Climate Change Impacts on the Productivity and Health of Aspen (CIPHA)

Methods Manual

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Part I Introduction

Intent

Moisture is a critical factor controlling the boundary between forest and prairie in western Canada (Hogg 1994,1997). Given the possibility of climate change, the southern boreal forest may develop a drier climate similar to that presently found in the aspen parkland. Since the 1980s dieback and reduced growth of trembling aspen forests has been noted over some areas of the prairie provinces, especially along the southern edge of the boreal forest and in the climatically drier aspen parkland (Hogg and Hurdle 1995). Furthermore, climate change may lead to an increased incidence and severity of forest insects and diseases. Thus drought stress could have a major impact on the productivity and health of trembling aspen. It is the intent of this study to examine the interactions between climate, insects and diseases, and trembling aspen.

Objectives:

1) To detect climate change impacts through monitoring of biomass, growth, and health of trembling aspen forests in the western boreal forest and aspen parkland.
2) To conduct detailed tree-ring analysis to understand how climatic variation, insects, and other factors have affected growth and health of trembling aspen forests at the regional scale over the past 50 years.
3) To apply a carbon-based model to predict future changes in biomass, productivity, and health of trembling aspen forests in west-central Canada under the most likely scenarios of global change.
4) To provide a framework aimed at linking, promoting and expanding collaborative research and regional monitoring of biomass, productivity, ecosystem functioning, and carbon sequestration of trembling aspen forests in west-central Canada.

Study design

The study consists of a balanced system of long-term forest health research plots in trembling aspen stands extending from the cold, moist boreal forest to the warmer, more drought-prone aspen parkland. The design is as follows:

2 zones - boreal forest & aspen parkland
12 nodes/zone - a node being a geographical area
3 stands/node - 3 trembling aspen stands within a 25 km radius
2 plots/stand - variable area plots with a minimum of 25 living trembling aspen

During the course of this study, basic mensuration, health, and dendrochronological assessments will be performed. Prior to plot establishment, potential sites will be scouted and potential stakeholders will be contacted to obtain their cooperation and support. The establishment year of the study includes three phases; plot establishment (May-June), basic mensuration and health assessment (June-July), and stem disk collection (August-September). Health assessments are conducted annually, while basic tree mensuration and stem disk collection are repeated every five years. The mensurational data, health

assessments, tree ring analysis and historic climate data are then used to determine climate-productivity relationships.

Data integrity and quality

Methods utilized in this study are intended to be practical, meaningful, and repeatable. Field personnel are responsible for the accurate collection, maintenance, and submission of error-free data. Both paper and electronic data forms are provided. Paper forms are intended for information such as sketch maps and as an alternative if data loggers fail.

Where possible, variable codes have been simplified and standardized. All character fields are entered in uppercase when using data loggers. Each variable has a specific format that must be followed (see variable descriptions below). In addition to the standard format, listed in the variable descriptions, the following codes are acceptable:

Single digit variables:

" - " = variable is not applicable

" . " = missing or unable to assess variable

Two or more digit variables:

" - - " = variable is not applicable

" . " = missing or unable to assess variable. The period is entered into the right position only. Using two periods per variable (". .") is not allowed.

Quality assurance and quality control sessions (QA/QC), involving all field personnel, are held annually. As well, a subset of plots, chosen at random, is cross-checked each year. Cross-check and QA/QC results are summarized annually. At the end of each collection season, data are checked for incorrectly coded entries and outliers. If these potential errors are not readily correctable they are flagged for reexamination in the following year.

Permission and entry approval

A number of provincial and federal agencies require that research permits and right of entry documents be carried whenever entering lands under their jurisdiction. As well, a number of these agencies require notification prior to entry. The appropriate permits, documents and contact numbers are supplied in site binders prepared for each node. Technicians are responsible for ensuring that they comply with all obligations and restrictions as specified in the permits.

Safety

Personnel involved with this project are required to be familiar with and comply with safety regulations and protocols describe by Occupational Health and Safety Canada and listed in the Northern Forestry Centre Safety Manual. Personnel must possess a valid standard-level first aid certificate. Personnel using power equipment, such as chain saws, must possess appropriate certification. Supervisors and coworkers are to be made aware of unsafe working conditions.

Part II Procedures

Stand Selection

1. Introduction

Surveys for potential sites are completed the year prior to plot establishment. This allows time to meet with the appropriate stakeholders to discuss suitable study areas, potential conflicts, and to obtain research and right-of-entry permits. Land protection reservations are placed on these stands following establishment of plots. Preliminary consent from the stakeholder, however, should be obtained before beginning the process of plot establishment.

2. Preliminary selection

Preliminary selection of stands is intended to be a quick survey of available trembling aspen stands in a desired geographical area or node. The survey provides information, such as stand density, age, size and access, which is used to assess the suitability of the stand. During plot establishment a number of unforeseen circumstances such as stand shape, unfavorable composition, undesirable gaps, firewood cutting, and bear baiting may become more apparent thus forcing the selection of a new stand. Therefore, at least five potential stands are identified, although only three stands will be used. Inventory maps and aerial photographs help locate potential stands. The criteria listed below for selecting a potential stand are general guidelines that represent the ideal. Satisfying all criteria may not be possible.

1) stand composition - at least 80% of trees are trembling aspen.
2) age - between 40-80 years.
3) density - crown closure >30% .
4) size - continuous forest with a minimum size of 250 m × 150 m (~4 ha) required for typical plot layout and 50 m buffer (Fig. 1).
5) slope -no greater than 10%.
6) elevation -all potential stands in a node should be at about the same elevation.
7) disturbance -no significant disturbance (e.g., grazing, recent fire).
8) health -no stands showing signs of severe dieback unless they are representative of the area.
9) access –no stands that require all-terrain vehicles or stands that will be difficult to access during wet weather. Stands must be within a 20-minute walking distance of the access road.
10) point source pollution -greater than1 km away from gas wells, flaring, pumping stations, other oil/gas installations, and garbage dumps.
11) water bodies -greater than1 km away from lakes and rivers.
12) agricultural lands, cut blocks, roads and stand edges -greater than 50 m from farmland, roads, cut blocks, and stand edges.
13) distance to other stands - all stands of a node should be within 25 km of each other.

Based on these criteria each potential stand is ranked according to suitability and marked on inventory maps and aerial photographs. Equipment required for completing the

preliminary stand selection form is listed in Appendix 6. The Preliminary Stand Selection form is available in paper form only.

3. Variable descriptions

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation (see Naming convention, page 6).
Zone, Easting, Northing	Record the UTM of the potential stand.
Location	Describe the location of the stand and tie point by referring to distances traveled along named roads.
NTS Map	Record the NTS map number that pertains to the stand.
Inventory Map	Record the inventory map and stand number.
Aerial Photos	Record the aerial photograph numbers that pertain to the stand.
Stand Dimensions	Record the approximate length of the long and short axes.
Stand Size	Record the approximate size in hectares.
Stand Composition	Record the approximate species composition.
Core Numbers 1-3	Record an identification number for increment cores taken from three co-dominant trees.
Stand Basal Area 1-3	Record the basal area estimate, by species, of three points within the stand.
Disturbance	Record any evidence of nearby disturbances, past or present, such as fire, flooding, cattle grazing, logging, seismic exploration, or oil and gas activity.
Remarks	Record other pertinent information such as current health, access, relevant stakeholders, contact numbers.

4. Preliminary stand selection form

Natural Resources Canada - Canadian Forest Service
Forest Health Network / Climate Change Network

PRELIMINARY
STAND SELECTION

CIPHA

DATE: ____ ____ ____ (YYYY MM DD)

Page: of

NODE: ____

ZONE: ____ EASTING: ____ NORTHING: ____

LOCATION: _____

NTS MAP: ____ INVENTORY MAP: ____

AERIAL PHOTOS: ____

STAND DIMENSIONS: ____ / ____ STAND SIZE: ____

STAND COMPOSITION: ____

CORE NUMBERS: 1 ____ 2 ____ 3 ____

STAND BASAL AREA:

Point 1		Point 2		Point 3	
Species	Basal Area	Species	Basal Area	Species	Basal Area

DISTURBANCE: _____

REMARKS: _____

Plot Establishment

1. Introduction

Final stand selection is made during plot establishment (usually the year following preliminary stand selection). The best three stands are chosen from the five previously identified potential stands. If, for any reason, less than three of the five potential stands are determined to be suitable, alternative stands are chosen using the listed selection criteria. Inventory maps and aerial photographs are used to aid the selection of new stands.

2. Naming convention

A three-letter code is used to designate the node based on the first three letters of the locality or the name of a nearby dominant geographic feature. Stands are numbered 1, 2, and 3. Plots are numbered 1 and 2. Within a stand, the plots are number so that when facing the center point with your back to the tie point, the left plot is Plot 1 and the right plot is Plot 2 (Fig. 1).

3. Locating stand center and plots

Aerial photographs are used to determine a suitable tie point, bearing and distance to approximate stand center, and approximate bearing of the stand's long axis. Using the appropriate magnetic declination and the predetermined bearing and distance, the stand center is marked with a 1 m length of metal electrical conduit. A nearby tree is then flagged and painted. The two plots are laid along the long axis of the stand, one on either side of the center point. If the stand length permits, each plot is located 50 m away from the stand center point with a minimum buffer of 50 m between plot boundaries and the stand edge. If the stand is too small, the distance from the stand center point to each plot is reduced to 25 m (minimum buffer of 50 m is not reduced). Plots are never to be less than 50 m apart.

Certain areas or pockets within a stand are not suitable for plot establishment:

1. Cut lines, clearings, agricultural fields and cut blocks within 50 m of the plot that are significant enough to affect the health or growth of trees in the plot.
2. Deciduous-to-conifer transitions within 50 m of the plot boundaries.
3. Large swamps, wet areas or gaps > 30 m in diameter within 50 m of the plot
4. Area high in species other than trembling aspen (>20% of other species by number, consider living trees >7 cm DBH only).

The above conditions are common to stands in the aspen parkland, which is often characterized by small stands surrounded by grasslands. In these areas the above conditions may be ignored if necessary. The following conditions are always ignored:

1. Game trails, or old overgrown seismic lines.
2. Changes in stand density and small wet areas or gaps (< 30 m diameter).
3. Changes in tree health or number of dead trees.

If plot areas are unsuitable, as defined above, the distance from the center point is extended by multiples of 25 m until suitable locations are found. If one plot area is not suitable even after extending the distance from the center point or if extending the distance is not possible (i.e., stand too small), a new plot bearing is selected at random (Fig. 1).

4. Determining and marking plot corners

Once a suitable plot area has been found, the appropriate distance to Plot 1 is measured along the long axis of the plot. This point is corner 1 of Plot 1 and is marked with a 1 m length of metal electrical conduit. The other fixed corner is measured and marked at 10 m perpendicular to the long axis (Fig. 2). The plot is always placed on the far side of the long axis, that is, away from the tie point (Fig. 1, 2 and 3). The width (X dimension) of the plot is always 10 m. The length (Y dimension) of the plot varies depending on stand density. Two 50 m tapes are stretched from the fixed corners, keeping10 m apart, to a length (rounded to the nearest metre) that yields a minimum of 25 living trembling aspen trees greater than 7cm diameter at breast height. The final two corners are placed at this distance. The plot is then checked to ensure that it is square and that a 50 m buffer exists between any plot border and the stand edge. All plot corner posts are painted fluorescent orange. This procedure is repeated for the second plot.

5. Tree numbering

Pre-numbered tree tags come in lots of 1 to 1000. Typically a stand with its two plots has no more than 150 trees in total (living and dead trembling aspen and other species). Therefore, the trees in a stand are tagged using lots of 150 tags. A total of 450 tree tags are needed to tag all trees in the three stands of a node. The following procedures are used when numbering trees:

1) All trees of any species, living or dead, greater than 7 cm at DBH and standing under their own support are numbered. Therefore, stumps less than 1.3 m tall and dead trees on the ground or suspended by others are not numbered.
2) Trees are considered in the plot if their point of germination is within the plot boundary.
3) A forked tree is considered to be two trees if the fork is below breast height (1.3 m).
4) Trees in the stands are numbered consecutively (e.g. Ministik Stand 1 tagged 1 to 150, Stand 2 tagged 151 to 300, Stand 3 tagged 301 to 450, Dundurn Stand 1 tagged 451 to 600, Stand 2 tagged 601 to 750, Stand 3 tagged 751 to 900).
5) Trees in the left plot (Plot 1) are numbered using tags 1 to 75. The process is repeated for the right plot (Plot 2) using tags 76 to 150 (Fig. 2).
6) In the instance where the long axis of the plot is just a continuation of the line from the tie point to stand center, the plot closest to the tie point is Plot 1.
7) When numbering trees, the plot is bisected into two 5-m-wide strips parallel to the long axis. Trees are numbered along the direction of travel down one strip and back along the other starting with the tree closest to the first corner (Fig. 2).
8) Tags are attached to trees using thin-gauge plastic coated wire, loose enough to accommodate tree growth for at least 5 years.

9) A horizontal line, 1.3 m above the ground, is painted on each tree facing the normal direction of travel through the plot. This ensures that repeated diameter measurements are always taken from the same point. If stem abnormalities exist at 1.3 m, the line is painted a standard 30 cm above or below 1.3 m (Appendix 1).
10) Tree numbers are painted as high as possible facing the normal direction of travel through the plot.

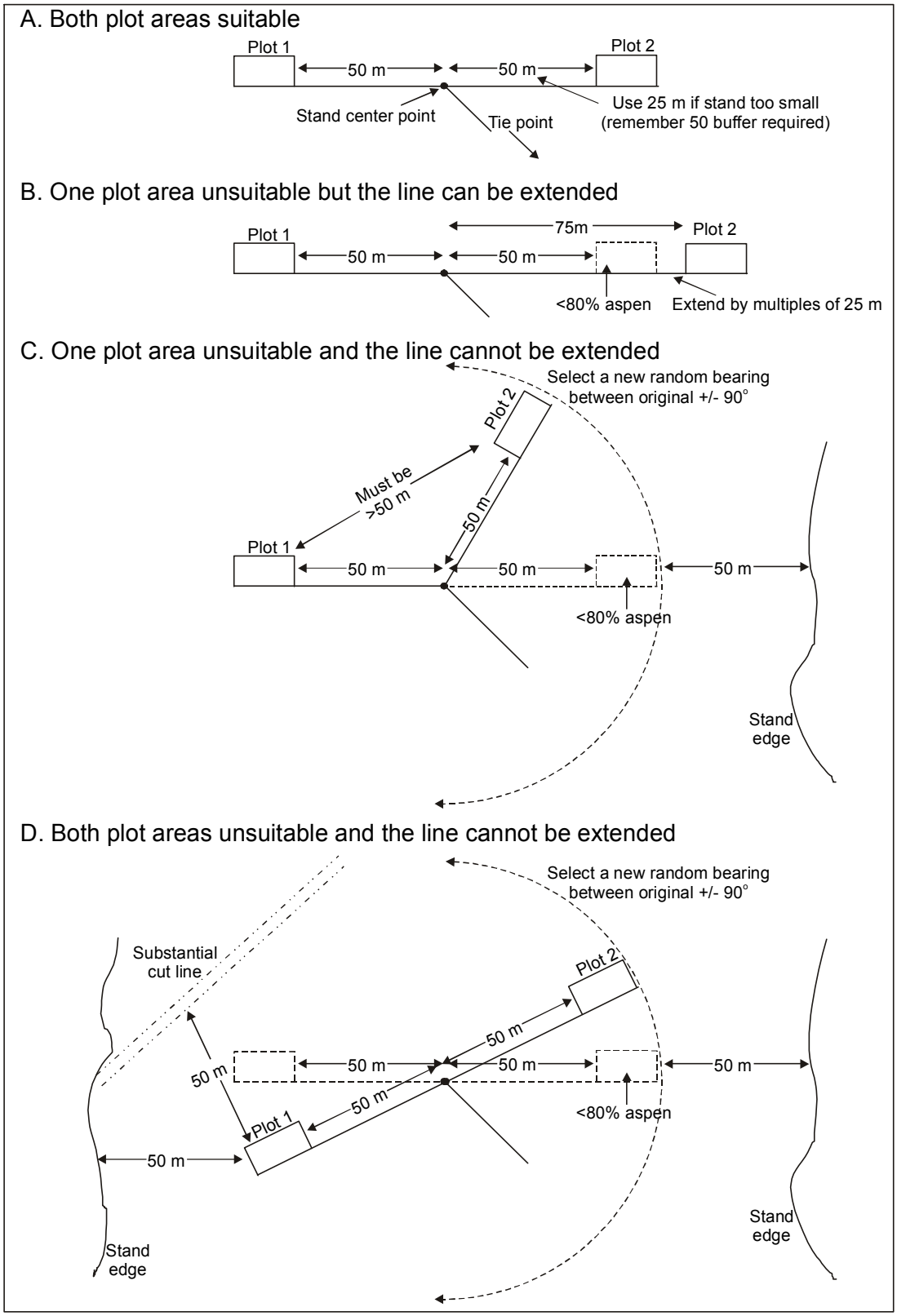

Figure 1. Determining plot locations within stands

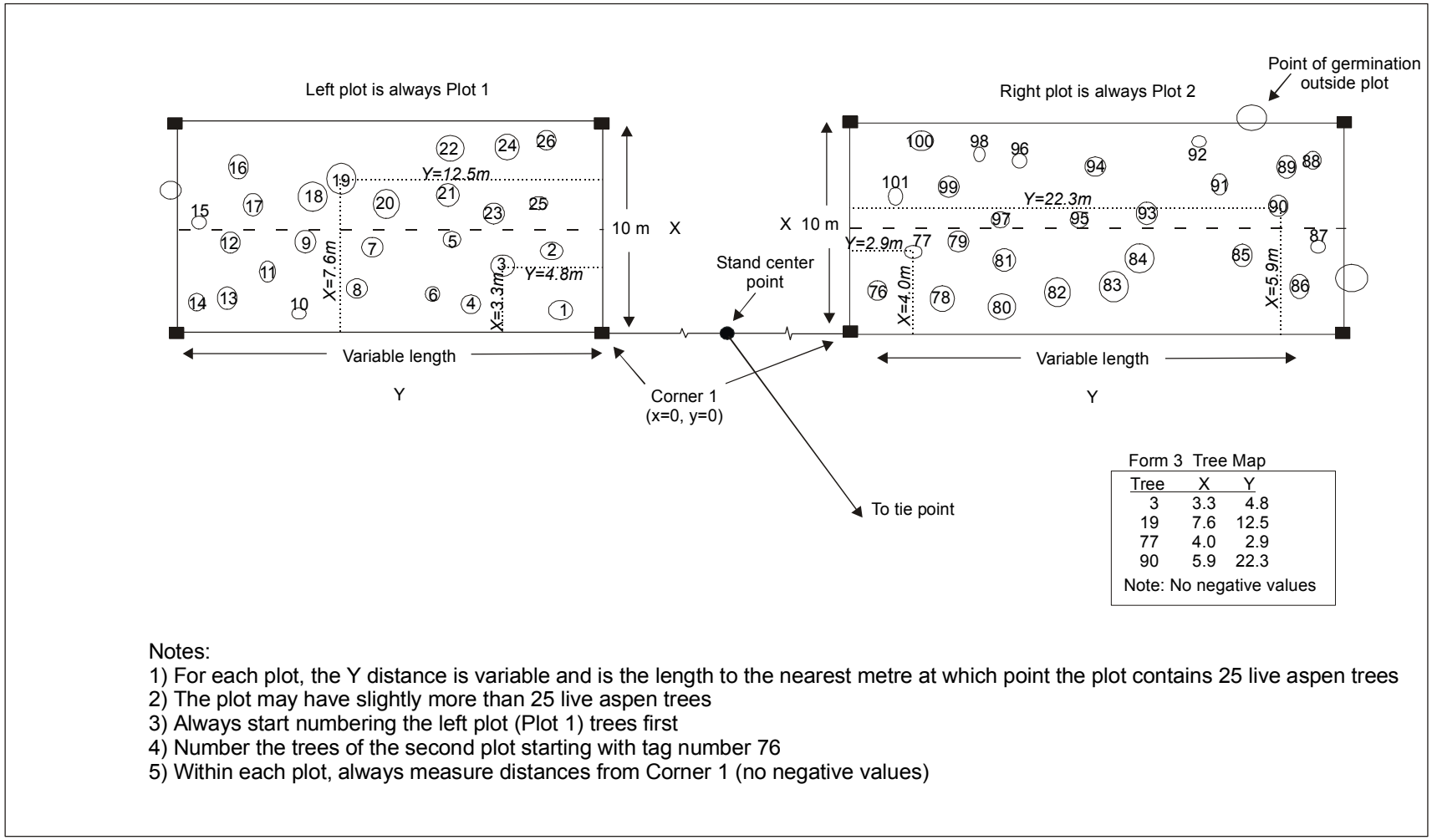

Figure 2. Numbering and mapping trees within plots.

Form 1: Basic Plot Information

1. Introduction

Form 1 provides basic plot information. All distances, bearings, plot dimensions, and Universal Transverse Mercator (UTM) grid coordinates are recorded in Form 1. UTM coordinates are obtained for the first corner of each plot, stand center point, and tie point using a hand-held Global Position System (GPS) unit. In addition, a detailed sketch map is made depicting stand boundaries, tie point, center point, plot locations and dimensions, locations of unsuitable gaps or pockets, road names and distances to major intersections. Form 1 is completed during plot establishment and exists as a paper form only. Equipment required for completing Form 1 is listed in Appendix 6.

2. Variable descriptions

Form 1 Front

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Declination	Record the declination in degrees for the year of establishment (see site binder or hand-held GPS).
Slope	Record the slope in 5 % increments. Ignore slopes less than 5 %.
Aspect	Record the downward direction of a slope greater than 5 % (e.g. N, NE).
Disturbance	Record any evidence of disturbance, past or present, such as cattle grazing, logging, seismic, industrial activity (e.g., oil and gas), fire, flooding.
Location	Describe the location of the stand and tie point by referring to distances traveled along named roads.
NTS Map	Record the NTS map that pertains to the stand.
Inventory Map	Record the inventory map and stand number.
Aerial Photos	Record the aerial photograph numbers that pertain to the stand.
Tie Point	Record the UTM zone, easting, northing to the metre. Record the elevation ± error if 3D navigation is obtained with the GPS.
Stand Center	Record the UTM zone, easting, northing to the metre. Record the elevation ± error if 3D navigation is obtained with the GPS. Record the bearing and distance to Stand Center from the Tie Point
Plot 1	Record the UTM zone, easting, northing to the metre. Record the elevation ± error if 3D navigation is obtained with the GPS. Record the bearing and distance (to the nearest metre) to Plot 1 from the Stand Center. Record the Y dimension of the plot to the nearest metre. X dimension will always be 10 m.
Plot 2	Record the UTM zone, easting, northing to the metre. Record the elevation ± error if 3D navigation is obtained with the GPS. Record the bearing and distance (to the nearest metre) to Plot 2 from the Stand Center. Record the Y dimension of the plot to the nearest metre. X dimension will always be 10 m.
Remarks	Record any other relevant information not previously captured.

Form 1 Back

Sketch Map

Draw a sketch map of stand boundary, tie point, center point, plot locations and dimensions, relevant gaps, trails or seismic lines, and all bearings and distances including distances to stand edge. Clearly indicate north on the sketch map with an arrow. See Figure 3 for an example of a thorough sketch map.

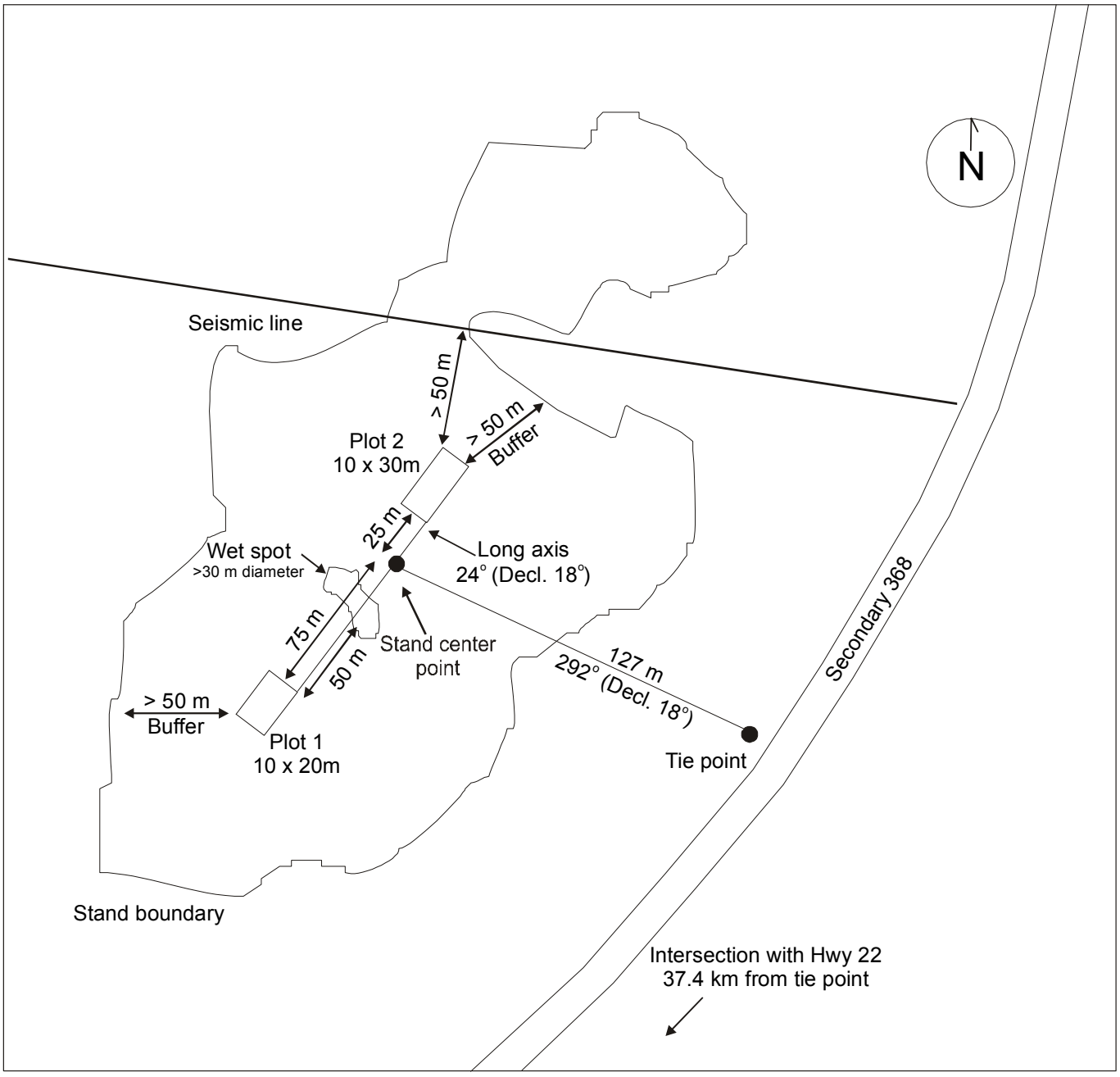

Figure 3. Example of a thorough stand and plot sketch map.

3. Form 1 Front

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BASIC PLOT INFORMATION

CIPHA 1 Front

DATE: ____ (YYYY) ____ (MM) ____ (DD) NODE: ____ STAND: ____ Page: of

DECLINATION: ____ SLOPE: ____ % ASPECT: ____

DISTURBANCE: _____

LOCATION: _____

NTS MAP: ____ INVENTORY MAP: ____ AERIAL PHOTOS: ____

GPS DETERMINED LOCATIONS:

	Zone:	Easting:	Northing:	Elevation:	Bearing to:	Distance to:	Y Length (m):
TIE POINT				+/-			
STAND CENTER				+/-			
PLOT 1				+/-			
PLOT 2				+/-			

REMARKS: _____

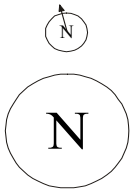
Map

4. Form 1 Back

PLOT LAYOUT AND SKETCH MAP CIPHA 1 Back

Draw a sketch map of stand boundary, tie point, center point, plot locations and dimensions, relevant gaps, trails or seismic lines, all bearings and distances including distance to stand edge. Include roads and the name of the roads along with distances to major intersections, bridges, etc. (See Figure 3 of manual).

Indicate North with an arrow



Form 2: Tree Map

1. Introduction

The location of each tree in the plot is entered in Form 2. Tree locations are always measured as the distance from corner 1 of each plot. The X distance is always measured perpendicular to the long axis of the plot. The Y distance is always measured along the long axis of the plot. Negative numbers are never recorded even if the plots are on opposite sides of the long axis. Form 2 is completed once during plot establishment and then updated every five years thereafter. Form 2 is available in electronic and paper format. After plot establishment, data logger pre-loads are available for subsequent assessments. Equipment required for completing Form 2 is listed in Appendix 6.

2. Ingrowth

During the five-year reassessment, trees that have grown to a diameter at breast height greater than 7cm are considered as ingrown trees. All ingrown trees are measured, numbered, tagged, and mapped.

3. Variable descriptions

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Plot	Record the plot number: 1 or 2.
Tree	Record the tree number.
Species	Record the three-digit tree species code (Appendix 2).
X distance	Record the distance perpendicular to the long axis, from the Y axis (long axis) to the **center** of the tree (to the nearest tenth of a metre). It cannot be greater than 10.0 m (Fig. 2).
Y distance	Record the distance parallel to the long axis, from the X axis to the **center** of the tree (to the nearest tenth of a metre).
Remarks	Record any remarks relevant to the tree.

4. Form 2

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TREE MAP

CIPHA 2

DATE: [ ] [ ] [ ]
YYYY MM DD

Page: of

NODE: [ ] STAND: [ ]

PLOT	TREE	SPECIES	X DISTANCE	Y DISTANCE	REMARKS

Form 3: Plot Tree Data

1. Introduction

Basic mensuration data are recorded in Form 3. It is completed after the majority of annual seasonal growth has occurred. Diameters, heights, dominance and stem form of all tagged trees and stumps are assessed once every 5 years. At each assessment, ingrown trees (those that have surpassed the 7 cm minimum diameter requirement) are tagged, mapped, and measured. Form 3 is available in electronic and paper format. After plot establishment, data logger pre-loads are available for subsequent assessments. Equipment required for completing Form 3 is listed in Appendix 6.

2. Measuring diameters

Diameters are measured at the breast height marker lines painted on the tree during the completion of tree mapping. Marker lines are usually at the standard 1.3 m height but are occasionally moved in accordance to the guidelines given in Appendix 1. The variable *Diameter Height* is used to record the actual height of diameter measurement if the marker line is not at the standard height. Breast heights for leaning trees are measured parallel to the lean. Diameters are recorded to the nearest centimeter.

3. Measuring heights

Total height and height of live crown are measured on each tagged tree. If a tree has fallen to the ground between plot establishment and the first Form 3 assessment, the height is recorded as "0". Tree heights are measured using a two-piece ultrasonic hypsometer consisting of a range finder and a target transponder. The following guidelines are applied when using ultrasonic hypsometers:

1) The instrument must be calibrated daily before use.
2) The instrument must reach ambient temperature before use. The unit cannot be stored in a warm jacket or pant pocket between height measurements.
3) The top of the tree must be clearly visible from the measurement position. If not, move to another position. Often, it is helpful to have someone shake the tree.
4) The measurement position must be perpendicular to the lean of the tree. Depending on the direction and severity of the lean, the height measurement can be erroneously high or low.
5) The measurement position must be a horizontal distance away from the tree equal to or greater than the height of the tree.
6) Normally the transponder is placed at 1.3 m above ground. Thick understory vegetation, however, may obscure it from view. In such cases, the transponder is attached to a tall stick, at a known height, and leaned against the tree above the understory vegetation. The range finder's offset DBH height must be changed before measuring the tree height.
7) A manual clinometer is used in situation when the ultrasonic hypsometer malfunctions.

4. Cross-check of heights

After heights of Plot 1 trees have been measured, a second technician reassesses the first ten trees. If more than two heights differ by over a metre the erroneously measured trees are assessed again and another 10 trees are cross-checked.

5. Variable descriptions

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Plot	Record the plot number: 1 or 2.
Tree	Record the tree number.
Species	Record the three-digit tree species code (Appendix 2).
Dominance	Record dominance as follows: 1 Dominant – crown extends above top of general canopy level and receives full sunlight from above and partial sunlight from sides. 2 Codominant – crown extends to top of general canopy level and receives full sunlight from above but little sunlight from sides. May be somewhat crowded at sides by other trees. 3 Intermediate – crown extends into general canopy level but shorter than codominant trees. Receives little sunlight from above or sides. 4 Suppressed – crown is entirely below general canopy level. 9 Dead.
Stem Form	Record stem form as follows: 0 Normal. 1 Main stem broken. 2 Top of tree broken off. 3 Forked below living crown. 4 Major crook. 5 Lean > 15 degrees. 6 Supported by other trees. 7 On ground. 8 Other.
Diameter	Record tree diameter to nearest centimetre.
Diameter Height	Record height at which diameter was measured. Default is 1.3 m.
Height	Record highest point of tree to nearest tenth of a metre.
Height of Live Crown	Record the highest level of live foliage to nearest tenth of a metre. Note: if the tree is dead Height of Live Crown = 0
Remarks	Record comments if necessary.

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PLOT TREE DATA

CIPHA 3

DATE: ____ ____ ____ (YYYY MM DD) NODE: ____ STAND: ____ Page: of

PLOT	TREE	SPECIES	DOMINANCE	STEM FORM	DIAMETER (cm)	DIAMETER HEIGHT (m)	HEIGHT (m)	HEIGHT OF LIVE CROWN (m)	REMARKS

Form 4: Health Assessment

1. Introduction

All living trembling aspen trees are assessed for level of dieback, type and amount of damage caused by biotic and abiotic agents, as well as, current foliage compliment. Trees dead less than one year are included in health assessments to determine the likely cause of death. Health assessments are conducted annually in June and July when the maximum level of damage due to the season's insect and disease activity is evident. The causal agent may no longer be present, therefore, all signs and symptoms are carefully considered before ascribing an agent. Form 4 is available in electronic and paper format. After plot establishment, data logger pre-loads are available for subsequent assessments. Equipment required for completing Form 4 is listed in Appendix 6.

2. Assessing health

A general survey of health conditions in the stand is conducted on off-plot trees prior to conducting the Form 4 survey. This survey allows for destructive sampling. Trees are examined for bark damage, roots and the lower bole are examined for root disease, and branches are cut to identify and collect insect and disease specimens. The purpose of this survey is to help attribute causal agents to similar signs and symptoms of on-plot trees. Destructive sampling is not allowed within the plot boundaries unless the tree is dead.

On-plot trees must be viewed from a number of vantage points using binoculars. Both type of damage agent and level of damage are recorded (Form 4 allows up to six damage agents and their levels of damage to be recorded). When more than one agent affects a tree it is important to determine which is the primary agent affecting health or causing death. These agents are recorded before those that are determined to be secondary in nature. For example, Cytospora canker may be a secondary pathogen in a tree already injured or killed by polar borer. In this case poplar borer is recorded before the canker.

3. Quantifying damage

The majority of damage agents are quantified in terms of percent foliage, crown or stem affected. These include defoliating insects, foliar diseases, cankers, abiotic conditions, and mechanical damage (Appendix 4). If a stem wound is closed the appropriate agent type and name is recorded and the agent level is coded as not applicable ("--"). If a tree has multiple cankers or wounds, the greatest amount of stem girdling, at a given cross section, is recorded. Other agents, such as *Phellinus tremulae* and wood borers are quantified by recording the number of conks or bore holes. A number of pests, however, are difficult to quantify. The level of Armillaria root disease, for example, is related to the time and effort spent looking for it, while agents such as Diplodia gall defy quantification. These types of agents are assessed on a presence/absences basis. Presence is recorded by entering the appropriate agent type and name. The agent level is coded as not applicable ("--").

4. Determining vigor

Vigor is not directly assessed. Defined as vitality or capacity for natural growth and survival, vigor is not easily measured. To evaluate vigor properly, the growth and health of a tree must be observed over time and weighed against the annual conditions it has faced. The health assessment methodology captures annual levels of pests, growth, dieback, defoliation, and foliage compliment (quantity and quality of foliage). Analysis of these variables will determine vigor classification. In this way definitions of vigor and its categories are tied directly to empirical findings and can then be retrospectively applied to individual trees.

5. Variable descriptions

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Plot	Record the plot number: 1 or 2.
Tree	Record the tree number.
Species	Record the three-digit tree species code (Appendix 2).
Flag	This column is marked with a number if some measurement was missing or inappropriate on a previous assessment. Check the current flag list of the electronic data logger to see what measure needs to be retaken (height, dbh, check a pest, new photograph needed, etc.).
Dieback	Estimate percent of exterior twigs and branches that are dead. Do not include branches in the lower bole or interior crown that died as a result of shading. Exclude mechanical damage. Record as follows: 05 = 0 to9%, 15= 10 to 19%, 25 = 20 to 29%, … 95 = 90 to 99%, "--" indicates a dead tree. "XX" indicates a dead tree on the ground.
Total Defoliation	Estimate current defoliation and non-functional foliage caused by biotic and abiotic damage agents. Exclude dieback and mechanical damage. Record as follows: 05 = 0 to9%, 15= 10 to 19%, 25 = 20 to 29%, … 95 = 90 to 99%,
Foliage Compliment	Estimate the relative amount of functional foliage compared to a similarly sized healthy tree. Consider number and size of leaves (i.e., thin crowns and stunted leaves). Exclude dieback, defoliation, and mechanical damage. Record as follows: 0 = 80 –100% of normal foliage compliment. 1 = 50 – 79% of normal foliage compliment. 2 = less than 50% of normal foliage compliment.
Agent Type, 1 to 6	Record the agent type (Appendix 3).
Agent Name, 1 to 6	Record the standard six- to eight-character abbreviation for the agent (Appendix 3).
Agent Level, 1 to 6	Using the following three agent level scales, record the appropriate agent level (Appendix 4) as indicated: 1) % Crown foliage affected or % stem girdled:

05 = 0 to 9%, 15 = 10 to 29%, …95 =90 to 100%.

2) Count of conks or bore holes: 1 to 10, where 10 represents ten or more.
3) Present/Absent:
"--" = present, absence is indicated by empty agent fields.

Agent Verification, 1 to 6

Record the appropriate agent verification using a three-digit code as follows:

Field identifications:

Digit1 – Primary indicator*, 0 = not observed, 1 = observed
Digit2 – Photograph, 0 = not taken, 1 = taken
Digit3 – Voucher specimen, 0 = not collected, 1 = collected

* Primary indicators include signs such as fruiting bodies, tendrils, hyphal pegs, etc., that is, features distinctive to a specific species. Primary indicators do not include symptoms such as sunken or discolored bark, bore holes, sap flow, etc., that is, features common to a number of species.

Laboratory identifications:

Once a mycologist or entomologist has examined the voucher specimen change the third digit as follows:

Digit3 – Voucher specimen, 2 = examined but not identified,
3 = identified

If the voucher specimen remains unidentified (2) a second specimen should be collected the following year. If the specimen has been identified, ensure the Agent Type and Agent Name fields match.

Remarks

Record any other information relevant to the tree or plot. Enter photograph or specimen voucher numbers if any were taken.

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HEALTH ASSESSMENT

CIPHA 4

DATE: YYYY MM DD NODE: STAND: PLOT: Page: of

TREE	SPECIES	FLAG	DIEBACK	TOTAL DEFOL	FOLIAGE COMPLIMENT	AGENT 1			AGENT 2			AGENT 3			AGENT 4			AGENT 5			AGENT 6			REMARKS
						T	NAME	L	T	NAME	L	T	NAME	L	T	NAME	L	T	NAME	L	T	NAME	L	

Form 5: Voucher Specimen and Photograph Log

1. Introduction

An essential part of health assessments is the identification of damage agents. A voucher specimen is collected when there is doubt as to the species, if the pest is rare or if it is unique to the area. These specimens are then identified in the laboratory. If a damaging agent cannot be collected as a voucher specimen (e.g., insect may be long gone, stem canker on an on-plot tree), photographs of the damage or agent are required as substitutes. Photographs are also taken of unidentified voucher specimens since many organisms quickly loose shape and color. Each voucher specimen and photograph is labeled with a unique identification number and entered into Form 5. Form 5 is available in electronic and paper format. Specimens and photographs can be taken during any visit to the plot but are most often taken while completing Form 4 health assessments. Since data loggers allow multiple forms to be opened, Form 5 can be accessed while Form 4 data is being entered. Equipment required for completing Form 5 is listed in Appendix 6.

2. Collecting voucher specimens

Insect and disease specimens are collected from within plot boundaries only if the tree is dead or if destructive sampling is not required. If destructive sampling is required, samples are collected from similarly affected off-plot trees. Voucher labels are placed in specimen vials and sample bags. A sheet of pre-made voucher labels is in each site binder (Appendix 5). The voucher labels are marked with pencil only because many inks are water/alcohol soluble**.** The voucher number is also recorded on paper bags or envelopes with a permanent marker. To avoid duplicate voucher numbers, a voucher label is always removed from the label sheet and included with the specimen.

3. Preserving voucher specimens

The following procedures are used for preserving and transporting voucher specimens:

- Insect
  - Eggs or larvae - placed in alcohol vial with voucher label
  - Adult, hard bodied – placed in alcohol vial with voucher label
  - Adult, soft bodied – placed in killing jar, then placed in tightly sealed envelope with voucher label
- Disease
  - Foliage – placed with voucher label in stapled paper bag or vegetation envelope marked with voucher number.
  - Stem or root – placed with voucher label in stapled paper bag marked with voucher number. Specimen is also marked with voucher number.

Plastic bags are never used to store samples. Foliage specimens are refrigerated when possible. Once back at the laboratory, specimens and photographs are identified and the species are recorded in Form 5 and Form 4, if required, as soon as possible. Voucher specimens and photographs are then archived.

4. Variable descriptions

Roll	Record roll number as follows: YY/TECHNICAN/ROLL# Example: 00MM01 is M. Michaelian's first roll for the year 2000. If you are not entering a photograph leave as "." missing.
Photo	Record photograph number: 1 to 24 or 1 to 36. If a photograph was not taken leave as "." missing.
Voucher	Enter voucher specimen number in Form 4 and record on the voucher label as follows: DD/MM/YY/NODE/STAND#/TREE#/SPECIMEN# Examples: 100600CAL103401 means 10/June/2000/CallingLake/Stand 1/Tree 034/Specimen 01 100600CAL1XXX02 means 10/June/2000/CallingLake/Stand 1/Off Plot Tree/Specimen 02 Ensure that three digits are used for tree number and two digits for specimen number. If you are entering a photograph and a voucher specimen was not collected, leave as "." (missing).
Agent Type	Record the agent type using the same codes as Form 4 (Appendix 3). If a voucher specimen was not collected leave as "." (missing).
Agent Name	Record the agent name using the same codes as Form 4 (Appendix 3). If the agent is new to the CIPHA agent list spell the full Latin name. If a voucher specimen was not collected leave as "." (missing).
Verification	Record the initials of the person who performed the laboratory verification.
Remarks	Record other information about the photograph or voucher specimen. Use this column if photograph is not of a damage agent (e.g., photographs of crews working, photographs of stand in general).

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VOUCHER SPECIMEN AND PHOTOGRAPH LOG

CIPHA 5

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ROLL	PHOTO	VOUCHER	VOUCHER/PHOTO IDENTIFICATION			REMARKS
			AGENT TYPE	AGENT NAME	VERIFICATION	

Form 6: Disk and Core Collection

1. Introduction

Initially, and every five years thereafter, tree-ring analysis is conducted on 12 selected off-plot trees per stand. In each stand, six trees are felled with four disks collected from each tree and six trees are cored with two radii being collected from each tree. Tree selection and sampling buffer-distances are based on analysis of Form 3 data. Disking and coring is completed during the fall, after the season's radial growth has occurred and after Form 3 has been completed. Form 6 is available in electronic and paper format. Equipment required for completing Form 6 is listed in Appendix 6.

2. Determining sampling buffers and diameter classes

Analysis of Form 3 data determines buffers and sampling diameter classes. A sampling buffer (distance to plot boundaries), equal to the maximum on-plot tree height, is applied when felling trees to avoid damaging on-plot trees. The buffer also is applied to stand edges, major gaps, and cut lines. Selection of trees is based on diameter classes. The range of on-plot diameters is divided into three classes with each class providing an equal contribution to the total plot basal area. The purpose of this structured selection process is to provide a statistically efficient means of sampling the stand for its annual growth in terms of basal area. A SAS® program to calculate sample buffers and diameter classes is provided in Appendix 9.

3. Selecting trees

Cutting zones are established at the distal end of each plot. Coring zones are established at plot end closest to stand center (Fig. 4). From an appropriate plot corner, the calculated sample buffer distance is measured along an appropriate bearing to a cutting or coring zone. The three trees, each satisfying a diameter class and closest to but beyond this point, are selected. Trees to be disked are painted D1 to D3. Trees to be cored are painted C1 to C3. This procedure is repeated for the second plot. Cored trees are marked well using flagging and paint because they may be cored again in the future. If the core or disk of a tree shows significant decay to a degree that precludes ring analysis, a new tree is selected.

4. Coring

Trees to be cored are painted with a mark at breast height (1.3 m unless affected by abnormalities as described in Appendix 1). The diameter at breast height is measured and recorded in Form 6. The two cores are obtained by collecting a single, diametric core running through the center of the tree, or by collecting two separate cores from opposite sides of the tree. Cores are placed in a stapled straw and labeled in two places with masking tape and permanent marker or pencil as follows:

NODE, STAND, PLOT, TREE, CORE A and/or B, YEAR

For example: CAL 3-2 C2 A+B 2000

-means Node Calling Lake, Stand 3 - Plot 2, Tree C2, Cores A and B, Year 2000

Cores are refrigerated, frozen, or mounted as soon as possible to minimize mold formation and twisting due to excessive drying. Cores are mounted in the same

orientation that that were extracted, that is with the top of the core facing up. A minimum amount of clear drying glue (LePage® white glue, but not LePage® carpenters glue or hide glue) is used to avoid obscuring tree rings.

5. Disking

The four disks are collected from each tree at the following points:

Disk 0 at 0.3 m above ground
Disk 1 at breast height, 1.3 m
Disk 2 at 1/3 total tree length
Disk 3 at 2/3 total tree length

If there are stem abnormalities, sampling points are moved up or down the stem a standard 30 cm according to the guidelines in Appendix 1.

Trees to be disked are first painted with marks at 0.3 m and 1.3 m. The diameter at breast height is measured and recorded in Form 6. Trees are cut down just above the 0.3 m mark taking care not to damage the basal disk (Disk 0) portion of the tree. Tree height is measured and divided by three. The thirds of the tree are then marked with paint and all heights are recorded in Form 6. Five to ten centimetre thick disks are cut at each mark as perpendicular to the stem as possible. Lower surfaces of the disks are labeled with a permanent marker as follows:

NODE, STAND, PLOT, TREE, DISK#, YEAR

For example: CAL 3-1 D1-1 2000

-means node Calling Lk., Stand3, Plot1, Tree D1, Disk1, Year 2000

Disks are placed in burlap bags labeled with node, stand, and plot information. Disks are kept in the shade and as cool as possible to avoid checking. In the laboratory, disks are refrigerated or frozen.

6. Variable descriptions

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Plot	Record the plot number: 1 or 2.
Tree	Record the tree number: D1, D2, D3, C1, C2 or C3.
Diameter	Record the breast diameter to nearest centimetre.
Total Height	Record the total height of tree (to nearest 0.1 m).
Disk 0 Height	Record the height at Disk 0 (basal disk, 0.3 m).
Disk 1/Core Height	Record the height at Disk1 or cores (1.3 m).
Disk 2 Height	Record the height at Disk 2 (1/3 of the total tree height).
Disk 3 Height	Record the height at Disk 3 (2/3 of the total tree height).
Remarks	Record any comments relevant to the tree, disk or core.

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DISK AND CORE COLLECTION

CIPHA 6

DATE: ____ ____ ____ (YYYY MM DD) NODE: ____ STAND: ____ Page: of

PLOT	TREE	ZONE	DIAMETER	HEIGHT (nearest 0.1 m) TOTAL	DISK 0	DISK 1/CORE	DISK 2	DISK 3	REMARKS
1	C1			—	—		—	—	
1	C2			—	—		—	—	
1	C3			—	—		—	—	
1	D1								
1	D2								
1	D3								
2	C1			—	—		—	—	
2	C2			—	—		—	—	
2	C3			—	—		—	—	
2	D1								
2	D2								
2	D3								

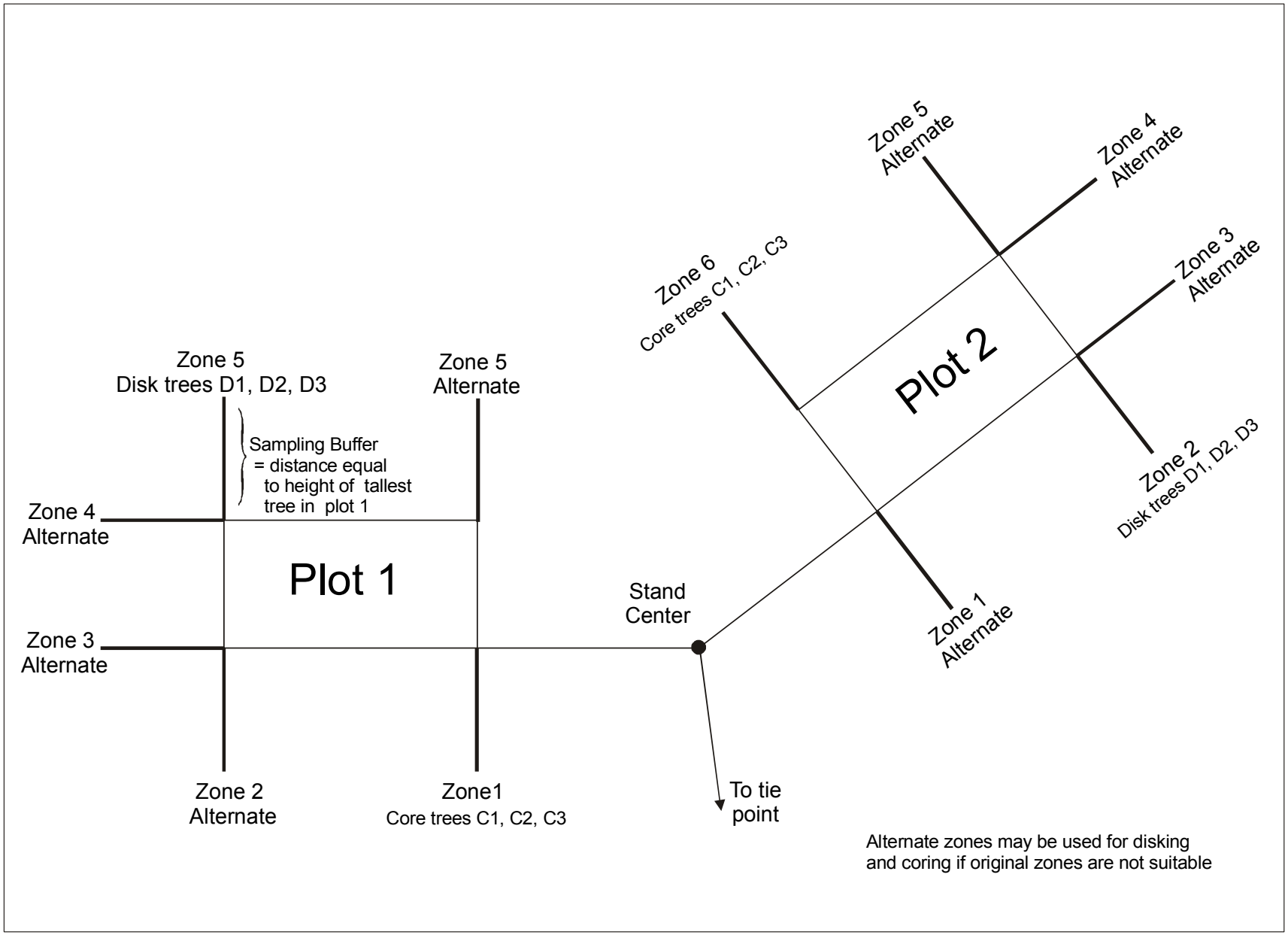

Figure 4. Layout of disking and coring zones

Form 7: Soil and Foliage Collection

1. Introduction

The objectives of soil and foliage collections are:

a) Assessment of the importance of climate versus site conditions (such as soil fertility and water-holding capacity) as factors affecting the productivity, health and biomass of aspen stands at the regional scale;

b) Estimation of the quantity of carbon in the soil, for the purpose of validating models of carbon cycling;

c) Measurement of foliar nitrogen content, for the purpose of assessing and modeling the combined effects of site conditions and climate on photosynthesis and productivity; and

d) Measurement of leaf characteristics to (i) make leaf area estimates from litter traps for remote sensing applications; (ii) express analytical measurements of nutrient content per unit leaf area; and (iii) determine/correct seasonal variation of the above measurements.

Typical soil sampling protocols are modified to meet these objectives with the limited resources of this large-scale, regional study. Thus, comprehensive classification of soil types is not conducted due to the size of the CIPHA project and the time/training required. Identification and measurement of soil horizons are also beyond the scope of this project.

Foliage collection provides a measure of the availability of soil nutrients, and thus foliage must be collected during the same season as soil collection. Ideally, foliage collection should be conducted after complete leaf growth but well before senescence (early-June to early-August depending on the year). Sampling very immature foliage should be avoided, as it will complicate the analyses of foliage, especially assessments of nitrogen content and dry mass per unit area. Soil and foliage collections are to be conducted only once during the course of the study, and need not be done during plot establishment or the five-year remeasurement. There are two data forms for the soil and foliage collection, Form 7A Soil and Foliage Collection and Form7B Soil Cooler Record. Both forms are available in paper format only. Equipment required for completing these collections is listed in Appendix 6.

2. Soil sampling

Soil sampling consists of two parts; the organic LFH layer and mineral soil collections. Soil is collected from three pits per plot as shown in figure 5. Ensure that excessive trampling or previous CIPHA work such as disk collection has not disturbed the sampling area. Avoid collection of soils from other disturbed areas such as game trails or squirrel

activity. If a new sampling site has to be chosen record the new location in the remarks column of Form 7A or on the backside of Form 7A.

a) LFH

Two samples of LFH (L=easily discernable leaves, twigs and woody material; F=partially decomposed leaves, twigs and woody material, less discernable; H=decomposed organic matter, the original structures indiscernible) are to be collected from each soil pit. One sample is to be used to determine bulk density, the other is to be used for chemical analyses.

Sample 1 - LFH Bulk Density (3/plot)

Delineated a fixed area quadrat (15 cm x 15 cm) using a wood or plexi-glass sampling square. LFH within the quadrat is carefully cut and removed down to the mineral soil using a knife or drywall saw and a small shovel. Ensure that the knife cuts are straight and parallel. Exclude all living matter from the sample including mosses, grass, plants and roots. Exclude intact large roots even if they are dead. Place the sample in a Ziploc® plastic bag a labeled as follows:

CAL1P2S1-LFH-BD 10/06/02

- Node Calling Lake, Stand 1, Plot 2, Sample 1, LFH, Bulk Density – June 10, 2002

Remove any excess air before closing the bag. Next, measure (to the nearest cm) the depth of the LFH, down to the mineral soil, at each corner of the quadrat. Record these four depths in Form 7A. The Bulk Density LFH sample need not be refrigerated but must be kept cool and out of the sun.

Sample 2 - LFH Chemical Analyses (3/plot)

Immediately next to the Bulk Density quadrat, collect an additional 0.5 l LFH sample. Exclude all living matter from the sample including mosses, grass, plants and roots. Also, remove intact dead leaves. Place the sample in a Ziploc® plastic bag a labeled as follows:

CAL1P2S1-LFH-CA 10/06/02

- Node Calling Lake, Stand 1, Plot 2, Sample 1, LFH, Chemical Analyses – June 10, 2002

Remove any excess air before closing the bag. The Chemical Analyses LFH sample must be refrigerated.

b) MINERAL SOIL

Two samples of mineral soil are to be collected from each soil pit. One sample is to be used to determine bulk density, the other is to be used for chemical analyses.

Sample 3 - Mineral Soil Bulk Density (3/plot)

Once the two LFH samples have been collected push aside additional LFH to allow easier extraction of the mineral soil. Using a slide-hammer soil corer (10 x 10 cm) pound the corer into the mineral soil until the hammer collar is just flush with the top of the mineral soil. Then extract the corer but do not to lift it straight up. Instead, try to "break the core sample off" with a lateral or twisting motion. If the soil is dry or sandy, slide a small garden hoe or similar device under the corer tube before pulling up the sample. Level the

core sample so that it is flush with the bottom of the corer. If too much sample has fallen out of the corer when it was extracted, a new sample must be taken. A wooden dowel can be used to push material out of the corer. Place the sample in a Ziploc® plastic bag labeled as follows:

CAL1P2S1-MS-BD 10/06/02

- Node Calling Lake, Stand 1, Plot 2, Sample 1, Mineral Soil, Bulk Density – June 10, 2002

Remove any excess air before closing the bag. The Mineral Soil Bulk Density sample need not be refrigerated but must be kept cool and out of the sun.

Sample 4 - Mineral Soil Chemical Analyses (3/plot)

Extract an additional 0.5 l sample of soil from the first 15 cm of mineral soil below the LFH layer using a small shovel. Ensure that all portions of the top 15 cm of mineral soil are equally represented when collecting the sample. In order to prevent contamination, the shovel must be quickly wiped clean of soil and debris between filling each mineral soil/LFH sample bag. Exclude all living matter from the sample including mosses, grass, plants and roots. Place the sample in a Ziploc® plastic bag labeled as follows:

CAL1P2S1-MS-CA 10/06/02

- Node Calling Lake, Stand 1, Plot 2, Sample 1, Mineral Soil, Chemical Analyses – June 10, 2002

Remove any excess air before closing the bag. The Mineral Soil Chemical Analyses sample must be refrigerated.

3. Foliage sampling

Foliage is to be collected from one codominant aspen tree per plot, at the location shown in figure 5, using either a pole pruner or after felling the tree with a chain saw. Do not select suppressed, intermediate or dominant trees unless absolutely necessary. Where possible, do not select trees with major symptoms of cankers, chlorotic leaves, armillaria root rot, bark or woodborers, etc. (phellinus okay). Record the dominance and dbh of the sampled tree in Form7A.

If the samples are to be collected using chainsaws the following precautions must be followed:

1) The feller must have completed chainsaw training
2) The feller must know the location of other personnel at all times.
3) The feller must maintain a distance of at least one tree length from the plot boundary and at least two tree lengths from other personnel working in the plot.
4) If two fellers are utilized, they must maintain a distance of at least four tree lengths between themselves.

Similar to the LFH and mineral soil collections, two separate analyses are to be conducted on the foliage samples. Therefore two samples of foliage are collected from each tree. The first sample is for chemical analysis; the second sample is for measuring leaf shape and size.

Sample 5 - Foliage Chemical Analyses (1/plot)
A 0.25 l sample (~30 gm dry weight) of foliage is collected from each of the lower, mid and upper thirds of the crown. If possible, collect samples from several locations at each height in the crown. Manually remove the leaves by detaching their petioles (stalks) at their insertion with the twig or branch and do not include any woody material in the sample. The sample is placed in a suitable paper bag labeled with a permanent marker as follows:

CAL1P2-U-CA 10/06/02
- Node Calling Lake, Stand 1, Plot 2, Upper Crown, Chemical Analyses– June 10, 2002

The bag should be compressed to save space and be stapled shut. Then staple all three samples (lower, middle and upper) together. The samples do not need to be refrigerated.

Sample 6 - Foliage Dimensions (1/plot)
While collecting the three Chemical Analyses foliage samples, retain 8 leaves from each of the three heights. If possible, collect leaves from several locations at each height in the crown. Choose leaves that represent the typical range of leaf size encountered (including second flush), but avoid abnormal or unhealthy leaves. Where possible, avoid leaves with signs of defoliation. Carefully place the 8 leaves flat into a letter sized envelope. Try not to overlap leaves in the envelope. Labeled the envelope as follows:

CAL1P2-U-D 10/06/02
- Node Calling Lake, Stand 1, Plot 2, Upper Crown, Dimensions– June 10, 2002

Seal the envelope closed. Care must be taken not to bend or fold the three envelopes. These samples do not need to be refrigerated but should be placed in a plant press as soon as possible.

4. Field and laboratory storage of samples
All samples (soil and foliage) must be returned to the lab and processed as soon as possible. The LFH and the Mineral Soil samples must not be allowed to dry out. Ensure that their plastic bags are securely sealed. If any bag becomes punctured, immediately place it inside of another.

a) Refrigerated Samples
The LFH Chemical Analyses and Mineral Soil Chemical Analyses samples must be stored in coolers and kept cool (~5 ^{o}C) with freezer packs and ice bags. Use max/min thermometers to record daily temperature in Form 7b. A few days prior to the start of a collection trip place the freezer packs and coolers in a –30 ^{o}C cold room. Ice bags may be purchased as needed. Do not allow water, from the ice bags, to contaminate the samples (make sure sample bags are not punctured). If the maximum temperature rises above 5 ^{o}C add more ice or freezer packs. Keep extra freezer packs in your camper freezer to be used as needed. Where possible, store the freezer and ice bags on top of the samples since cold air sinks. Open the coolers as little as possible. If possible, use the camper fridge to pre-chill samples before adding them to the coolers. During working days, keep coolers outside, in the shade, and covered with a tarp. Do not store the coolers inside warm vehicles. If there is no alternative but to store coolers inside a vehicle or camper, make

sure windows are open to allow good ventilation. Store the coolers outside during the night.

Upon returning to the laboratory, transfer the refrigerated samples to cardboard boxes labeled with node/s, sample type/s, technician' name and date. The LFH Chemical Analyses and Mineral Soil Chemical Analyses samples must immediately be placed in a -5 ^{o}C cold room. The LFH Bulk Density and Mineral Soil Bulk Density samples, although not refrigerated in the field, should also be refrigerated at -5 ^{o}C once back at the laboratory.

b) Non-refrigerated Samples
The Foliage Chemical Analyses samples do not need to be refrigerated upon returning to the laboratory. Foliage Dimensions samples must NOT be frozen or refrigerated. Instead place the sample envelopes in a plant press and then dry the samples at 40-50 degrees C.

5. Variable descriptions

Form7A Soil and Foliage Collection

Date	Record the date as YYYYMMDD.
Node	Record the three-letter node abbreviation.
Stand	Record the stand number: 1, 2 or 3.
Dominance	Record dominance as follows: 1 Dominant – crown extends above top of general canopy level and receives full sunlight from above and partial sunlight from sides. 2 Codominant – crown extends to top of general canopy level and receives full sunlight from above but little sunlight from sides. May be somewhat crowded at sides by other trees. 3 Intermediate – crown extends into general canopy level but shorter than codominant trees. Receives little sunlight from above or sides. 4 Suppressed – crown is entirely below general canopy level. NOTE: Should always select codominant unless impossible.
DBH	Record the breast diameter to nearest centimetre.
Depth 1 to 4	Record the depth of the LFH layer at each quadrat corner to nearest centimetre.
Remarks	Record any comments relevant to the soil, LFH or foliage samples.

Form7B Soil Cooler Record

Cooler #	Record the cooler number
Date	Record the date as YYYYMMDD.
Max	Record the daily maximum temperature

Min	Record the daily minimum temperature
Samples Added	Record the Node, Stand and sample types. For example: CAL2LFH,MINERAL – means Calling Lake, Stand2, both LFH & mineral soil samples. Note: Assuming the samples are not moved from cooler to cooler during a sampling trip, you only need to enter the sample once (i.e. on the day it was first placed in the cooler).

Volume calculations

Refrigerated Volume calculations Per trip:
Mineral Soil Chemical Analyses:
3nodes x 3stands x 2plots x 3 soil samples x0.5 L sample =27 l
LFH Chemical Analyses:
3nodes x 3stands x 2plots x 3 LFH samples x0.5 L sample =27 l

Therefore need 60 l of cooler space (more likely 2 x 30 l coolers).

Non-refrigerated Volume calculations Per trip:
LFH Bulk Density
3nodes x 3stands x 2plots x 3 samples x0.5 L sample =27 l
Mineral Soil Bulk Density
3nodes x 3stands x 2plots x 3 samples x0.8 l sample =43.2 l
Foliage Chemical Analyses:
3nodes x 3stands x 2plots x 3 crown levels x 0.5 L sample= 27 l
Foliage Dimensions
One plant Press.

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SOIL & FOLIAGE COLLECTION

FORM 7A

Page of

DATE: _____ _____ _____ NODE: _____ STAND: _____
YYYY MM DD

	FOLIAGE	DOMINANCE	DBH (cm)	LFH	DEPTH (cm) 1	2	3	4	REMARKS
PLOT 1	SAMPLE 1			SAMPLE 1					
	———	———	———	SAMPLE 2					
	———	———	———	SAMPLE 3					
PLOT 2	SAMPLE 2			SAMPLE 1					
	———	———	———	SAMPLE 2					
	———	———	———	SAMPLE 3					

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SOIL COOLER RECORD

CIPHA 7B

COOLER # [ ]

DATE	MAX	MIN	SAMPLES ADDED	DATE	MAX	MIN	SAMPLES ADDED

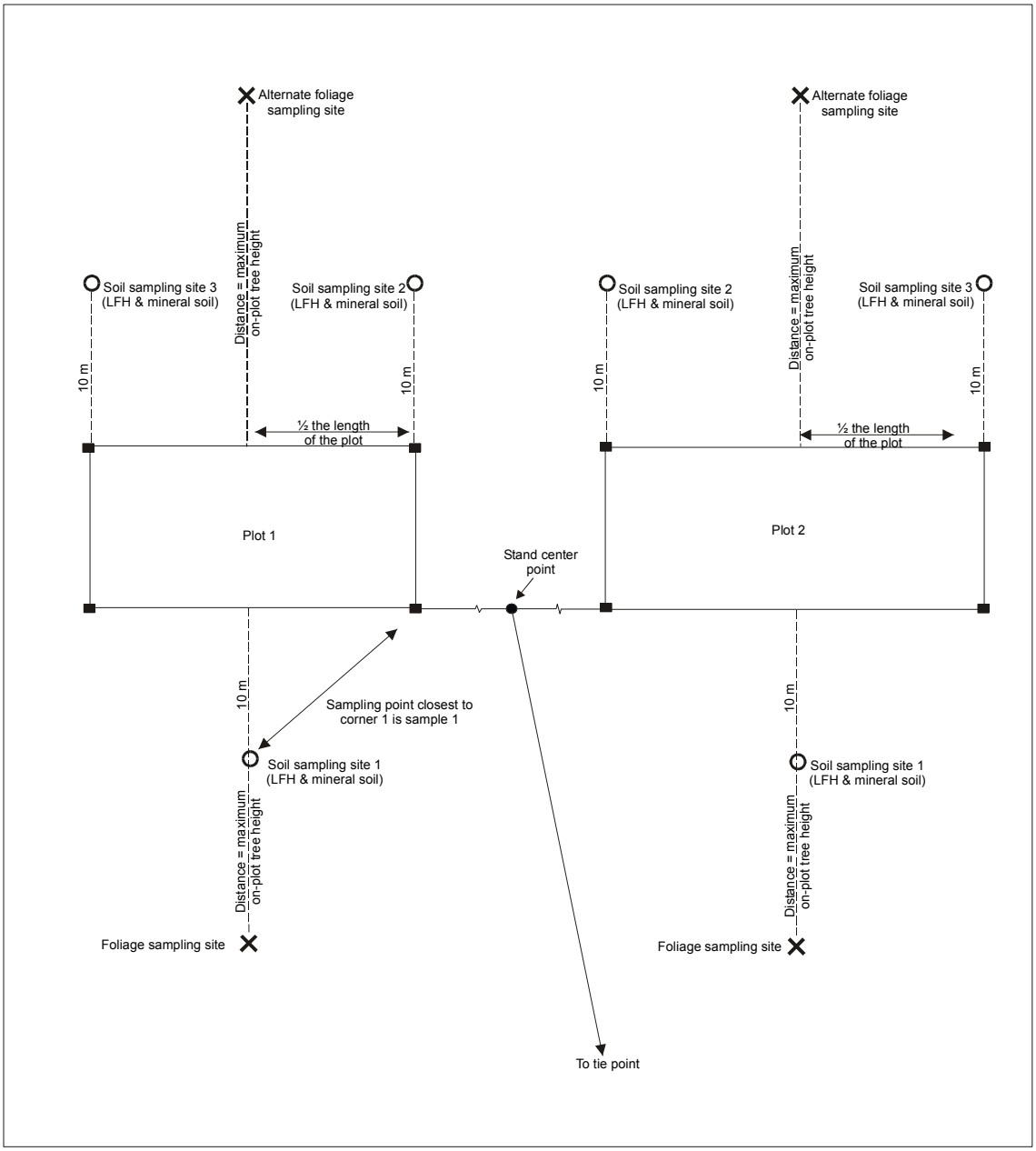

Figure 5. Soil, LFH and foliage sampling diagram

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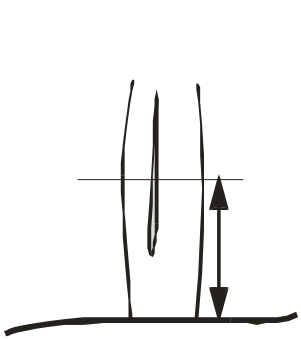
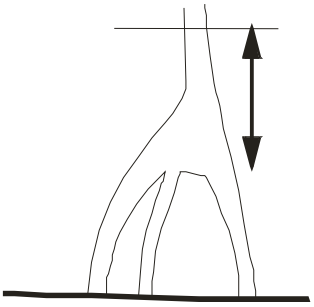
Millers, I.; Lachance, D.; Burkman, W.G.; Allen, D.C.1991. North American Sugar Maple Decline Project: Organization and Field Methods. United States Dept. Agric., For. Ser., Northeastern Forest Exper. Station., Gen. Tech. Rep. NE-154

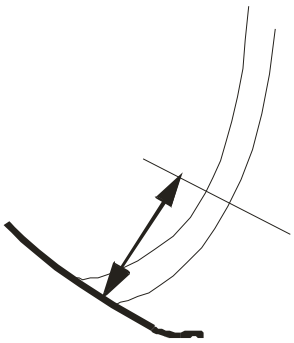
Appendix 1. Measurement of DBH on abnormal trees



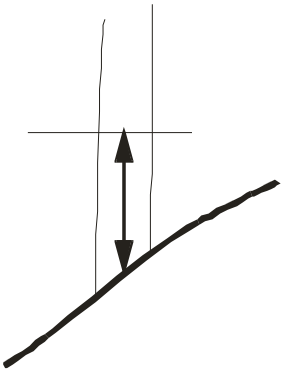
A. MAJOR CRACKED STEM



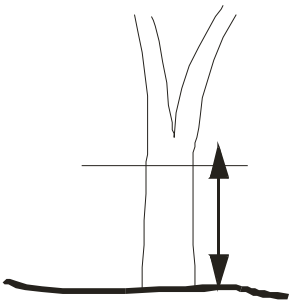
B. ELEVATED ROOT SYSTEM
(MEASURE 1.3 M ABOVE ROOT COLLAR)



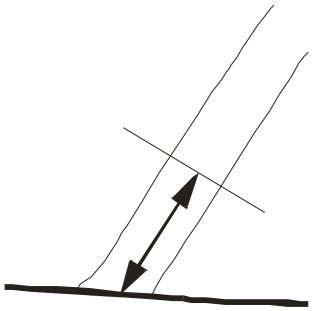
C. STEM BASE CURVED
(PERPENDICULAR TO STEM AT 1.3 M)



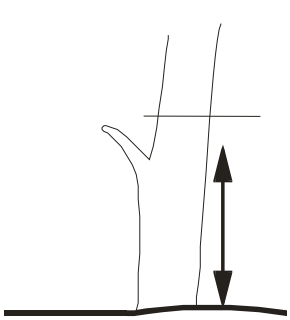
D. TREE ON SLOPE



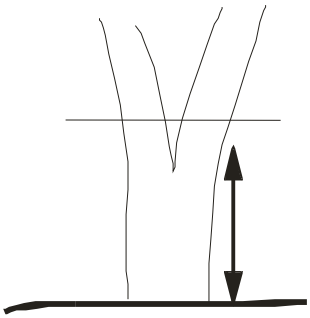
E. TREE FORKS AT 1.3 TO 1.5 M
(MEASURE AT 30 CM BELOW FORK)



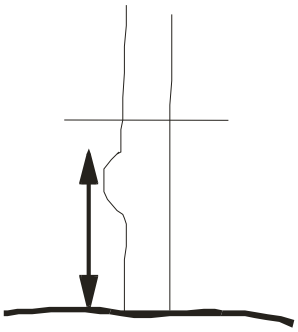
F. TREE LEANING



G. BRANCH AT 1.3 M
(MEASURE AT 30 CM ABOVE)



H. TREE FORKED AT 1.0 TO 1.3 M
(MEASURE EACH STEM 30 CM ABOVE)



I. SWELLING AT 1.3 M
(MEASURE AT 30 CM ABOVE)

From ARNEWS Information Report PI-X-117

Appendix 2. Tree species codes

Species Code	Common Name
003	Balsam fir
007	Alpine fir
032	Tamarack
043	White spruce
045	Black spruce
052	Jack pine
054	Lodgepole pine
060	Red pine
062	Eastern white pine
072	Douglas fir
104	Manitoba maple
130	Alder species
168	White birch
253	Black ash
254	Red ash
304	Balsam poplar
308	Largetooth aspen
311	Trembling aspen
357	Bur oak
400	Willow species

Appendix 3. Damage agent names and type codes (Form 4 and 5)

CIPHA PEST AGENT MASTER LIST Revised 13 November, 2001

AGENT NAME[1]	COMMON NAME	SCIENTIFIC NAME	AGENT TYPE[1]
Foliar Insects			
DASVAG	Tussock moth	*Dasychira vagans*	01
HYACEC	Cecropia moth	*Hyalophora cecropia*	01
LOBNIV	Twolined aspen looper	*Lobophora nivigerata*	01
MALDIS	Forest tent caterpillar	*Malacosoma disstria*	01
NEOSPP	Sawfly, *Neodiprion* species	*Neodiprion spp.*	01
OPEBRU	Bruce spanworm	*Operophtera bruceata*	01
SAWFLY	Unknown sawfly		01
CHOCON	Large aspen tortix	*Choristoneura conflictana*	02
ENADEC	Aspen twoleaf tier	*Enargia decolor*	02
PSEORE	Aspen leafroller	*Pseudexentera oregonona*	02
FENPUS	Birch leafminer	*Fenusa pusilla*	03
PHYNIP	Balsam poplar leafblotch miner	*Phyllonorycter nipigon*	03
PHYPOP	Poplar leafminer	*Phyllocnistis populiella*	03
PHYSAL	Willow leafblotch miner	*Phyllonorycter salicifoliella*	03
PROTHO	Ambermarked birch leaf miner	*Profenusa thomsoni*	03
BUCCAN	Birch skeletonizer	*Bucculatrix canadensisella*	04
TRIDEC	Gray willow leaf beetle	*Tricholochmaea d. decora*	04
GONAME	American aspen beetle	*Gonioctena americana*	04
CHRCRO	Aspen leaf beetle	*Chrysomela crotchi*	04
CHRFAL	Leaf beetle	*Chrysomela falsa*	04
CHRMAI	Alder leaf beetle	*Chrysomela mainensis*	04
PHRSPP	Leaf beetles	*Phratora spp.*	04
LFBEET	Unknown leaf beetle		04
ACOSPP	Leaf gall mite	*Acotyledon spp.*	07
ERISPP	Gall mites	*Eriophyes spp.*	07
PARTUM	Balsam gall midge	*Paradiplosis tumifex*	07
PEMPOP	Poplar petiolegall aphid	*Pemphigus populitransversus*	07
PEMSPP	Pemphigus gall aphids	*Pemphigus spp.*	07
APHID	Unknown aphid species		08
CHAPOP	Smokywinged poplar aphid	*Chaitophorus populicola*	08
MITE	Unknown mite		08
Foliar Diseases			
VENMAC	Leaf and twig blight	*Venturia macularis*	10
CIBWHE	Ink spot	*Ciborinia whetzellii*	11
MELMED	Leaf rust	*Melampsora medusae*	13
UNCADU	Powdery mildew	*Uncinula adunca*	14
BLOTCH	Unknown blotch		19

Woody Tissue Insect			
ACEPAR	Poplar budgall mite	*Aceria parapopuli*	21
BATPRA	Petiole crotch borer	*Batrachedra praeangusta*	23
SAPCAL	Poplar borer	*Saperda calcarata*	25
AGRLIR	Bronze poplar borer	*Agrilus liragus*	25
TRYRET	Poplar ambrosia beetle	*Trypodendron retusum*	25
ANTSPP	Unknown ant species		26
CAMHER	Boreal carpenter ant	*Camponotus herculeanus*	26
CAMFER	Red carpenter ant	*Camponotus ferrugineus*	26
CAMSPP	Carpenter ant	*Camponotus spp.*	26
Woody Tissue Diseases			
CYTCHR	Cytospora canker	*Cytospora chrysosperma*	30,31
NECCIN	Nectria canker	*Nectria cinnabarina*	30,31
CERFIM	Ceratocystis canker	*Ceratocystis fimbriata*	31
CRYLIG	Cryptosphaeria canker	*Cryptosphaeria lignyota*	31
ENCPRU	Sooty-bark canker	*Encoelia pruinosa*	31
ENTMAM	Hypoxylon canker	*Entoleuca mammata*	31
RHYBAR	Rough bark	*Rhytidiella baranyayi*	31
TARGET	Unknown target canker		31
BLINDCNK	Blind conk		34
PENPOL	White rot	*Peniophora polygonia*	34
PHETRE	False tinder conk	*Phellinus tremulae*	34
BLKGALL	Black gall		32,33
DIPTUM	Diplodia galls	*Diplodia tumefaciens*	32,33
ARMSPP	Armillaria root disease	*Armillaria spp.*	35
ROOTROT	Unknown root disease		35
Other			
HERBICI	Herbicide damage		40,41,42
HYDCARB	Hydrocarbons		40,41,42
NOX	Nitrogen oxides		40,41,42
OZONE	Ozone flecking		40,41,42
SO2	Sulfur dioxide		40,41,42
FROST	Frost crack, frost damaged foliage		40,41,42,43
STRESSCK	Stress crack		43
SUNSCALD	Sun scalding		43
MECHSCAR	Mechanical scars		43,44,45
FIRE	Fire scar		43,44,45
HAIL	Hail damage		41,42,43, 44,45
WIND	Windthrow or broken branch or stem		43,44,45
WHIPPING	Whipping		43,44,45
DROUGHT	Drought		40,41,42
SAPFLOW	Sap flow of unknown cause		43
SNOWLEAN	Snow damage leaning		43,44,45
LOGGED	Logged	*Homosapien*	46
ALCALC	Moose	*Alces alces*	43,44,45

ODOVIR	White-tailed deer	*Odocoileus virginianus*	43,44,45
URSARC	Grizzly bear	*Ursus arctos*	43,44,45
URSAME	Black bear	*Ursus americanus*	43,44,45
CASCAN	Beaver	*Castor canadensis*	43,44,45
EREDOR	Porcupine	*Erethizon dorsatum*	43,44,45
DRYPIL	Pileated woodpecker	*Dryocopus pileatus*	43,44,45
PICSPP	Woodpecker species	*Picoides spp.*	43,44,45
SPHVAR	Yellow-bellied Sapsucker	*Sphyrapicus varius*	43,44,45
TAMHUD	Red Squirrel	*Tamiascurus hudsonicus*	43,44

[1] Form 4 and Form 5 variables
XXXX = new or changed for 2002

Appendix 4. Agent type and agent level codes (Form 4 and 5)

CIPHA PEST TYPE MASTER LIST Revised 13 November, 2001

AGENT TYPE[1]	DAMAGE AGENT OR SYMPTOM	EXAMPLES	AGENT LEVEL[2]
Foliar Insects			
01	Free feeding	Forest tent caterpillar, sawflies.	% Crown Affected
02	Leaf roller	Large aspen tortrix, aspen twoleaf tier, aspen leafroller.	% Crown Affected
03	Leaf miner	Serpentine leaf miner.	% Crown Affected
04	Leaf skeletonizer	Leaf beetles	% Crown Affected
05	Tent/nest maker	Fall webworm.	% Crown Affected
06	Bud/shoot miner		% Crown Affected
07	Gall maker	Mites, midges, aphids.	% Crown Affected
08	Sucking insects	Aphids, mites, spittlebugs, stink bugs.	% Crown Affected
09	Other foliage insect		% Crown Affected
Foliar Diseases			
10	Leaf/twig blight	Venturia leaf blight.	% Crown Affected
11	Leaf spot	Ink spot.	% Crown Affected
12	Leaf blister	Taphrina spp.	% Crown Affected
13	Leaf rust	Leaf rust.	% Crown Affected
14	Leaf mildew	Powdery mildew of aspen.	% Crown Affected
15			
16			
17			
18			
19	Other foliage disease		% Crown Affected
Woody Tissue Insects			
20	Sucking insect	Scurfy scale, scale, aphids.	'--' not applicable
21	Branch gall maker	Poplar twig gall fly.	'--' not applicable
22	Stem gall maker	Mite gall	'--' not applicable
23	Twig borer	Poplar gall borer.	'--' not applicable
24	Bark beetle		'--' not applicable
25	Wood borer	Poplar borer, flatheaded apple tree borer, clearwing moth.	Count entry holes to a max. of 10.
26	Carpenter ants	*Camponotus* spp.	'--' not applicable

27	Root/root collar		'--' not applicable
28			
29	Other woody tissue insect		Choose appropriate code or '--' not applicable
Woody Tissue Diseases			
30	Twig or branch canker	Nectria canker, cytospora canker.	% Crown Affected
31	Stem canker	Hypoxylon canker, nectria canker, cytospora canker.	% Stem Girdled (see notes above)
32	Twig or branch gall	Diplodia gall, black gall.	'--' not applicable
33	Stem gall	Diplodia gall, black gall.	'--' not applicable
34	Stem conk	Phellinus decay, peniophora decay, blind conks.	Count # of conks to a max. of 10.
35	Root rot	Armillaria root rot.	'--' not applicable
36			
37			
38			
39	Other woody tissue disease		Choose appropriate code or '--' not applicable
Other			
40	Chlorotic foliage	flooding, pollutants, agricultural chemicals, drought.	% Crown Affected
41	Damaged foliage	flooding, pollutants, agricultural chemicals, drought, hail, frost.	% Crown Affected
42	Dead foliage	flooding, pollutants, agricultural chemicals, drought.	% Crown Affected
43	Stem wounds	mechanical, wind, snow, hail, fire, animal, human, frost and stress cracks.	% Stem Girdled Use "--" if closed wound
44	Broken branch	mechanical, wind, snow, hail, fire, animal, human.	% Crown Affected
45	Broken stem/top	mechanical, wind, snow, hail, fire, animal, human.	% Crown Affected
46	Logged	human	'--' not applicable
47			
48			
49	Other damaging agents		Choose appropriate code or '--' not applicable

[1] Form 4 and Form 5 variable
[2] Form 4 variable
XXXX=new or changed for 2002
nb make changes to master pest list and type list files used in SAS and easydc for 2002

Appendix 5. Specimen voucher labels

Voucher Labels 2002

Format: DD/MM/YY/NODE/STAND#/TREE#/SPECIMEN#

Use Pencil Only. Place a voucher label with the collected specimen.

Be sure to enter the same voucher number in the appropriate data forms.

Use a different column for each stand

____/____/02/___/_/____/01	____/____/02/___/_/____/01	____/____/02/___/_/____/01	____/____/02/___/_/____/01
____/____/02/___/_/____/02	____/____/02/___/_/____/02	____/____/02/___/_/____/02	____/____/02/___/_/____/02
____/____/02/___/_/____/03	____/____/02/___/_/____/03	____/____/02/___/_/____/03	____/____/02/___/_/____/03
____/____/02/___/_/____/04	____/____/02/___/_/____/04	____/____/02/___/_/____/04	____/____/02/___/_/____/04
____/____/02/___/_/____/05	____/____/02/___/_/____/05	____/____/02/___/_/____/05	____/____/02/___/_/____/05
____/____/02/___/_/____/06	____/____/02/___/_/____/06	____/____/02/___/_/____/06	____/____/02/___/_/____/06
____/____/02/___/_/____/07	____/____/02/___/_/____/07	____/____/02/___/_/____/07	____/____/02/___/_/____/07
____/____/02/___/_/____/08	____/____/02/___/_/____/08	____/____/02/___/_/____/08	____/____/02/___/_/____/08
____/____/02/___/_/____/09	____/____/02/___/_/____/09	____/____/02/___/_/____/09	____/____/02/___/_/____/09
____/____/02/___/_/____/10	____/____/02/___/_/____/10	____/____/02/___/_/____/10	____/____/02/___/_/____/10
____/____/02/___/_/____/11	____/____/02/___/_/____/11	____/____/02/___/_/____/11	____/____/02/___/_/____/11
____/____/02/___/_/____/12	____/____/02/___/_/____/12	____/____/02/___/_/____/12	____/____/02/___/_/____/12
____/____/02/___/_/____/13	____/____/02/___/_/____/13	____/____/02/___/_/____/13	____/____/02/___/_/____/13
____/____/02/___/_/____/14	____/____/02/___/_/____/14	____/____/02/___/_/____/14	____/____/02/___/_/____/14
____/____/02/___/_/____/15	____/____/02/___/_/____/15	____/____/02/___/_/____/15	____/____/02/___/_/____/15
____/____/02/___/_/____/16	____/____/02/___/_/____/16	____/____/02/___/_/____/16	____/____/02/___/_/____/16
____/____/02/___/_/____/17	____/____/02/___/_/____/17	____/____/02/___/_/____/17	____/____/02/___/_/____/17
____/____/02/___/_/____/18	____/____/02/___/_/____/18	____/____/02/___/_/____/18	____/____/02/___/_/____/18
____/____/02/___/_/____/19	____/____/02/___/_/____/19	____/____/02/___/_/____/19	____/____/02/___/_/____/19
____/____/02/___/_/____/20	____/____/02/___/_/____/20	____/____/02/___/_/____/20	____/____/02/___/_/____/20
____/____/02/___/_/____/21	____/____/02/___/_/____/21	____/____/02/___/_/____/21	____/____/02/___/_/____/21
____/____/02/___/_/____/22	____/____/02/___/_/____/22	____/____/02/___/_/____/22	____/____/02/___/_/____/22
____/____/02/___/_/____/23	____/____/02/___/_/____/23	____/____/02/___/_/____/23	____/____/02/___/_/____/23
____/____/02/___/_/____/24	____/____/02/___/_/____/24	____/____/02/___/_/____/24	____/____/02/___/_/____/24
____/____/02/___/_/____/25	____/____/02/___/_/____/25	____/____/02/___/_/____/25	____/____/02/___/_/____/25

Appendix 6. Equipment Lists

The site binder, included in the equipment lists of Forms 1 – 6, contains:

a) aerial photographs showing location of potential stands
b) National Topographic Series maps, inventory maps, or other map showing the location of potential stands
c) a list of the UTM locations of the 3 best potential stands and alternatives
d) the magnetic declination for the node calculated for the establishment year can be obtained from your hand-held GPS or Internet sites such as; www.ngdc.noaa.gov/seg/potfld/java/GeoMag.shtml
e) access permits if applicable
f) a contact list with names and telephone numbers of all relevant persons
g) voucher specimen labels
h) blank paper forms

Preliminary Stand Selection:

a) aerial photographs, NTS maps, inventory maps, or other maps
b) hand held GPS unit plus extra batteries
c) basal area prism
d) ultrasonic hypsometer plus extra batteries (clinometer and fiberglass tape as backup)
e) increment corer
f) Preliminary Stand Selection forms
g) clipboard
h) pencils and permanent markers

Forms 1 and 2, Basic Plot Information and Tree Map:

a) site binder
b) clipboard
c) data logger plus extra batteries, EASYDC® pre-load for Form 2
d) compass
e) hand held GPS unit plus extra batteries
f) fiberglass tapes (two 50 m tapes, and at least one 30 m tape)
g) DBH tape
h) 1 m electrical conduit (9/stand)
i) sledge hammer, or axe
j) flagging – orange (1 roll/stand)
k) tree paint - orange (2 cans/stand)
l) tree tags (450/node) plus wire
m) hip chain
n) camera and film (slide film or digital only)
o) pencils and permanent markers

Form 3, Plot Tree Data:

a) site binder
b) clipboard
c) data logger plus extra batteries, EASYDC ® pre-loads for Forms 3

d) ultrasonic hypsometer plus extra batteries (clinometer and fiber glass tape as backup)
e) DBH tape
f) camera and film (slide film or digital only)
g) pencils and permanent markers

Forms 4 and 5, Health Assessment and Pest Voucher and Photograph log:
b) site binder
b) clipboard
c) data logger plus extra batteries, EASYDC ® pre-loads for Forms 4, and 5
d) reference texts for damage agent identifications
e) binoculars
f) knife for sample collections
g) pole pruners for foliage collection
h) insect vials with stoppers (10/stand) plus alcohol
i) paper bags (10/stand)
j) vegetation envelopes
k) small killing jar plus killing agent
l) stapler
m) camera and film (slide film or digital only)
n) pencils and permanent markers

Form 6, Disk and Core Collection:
a) site binder
b) clipboard
c) data logger plus extra batteries
d) chainsaw, fuel, oil
e) extra chain
f) extra spark plug
g) chain sharpener
h) wedges
i) roll straps for dislodging trees
j) sledge or hatchet for wedges
k) chainsaw chaps
l) hardhats (1/person), screen & muffs
m) burlap bags (5/stand, 15/node)
n) increment corer
o) straws (12/stand, 36/node)
p) camera and film (slide film or digital only)
q) compass
r) fiberglass tapes (two tapes, 30 or 50 m)
s) ultrasonic hypsometer plus extra batteries (clinometer and fiber glass tape as backup)
t) flagging orange (1 roll/node)
u) tree paint (1 can/node)
v) labels for burlap bags
w) string or wire to tie up burlap bags and attach labels
x) pencils and permanent markers

Form7 Soil and Foliage Collection

NOTE: all quantities are **PER NODE**

a) site binder
b) clipboard
c) 2 x 36 quart (34 l) cooler/coolers.
d) freezer packs (should be frozen (-30 freezer) prior to field trip) Soft flexible ones the best. ~7/node.
e)Plastic Ziploc® sample bags

- 0.75 l x 54 bags/**node** for LFH Bulk Density & Chemical Analyses, Mineral soil Chemical Analyses

1.0 l x 36 bags/**node** Mineral Soil Bulk Density & extras for large volume LFH Bulk Density samples
f)Plastic bags

- # 12 size plastic bags 6/**node** to group refrigerated samples from each plot

g)Paper bags – #5 size (approx. 0.5 l) x 18 bags /**node** for Foliage Chemical Analyses
h) Envelopes – Letter size x 18/node for Foliage Dimensions
i) permanent markers – 2/node
j) soil shovel
k) hand trawl
l) cleaning cloth/towel for shovel
m) chainsaw, fuel, oil
n) extra chain
o) extra spark plug
p) chain sharpener
q) wedges
r) roll straps for dislodging trees
s) sledge or hatchet for wedges
t) chainsaw chaps
u) hardhats (1/person), screen & muffs
v) fiberglass tapes (two tapes, 30 or 50 m)
w) max/min thermometer - one/cooler
x) metal ruler or metal tape for measuring LFH & soil depth
y) DBH tape
z) stapler & staples
aa) tarp (6 x 8 ft.)
ab) knife or small drywall saw for cutting through LFH
ac) 15 x 15 cm LFH quadrat square
ad) Forms water proof– Form7 – 3/node
Form8 – 1/cooler
ae) Burlap bags or boxes for storing Foliage Chemical Analyses, Mineral Soil Bulk Density & LFH Bulk Density samples - 6/node
af) slide-hammer soil corer and extra coring tube (size 10 x cm x 10 cm)
ag) file – for sharpening soil corer
ah) waterproof sample bag labels (if premade)
ag) plant press for foliage dimension samples

Appendix 7. SAS® program to determine criteria for disk and core sampling (Form 6)

```
/*  SAS program to determine diameter class contributions
    to cumulative on-plot basal areas for CIPHA form 6 sampling


    set options and library reference */
options linesize=120  pagesize=55;
libname cipha '~/cipha';

/*  input Form 3 data files
    dom = tree dominance, s = stem form, dbh= diameter at breast height
*/
data one  ; infile 'FTN1-3.LIS'  firstobs= 1    missover;
   input date node $ stand plot tree species dom s DBH height  ;
data two  ; infile  'FTN2-3.LIS'  firstobs= 1    missover;
   input date node $ stand plot tree species dom s DBH height  ;
data three  ; infile 'FTN3-3.LIS'  firstobs= 1    missover;
   input date node $ stand plot tree species dom s DBH height  ;

/*  step to select live trembling aspen and calculate basal areas (ba)
    for individual trees and sort data by diameter  */
data step; set one two three;
   if dom = 9 then delete;   if species ne 311 then delete;
     ba = 22/28*DBH**2;
   keep node stand plot dom DBH height ba;
     proc sort; by stand plot DBH;

/*  step to calculate cumulative basal area (cba) contributions
    for trees sorted by diameter */
data step1; set step;
   if _n_ = 1 or plot ne lag(plot) then cba = ba;
     else cba = ba + cba;    retain;

/*  procedure to determine plot basal area (sba)
    and maximum tree height (xht) */
proc means max sum noprint;
   var DBH height ba;    by stand plot;
     output out = temp1  max = xDBH xht xba   sum = sDBH sht sba;

/*  step to merge tree and plot data and
    calculate sampling class (cut) and boundaries (trandb) */
data temp2; merge temp1 step1; by stand plot;
   if cba gt 2/3*sba then cut = 3;
     if cba gt 1/3*sba and cba le 2/3*sba then cut = 2;
       if cba le 1/3*sba then cut = 1;
         if DBH = xDBH then cut = 4;
           if cut ne lag(cut) then trandb = DBH;

/*  step to select only class boundaries or transitional diameters */
data temp3; set temp2;
   if DBH = trandb;

/*  step to average sample class (cut) for transitional diameters */
```

```
data temp4; merge temp3 temp2; by stand plot;
   proc means mean noprint;
     var cut; by stand plot DBH;
   output out=temp4 mean = meancut;

/*  step to adjust the class boundary
    if the majority of trees of transitional diameter
    fall into the lower sample class,
    and to rename variables for output */
data temp5; merge temp4 temp3; by stand plot DBH;
   if DBH = trandb;
     if ceil(meancut)-meancut gt .5 then trandb = trandb + 1;
       if cut = 1 then DBH1 = trandb; retain;
         if cut = 2 then DBH2 = trandb; retain;
           if cut = 3 then DBH3 = trandb; retain;
             if cut = 4 then DBHmax = trandb; retain;
               if cut = 4; buffer = xht;
   keep node stand plot buffer DBH1-DBH3 DBHmax;

/*  step to print sampling classes and buffers
    for each plot in a node, required when completing form 6 */

proc print; by node stand;
   title1 'Parameters for selecting trees to CUT or CORE'   ;
   title2 'DBH1, DBH2, & DBH3 are minimum diameters (cm) for each
sample class';
   title3 'do not exceed DBHmax for third sample class';
   title4 'buffer (m) from plot is equal to the maximum tree height on
plot';
   title5 ' ';
   title6 'for example, DBH1 = 7, DBH2 = 12, DBH3 = 18, DBHmax = 21,
buffer = 23.3';
   title7 ' trees from  7 to 11 cm DBH represent sample class one';
   title8 ' trees from 12 to 17 cm DBH represent sample class two';
   title9 ' trees from 18 to 21 cm DBH represent sample class three';
   title10 '       samples should be taken beyond 23.3 m from plot';
```

Appendix 8. Table of maximum tree heights and ½ plot Y dimension.
To be used with Form 7 Soil and Foliage Collection. Produced by /data/fhn2/7/mike/fhn/cipha/anayses/yr2001-02/analyses/form7.sas using 2000 form1 and form3 data.

NODE	STAND	PLOT	HALF_Y	MAX_HT
ALD	1	1	6	25.2
ALD	1	2	8	26.6
ALD	2	1	8.5	22.3
ALD	2	2	6	21.6
ALD	3	1	6	22.2
ALD	3	2	7	21.9
BAT	1	1	16.5	19.0
BAT	1	2	10.0	20.1
BAT	2	1	9.5	16.1
BAT	2	2	21.5	20.0
BAT	3	1	18.0	17.9
BAT	3	2	16.5	15.9
BIG	1	1	5.0	13.3
BIG	1	2	4.5	13.7
BIG	2	1	7.5	15.4
BIG	2	2	10.0	15.1
BIG	3	1	8.5	16.5
BIG	3	2	5.5	13.1
CAL	1	1	10.0	20.1
CAL	1	2	7.0	18.3
CAL	2	1	13.0	20.8
CAL	2	2	5.0	21.4
CAL	3	1	12.5	25.1
CAL	3	2	11.5	25.4
DUN	1	1	4.5	11.0
DUN	1	2	9.0	13.0
DUN	2	1	7.5	13.2
DUN	2	2	11.0	17.2
DUN	3	1	4.0	13.7
DUN	3	2	6.5	16.1
DVG	1	1	10.0	19.3
DVG	1	2	9.0	18.4
DVG	2	1	10.0	13.9
DVG	2	2	7.5	15.4
DVG	3	1	7.0	15.6
DVG	3	2	12.5	15.4
EDG	1	1	13.0	18.7
EDG	1	2	13.5	18.8
EDG	2	1	18.5	24.2
EDG	2	2	11.0	15.8
EDG	3	1	18.5	16.1
EDG	3	2	12.5	15.1
FIS	1	1	18.5	24.6
FIS	1	2	15.0	24.7
FIS	2	1	16.5	30.3
FIS	2	2	16.0	25.6
FIS	3	1	12.0	19.3
FIS	3	2	9.0	20.5
FTN	1	1	6.5	24.5

FTN	1	2	6.0	22.2
FTN	2	1	5.5	23.1
FTN	2	2	4.5	20.9
FTN	3	1	6.5	24.3
FTN	3	2	5.5	25.7
GLA	1	1	14.0	22.0
GLA	1	2	13.0	21.6
GLA	2	1	20.0	19.5
GLA	2	2	13.0	19.7
GLA	3	1	16.5	17.6
GLA	3	2	19.0	17.8
HAR	1	1	24.5	21.9
HAR	1	2	15.0	17.3
HAR	2	1	25.0	19.3
HAR	2	2	28.5	21.3
HAR	3	1	20.5	19.4
HAR	3	2	20.0	23.3
HIG	1	1	7.5	21.4
HIG	1	2	5.5	21.7
HIG	2	1	9.0	22.2
HIG	2	2	9.0	24.1
HIG	3	1	6.5	24.2
HIG	3	2	6.0	20.4
MIN	1	1	25.0	18.5
MIN	1	2	14.5	21.3
MIN	2	1	16.0	17.8
MIN	2	2	20.5	20.3
MIN	3	1	8.0	23.3
MIN	3	2	20.5	20.4
MOO	1	1	8.0	11.9
MOO	1	2	12.5	11.7
MOO	2	1	12.5	13.9
MOO	2	2	15.5	11.9
MOO	3	1	9.0	17.8
MOO	3	2	5.5	12.8
MOR	1	1	5.5	14.5
MOR	1	2	6.0	11.8
MOR	2	1	12.5	21.7
MOR	2	2	11.5	20.2
MOR	3	1	12.5	18.2
MOR	3	2	12.5	18.8
NOT	1	1	14.5	25.8
NOT	1	2	15.0	24.6
NOT	2	1	10.0	22.9
NOT	2	2	7.5	22.4
NOT	3	1	10.0	21.1
NOT	3	2	15.5	18.7
PAS	1	1	15.0	22.8
PAS	1	2	10.5	20.1
PAS	2	1	8.5	21.6
PAS	2	2	12.5	25.0
PAS	3	1	11.5	22.7
PAS	3	2	12.5	21.9
PET	1	1	12.5	23.9
PET	1	2	10.0	26.5
PET	2	1	12.5	24.6

PET	2	2	7.5	24.3
PET	3	1	10.5	24.5
PET	3	2	12.5	24.4
POP	1	1	6.5	22.0
POP	1	2	7.0	21.3
POP	2	1	6.5	18.4
POP	2	2	5.0	16.8
POP	3	1	5.5	24.3
POP	3	2	7.5	25.2
POR	1	1	13.5	25.5
POR	1	2	16.5	25.3
POR	2	1	16.0	25.7
POR	2	2	11.5	23.3
POR	3	1	14.0	20.1
POR	3	2	11.0	22.1
RED	1	1	6.5	22.7
RED	1	2	7.5	23.4
RED	2	1	10.0	23.4
RED	2	2	7.5	24.2
RED	3	1	10.0	26.9
RED	3	2	9.0	27.0
TAT	1	1	6.5	19.9
TAT	1	2	7.0	18.8
TAT	2	1	8.0	20.8
TAT	2	2	9.0	23.2
TAT	3	1	8.5	21.0
TAT	3	2	7.0	20.3
TOB	1	1	12.5	27.7
TOB	1	2	9.0	27.5
TOB	2	1	15.0	28.4
TOB	2	2	10.0	27.3
TOB	3	1	12.5	27.2
TOB	3	2	10.0	27.4
YPT	1	1	8.5	19.5
YPT	1	2	11.0	18.7
YPT	2	1	5.5	19.7
YPT	2	2	12.5	19.4
YPT	3	1	5.5	20.6
YPT	3	2	7.0	18.7
YRK	1	1	8.0	18.8
YRK	1	2	11.0	19.6
YRK	2	1	10.0	16.8
YRK	2	2	10.5	20.0
YRK	3	1	7.0	16.7
YRK	3	2	10.0	15.3