. For spot MPB infestations record the number of red trees.



Figure 7.5 Discrete Spot Infestation

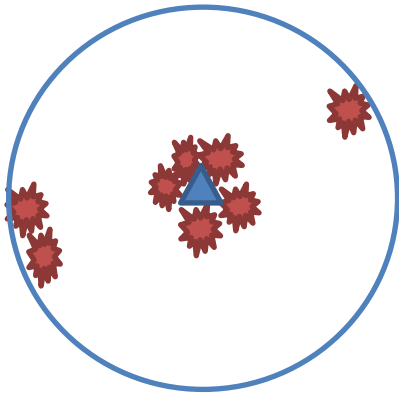
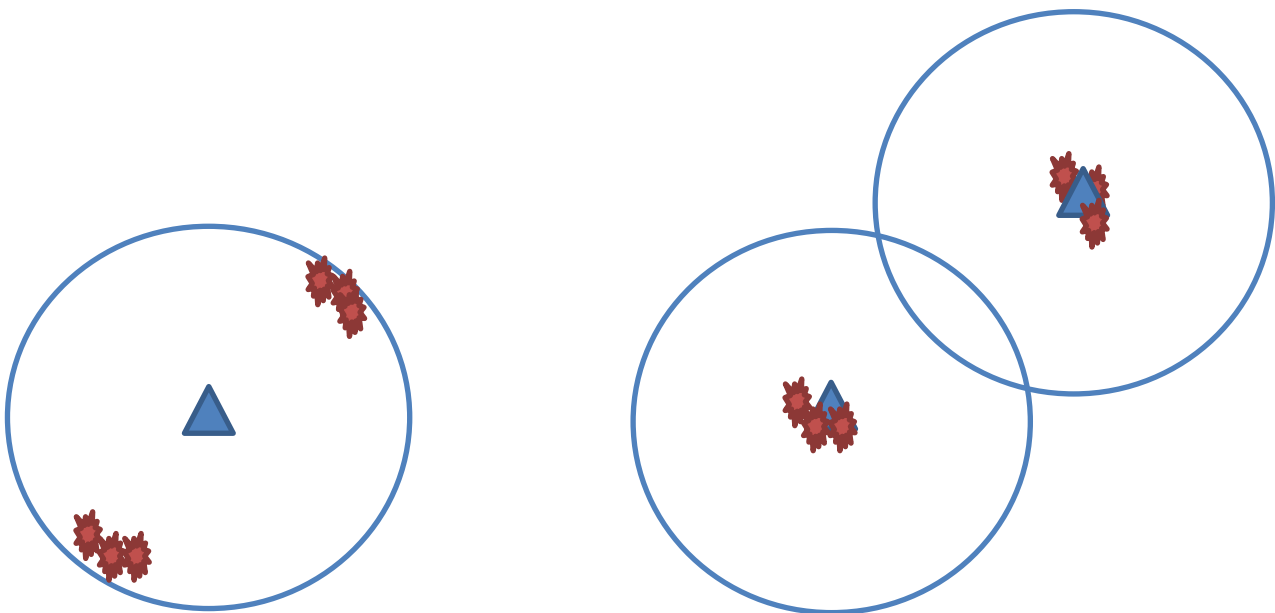


Figure 7.6 Correct Discrete Spot GPS Location



Incorrect GPS Placement

Correct GPS Placement

Figure 7.7 Corrected Discrete Spot GPS Location

A **clustered spot infestation** may be established where a very small (<3 Ha), heavily hit location can easily be covered by 4 or less 50m radius plots less than 200m apart (Figures 7.8 and 7.9). Locating centre of plot on largest patches may not be possible in these circumstances. This is a practical exception where a polygon would not be warranted. Green to red surveys taken as per blue book procedure.



Figure 7.8 Clustered Spot Infestation

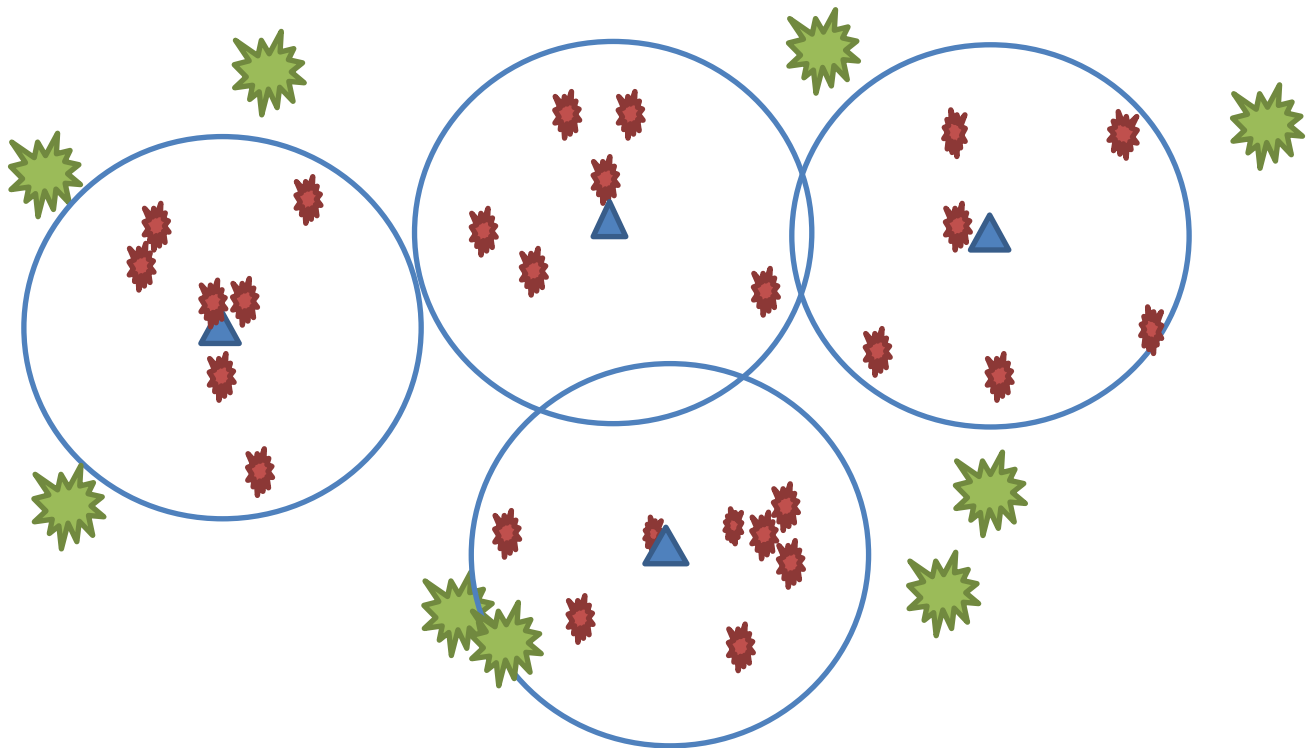


Figure 7.9 Correct GPS Placements for Clustered Spot Infestation

Polygons

A **polygon infestation** is defined as an area where red trees are no longer in discrete locations and the trees or patches are closer than 200m apart. Density of killed trees is too high for 50m radius plots to be taken efficiently and safely. Polygon is drawn tight around the red trees and it is recommended that the ground survey extend to the edge of the stand type.

Record the overall cumulative % of pine that is dead at time of survey (red, brown, grey) in stand in 10% classes. Create a new polygon if the infestation rate changes by more than 20% (i.e. 0 -10% infestation class to 20-30% class).

****Polygons are taken when quality inspectors would no longer be able to replicate the work if the area was to be surveyed as a spot location due to attacked trees being more continuous.**

One 50m radius concentric plot will be surveyed to blue book standards per polygon to assess # of new attack per hectare for an estimate of control trees. Plot will be located at geographic centre of polygon. Red tree #'s are not relevant to this assessment of green attack. Data is submitted at same time as when standard green to red survey data is submitted.



Figure 7.10 Polygon Infestation (in photo, 35% of pine is cumulatively dead)

7.6 MPB Heli-GPS Survey Performance Measures

For all heli-GPS and sketch-mapping surveys conducted the following performance measures apply:

Timing

- Surveys to start in early to mid-August.
- Surveys to be complete by September 15.
- All survey polygon, point data and track logs must be submitted to the Forest Health & Adaptation Information Management Technologist by September 20.

Detection Accuracy

- It is mandatory that the Contractor completes the Heli-GPS Survey that covers 100% of the area assigned by the Province.
- Only patches of 3 or more fader trees are to be detected unless the Provincial Designate directs surveyor to detect 1 or 2 fading tree patches.
- Based on the Province's quality inspection of 10% (minimum) of the spots/polygons detected by the Contractor, the number of missed and/or excess spots must not exceed 7% of the total checked.

Spatial Accuracy

- GPS locations of spots must be within +/- 30 meters.
- Based on the Province's quality inspection of 10% (minimum) of the spots detected by the Contractor, the number of inaccurate spot locations must not exceed 5% of the total checked.

Tree Count Accuracy

- The accuracy of fader tree counts in spot infestations is relative to the number of faders in the spot as follows:
 - 1 or 2 trees - +/- 0 trees
 - 3 - 5 trees - +/- 1 tree
 - 6 – 10 trees - +/- 2 trees
 - 11 – 15 - +/- 3 trees
 - 16 - 24 trees - +/- 5 trees
 - 25+ - +/- 10 trees
- Based on the Province's quality inspection of 10% (minimum) of the spots detected by the Contractor, the number of spots with inaccurate fader tree counts must not exceed 10% of the total checked.

Ground Truthing

- A minimum of 1% of spots/polygons up to a maximum of 5% must be ground truthed for mortality agent. The Provincial Designate will set the sampling percentage prior to beginning the survey

Polygon Mapping

- Polygon boundaries must encompass all fading/red trees
- Polygon infestation severity is the percent affected pine in the polygon, not the percent of the total polygon
- Polygon infestation severity estimated must be within +/- 10%

<i>SEVERITY CODE</i>	<i>SEVERITY RANGE</i>
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<i>0</i>	<i>1 to 10%</i>
<i>1</i>	<i>11 to 20</i>
<i>2</i>	<i>21 to 30</i>
<i>3</i>	<i>31 to 40</i>
<i>4</i>	<i>41 to 50</i>
<i>5</i>	<i>51 to 60</i>
<i>6</i>	<i>61 to 70</i>
<i>7</i>	<i>71 to 80</i>
<i>8</i>	<i>81 to 90</i>
<i>9</i>	<i>91 to 100</i>

Quality Inspection

The following outlines the quality inspection procedures for Heli-GPS contractors, and can be adapted for internal inspections as well

Quality inspection cannot be completed after the surveys are completed.

A minimum of 10% of the spots/polygons detected by the Contractor will be inspected for quality by the Province. If greater than 4,000 spots are taken in the contract area, a maximum of 400 spots will be inspected.

If in a given period detection accuracy, location accuracy, or tree count accuracy performance measures are not achieved, the Province will issue a written warning to the Contractor. The Contractor will be given the opportunity to fix problems and improve quality prior to a second quality inspection.

Following the second quality inspection (minimum of 10% of the total spots/polygons – or maximum 400 spots if greater than 4,000 spots taken in the area), if the detection accuracy, location accuracy, or tree count accuracy performance measures are not achieved, the Province will either:

- Select all or a portion of the contract area to be re-surveyed to quality standard by the Contractor, or
- Terminate the agreement.

If the Province directs the Contractor to undertake a re-survey, 10% of the spots/polygons within the re-survey area (maximum 400 spots if greater than 4,000 spots in the re-survey area) will be quality inspected by the Province. If the detection accuracy, location accuracy, or tree count accuracy performance measures are not achieved, the Province may terminate the agreement.

All Quality Inspection data will be submitted to the Forest Health & Adaptation Information

Management Technologist with the Aerial Survey data.

Collecting Quality Inspection Data

- Data can be collected using a tablet by utilizing the Aerial Survey Quality Inspection application
- Load survey data from area to be QI'd 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'd.
- 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.