DOFAW - HFCI

FOREST INVENTORY MANUAL

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Department of Land and Natural Resources

Division of Forestry and Wildlife

Planning and Information Services

SECTION 1

DOFAW-HFCI FOREST INVENTORY BACKGROUND AND OBJECTIVES

Between 1997-2000 the Division of Forestry and Wildlife (DOFAW) and the Hawaii Forestry and Communities Initiative (HFCI) cooperatively conducted several timber inventory projects throughout Hawaii. This document was designed as a training and reference manual for crews conducting the field measurements during that period. Concepts such as forest type mapping the use of geographic information systems, data compilation, statistical analyses and reporting are not addressed here.

The principal objective of this field survey methodology is to collect data that can be used in the development and management of timber resources. Field survey work provides managers with information such as species composition, wood volume, grade or quality of the wood volume measured. The survey is designed to allow future remeasurement of established plots, which could be used to provide estimates of forest growth and changes in timber volume over time.

SECTION 2

PHOTO AND MAP INTERPRETATION

Photo interpretation and map reading of survey areas can supply important information about survey areas and their associated forest resources. Photo interpretation involves the identification of objects from their photographic images. A vertical aerial photo provides the photo interpreter with an image of ground features. A stereoscopic pair of vertical aerial photos can be used to view images in 3-D.

Aerial photo interpretation is in part an art. The amount of information obtained from aerial photos is a function of the ability and experience of the interpreter, as well as photo quality. All crew members are encouraged to continuously improve their abilities during the course of the survey. One of the best means for improving photo interpretation skills is by frequent and careful study of photo features while comparing them in the field with the ground features they represent.

Map interpretation: Review U.S. Geological Survey (USGS) quadrangle map symbology to become familiar with the following map items. Try to identify mapped objects on corresponding aerial photos.

Scale	Open areas	Hydrology
Contour intervals	Roads	Structures
Forest areas	Preserve boundaries	North arrow

Map scales can be provided in two forms. Map:ground ratios indicate how a measured unit on the map is converted to ground distance. The USGS quad maps we use are 1:24,000, indicating that one unit (e.g. inch) of distance measured on the map is the equivalent of 24,000 units on the ground. A second form are scale bars, which are graphical representations of scale ratios in common units of measure, such as miles, feet, or kilometers.

For example, assume you measure a distance of 4.5 inches on a map with a scale of 1:24,000. What is the corresponding ground distance? At the given scale, 4.5 inches on the map x 24,000 = 108,000 inches, or 9,000 feet on the ground.

Cruise base map: Each project area should be shown on a master base map. Map information should include roads, streams, Forest Reserve boundaries, color coded forest types, and all potential inventory plot locations. At the end of each day, crew leaders should add notes directly to this map showing which plots were measured, what the access starting point was (e.g. 12" Ohia), azimuth followed, and distance to the plot. This map should **always** remain at the office.

Field maps and aerial photos: Each crew should carry USGS quad maps, a copy of timber stand or type maps, and color infra-red aerial photos. These materials should assist in field referencing

your ground location while accessing inventory plots. Maps and photos should be carried in water resistant plastic sleeves.

Field exercises: The goal of these exercises will be to begin recognizing vegetation types as seen on aerial photos. First, select several areas on photos which appear to represent different vegetation types, and follow up with close examination of these areas in the field. When in the field, try to relate photo features to vegetation and other land features on the ground.

SECTION 3

SURVEY METHODOLOGY AND FIELD PROCEDURES

This survey method employs a systematic sampling design. Use a grid map overlay for each project area, with one potential field plot location for every 5 acres of land. The project coordinator should systematically select approximately 30 plots in each cover type for you to sample. Data from main plot trees will be used to estimate merchantable tree volume. Data from sub plots will be used to provide information on low stature vegetation and tree regeneration. Additional sample indices (e.g. soil, pest/disease problems, etc.) may be specified for collection by the project coordinator in relation to unique project goals.

3.1 Crew structure

Timber inventory field work should be conducted by two-person crews. Overall organization and leadership for the inventory team should be the responsibility of the project coordinator. Crew leaders should be directly responsible for daily field work organization and implementation. Each crew should have one forest technician working under the direct guidance of their crew leader. It is extremely important that crews function as a team. Though crew leaders make decisions and provide direction in the field, all members of the crew are expected to learn and perform all inventory tasks throughout the cruising season. Crew assignments are not fixed, and may be adjusted as specific circumstances arise over the inventory season.

3.2 Accessing Plots

Detailed cruise maps are to be used in determining starting points, azimuths, and distances to target plot locations.

Truck: Plan your road access route prior to leaving the office. As you become more familiar with roads that are passable, crew leaders may want to highlight them on the base map, and flag intersections in the field. **Never** use 4WD to get into your starting point when road conditions degrade, only use 4WD to get out if you are stuck. The time you save trying to force your way driving a few hundred feet further on an overgrown or poor road instead of walking is **zero**. Calling for help if you get stuck is embarrassing, and an immense waste of time and money.

Ground: Each plot has a "starting point," defined as the point where an "access line" drawn from your plot location intersects the nearest road , trail, or prominent geographic feature. Drive to the starting point if practical. If driving is not possible, park and proceed on foot. In most cases, you must measure (by taping) the distance from a known geographic feature (major intersection, fence corner, bridge, etc.) to your starting point to insure that you are in the correct field location. Use your cruise map to keep track of your progress between road intersections or other known points - this should help insure you are in the correct location.

Starting point: At the starting point, find the nearest highly visible large tree or rock (within 20 feet), and paint the following information:

Information	Example
1. Plot ID	574218
2. Azimuth	247
3. Feet to plot	720

Note the distance and direction from the marked object to the starting point on the plot data form. Use a pen to put the same information on flagging where the access line enters the forest.

Access line: Using compass and tape, navigate along the access line at the appropriate azimuth and distance . At regular intervals, paint X marks on trees along access line, especially in the first 50 feet. Also hang a piece of flagging at every 100 foot interval, with total distance from the starting point written on it. This could assist in future location of the access line if the road has been widened, or the starting point can't be found. While accessing plots, painting occasional X marks on the back side of trees may expedite your exit from the plot (if you plan to follow the same line out).

3.3 Measuring Plots

Establishing plot center: Once the crew has traveled the specified azimuth and distance, pound in a short galvanized pipe to mark plot center. Do not shift this location from the measured point for any reason, otherwise serious measurement bias could be introduced into the survey. Paint reference "X" marks on four objects within six inches of the ground near the pin such that a tape drawn between opposite pairs of marks passes within six inches of plot center.

Plot size: Each main plot will be either 1/5 acre (radius = 52.66 feet) or 1/10 acre (radius = 37.24 feet), while each sub-plot (nested within main plot) will be 1/20 acre in size (radius = 26.33 feet). Use a 100 foot tape or fixed-length cord while measuring trees to determine whether borderline trees are in or out of the plot. "Out" trees should be marked with an X.

Measuring trees: Starting from due North, measure and record all trees which are at least partially living (green cambium), in a clockwise manner around the plot. Only species defined as trees in stature are measured and recorded. Measure diameter at breast height (DBH, or 4.5 feet above ground) to the nearest $1/10^{th}$ of an inch. Identifying DBH position may be modified based on tree form or topography (Section 4), and is measured using a tape on **every** tree. All trees on the main plot 5.6 inches or larger at DBH should be recorded on the plot data form. Paint the tree number and location of DBH measurement on each tree, facing plot center. Height, form, and defect information is collected for every fifth tree of **each** species on the plot (tree 1, 6, 11, etc. if only one species is encountered on plot). Use the dot tally system to record all trees which range from 1.6-5.5 inches DBH in the sub-plot section of the form. Do not assign a tree number to sub-plot trees, but mark a line at DBH. Make a separate tally of any dead or down koa trees having DBH 11.6" or more on the main plot.

Important! If you encounter an unusual situation and are unsure how to measure a tree properly,

take several alternative measurements. Be careful to record what each measurement represents, and bring the information back to the office. We can then discuss each unique case and decide which data to use, while avoiding the need to return to the plot to measure the tree again.

Just prior to leaving a completed plot, review plot data form to insure all data have been properly collected and recorded. Also check to make sure you have collected all of your equipment. Appendix F provides a condensed outline of a daily work routine for forest inventory crews.

SECTION 4

EQUIPMENT OPERATION AND FIELD TECHNIQUES

The survey crew should learn and practice the following information during classroom and field training. Use this section as a reference guide during field work if needed. A typical forest inventory equipment list is provided in Appendix E.

4.1 Pacing and taping distances

Pacing: Pacing can be very useful in keeping track of your ground progress on maps or photos. One step is half of a pace, two steps is one pace. Practice pacing on flat open ground. Record the number of paces required to cover 100 feet of horizontal distance three or more times and take an average. This is your individual pace number. Repeat the exercise in flat, uphill, and downhill zones of forested areas. Note how your pace number may change depending on terrain. Some people prefer to compensate for such differences by stepping out more or less, while others add or subtract paces or half-paces from their pace number.

Taping: Taping is a more accurate measure of horizontal distances. Taping along road grades or through forested areas is most efficiently conducted by two people. The lead person uses visual or compass sighting to select a target direction, and pulls the tape end towards that point so that the tape does not wander or bend off course. The trailing person holds the tape spool, and stops the lead taper when the desired distance is reached. Over long distances, measure legs of 50 or 100 feet, depending on visibility. Both people communicate total distance traveled at the end of each leg - this helps insure that the correct total distance count is maintained.

4.2 Compassing

Use compasses primarily for determining bearings to plots through the forest, and recording plot aspect. Use the azimuth scale of our compasses. Azimuth direction is expressed in degrees: North at 360 (zero) degrees, East at 90, South at 180, and West at 270. Compasses have been calibrated to compensate for magnetic declination, or the local difference between magnetic and true north. Local magnetic north varies from 11 degrees east of true north on the Big Island to 11½ degrees East of true North on Kauai. Once set, this adjustment should **never** be changed.

Direction: Select the desired bearing in degrees on the azimuth dial. Hold the compass at eye height, making sure it is level with the ground. With practice, you will know when the compass is reasonably level by seeing the needle floating freely in the mirror. Rotate your position until the floating needle is aligned with the orienting red arrow. Now that you are facing the desired bearing, look through the sight and select a target object. Advance to the target and repeat the above procedure.

Aspect: Determine which direction is directly down hill from plot center. While pointing the sight in that direction, turn the azimuth dial until the red arrow on the compass case is aligned with the floating needle. Again, the compass must be held horizontally for a proper reading. Read the resulting azimuth value and record on the plot data form, to the nearest whole percent. Aspect should be recorded to the nearest of eight directions: N, S, E, W, NE, SE, NW, SW. This same procedure can be used to determine the azimuth to any desired target object, such as a tree, from your standing location.

4.3 Species Identification

All crew members are required to have basic tree and plant identification skills. Appendix A summarizes the species and associated plot form codes that each crew member should become familiarized. As new species are encountered, the list can be updated as appropriate. If there is a tree which is difficult to identify, take and record measurements normally, and bring a leaf/branch sample back to the office to receive help in identifying it.

Native, threatened and endangered, and noxious weed species: Indicate the presence of these species by listing their name in the notes section of the plot data sheet. The project coordinator should offer guidelines for which species are likely to be found in the project area.

4.4 DBH

In forest inventory work, tree diameter has been traditionally measured 4.5 feet above the ground, a point defined as diameter at breast height (DBH). The exact position of DBH is also dependent of individual tree form and topography (Figure 4.1). Diameter tapes are used in the following manner:

1. Stand on the uphill side of tree, and measure height to DBH on **every** tree. This height is defined as 4.5 feet above the forest floor, or 4.5 feet above the root crown if the root crown is exposed.
2. Hold the tape roll in your left hand, reach behind tree with right hand to pull tape end around to the front of the tree, at measured DBH level.
3. Pull tape back and forth to ensure proper alignment on tree trunk, and pull both ends tightly so that they cross over on the front side of the tree. The tape roll end should always be on top.
4. Read tape to nearest 0.1 inch increment.

4.5 Borderline trees

Accurate determination of whether a borderline tree is inside or outside the plot measurement area is critical for quality control. In the case of 1/5 acre fixed radius plots (radius = 52.674 feet) the center point of the tree trunk just above the root collar must be less than 52.7 feet from plot center for the tree to be considered in. On slightly sloping ground, hold a 100 foot tape

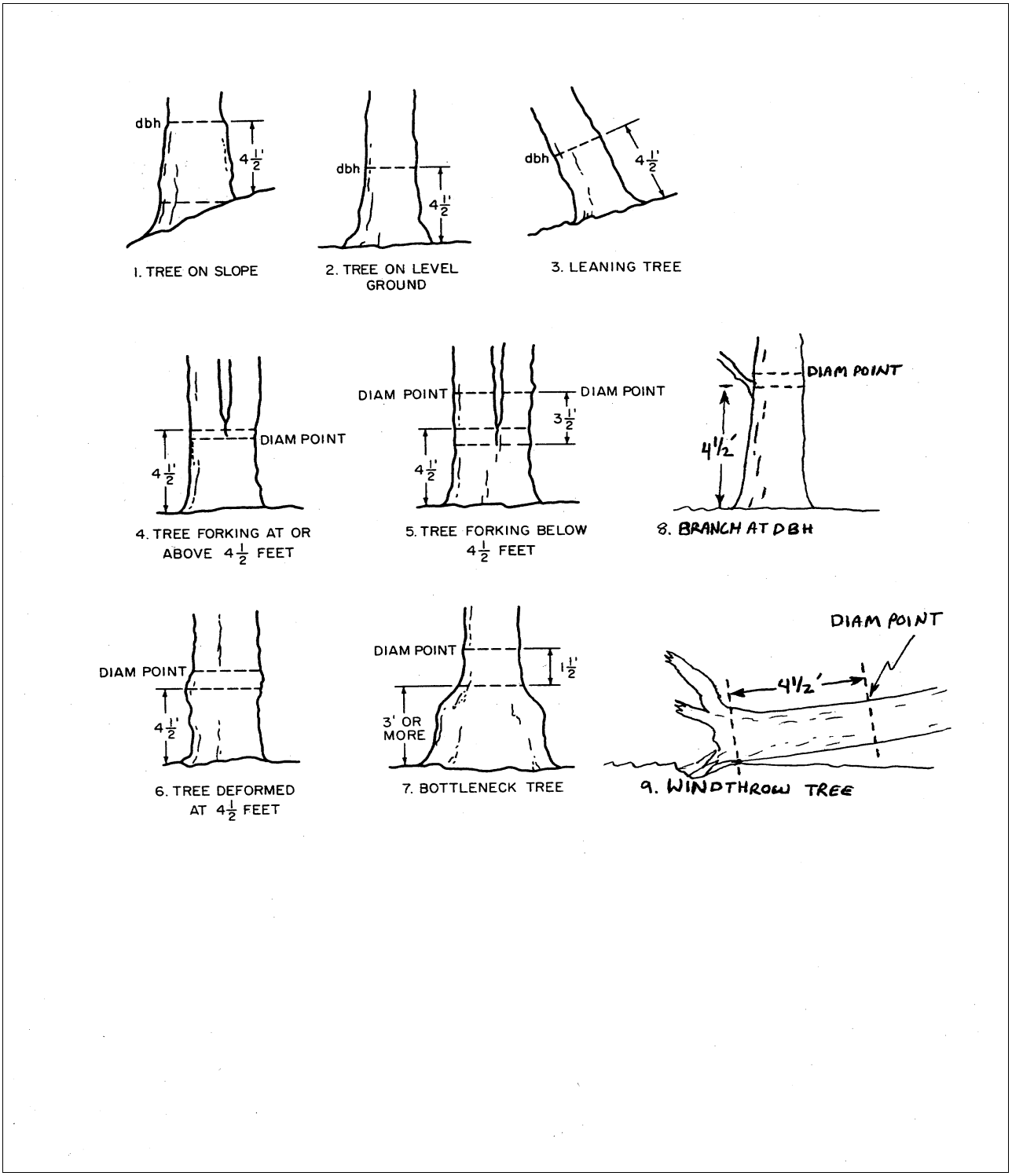


Figure 4.1 DBH measurement as modified by topography or tree irregularities. Reprinted from Forest Measurements by T. E. Avery, and H. E. Burkhart, 1983.

horizontally to see if lower trunk is in. On slopes of 5% or greater, we need to correct the distance measured to the tree. The mathematical function describing this correction is:

horizontal distance = (feet along slope) x (Cosine (ArcTangent (slope percent))

Appendix B contains correction values for the most commonly encountered slope conditions. First determine slope from plot center to the tree in question. Standing over plot center, sight your clinometer on the tree in question at the same height as your eye level. Your partner can either measure this distance on the tree trunk for you, or you may have him/her stand next to the tree, and sight on their profile at your known eye height. Second, find the slope correction value in Appendix B, and use the corresponding slope distance to measure from the plot center pin to the center of the tree just above the root collar. Paint an X on borderline out trees.

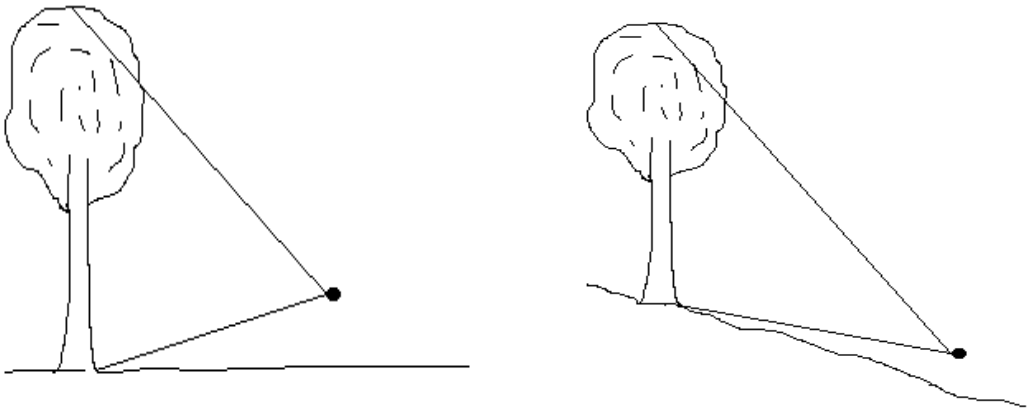
4.6 Clinometer use for tree heights

For this survey method, height measurements are collected for every fifth tree of each species encountered on the plot. For each "height" tree, measure total height, or the distance from the top of the crown to the ground. Tree height determination requires clinometer readings of both tree top and base levels. If the measurers eye level is above tree base level, the two instrument readings will be opposite in sign, and must be added to obtain total height (Figure 4.2 A). If the measurers eye level is below tree base level, the two instrument readings will have the same sign, and the base value is subtracted from the top value (Figure 4.2 B).

The Suunto Clinometers which we use have two scales - the left is percent, the right is topographic. The distance of the measurement point from a specified tree depends on the scale chosen. Standard distances, and the percent scale are recommended for this survey. The percent scale (left scale as seen in the viewer) should be read at 50 or 100 feet from the center of the tree trunk. Readings from 100 feet are more accurate than from 50 feet. If lines of sight to the tree top or base are obscured by other vegetation from the 100 foot position, change to 50 foot distance. From the 100 foot position, the scale readings in percent represents tree height in feet. From the 50 foot position take top and bottom readings and add or subtract as described above. However, the final value is then divided by 2 to get the correct total height value. Read clinometer scales to the nearest whole increment.

To give examples, assume a top reading of 58 and a bottom reading of -9 from a position as illustrated in Figure 4.2A. If these readings were taken from a 100 foot distance, tree height would be 58 + 9 = 67 feet. If the same readings were observed from a 50 foot distance, tree height would be (58 + 9) / 2 = 33.5 = 33 feet. If top and bottom readings were 46 and 4 from a position as illustrated in Figure 4.2B, tree height would be 46 - 4 = 42 feet if measured from a 100 foot distance.

Tree lean can introduce error into height measurements. To avoid this error, stand in a position which is perpendicular to the leaning plane of the tree. When deciding which direction from



A **B**

Figure 4.2. (A) Height reading from above tree base level: add base reading to top reading. (B) Height reading from below tree base level: subtract base reading from top reading.

which to take height readings, get in the habit of simultaneously accounting for tree lean and clear viewing planes. A second source of error is difficulty in sighting the actual tree top. As apparent in Figure 4.2, there may not be a clear line of sight to the true top of a tree having a wide canopy. In such cases, it is up to the cruiser to judge whether they are looking at the true tree top or not. If not, they must then estimate where the actual tree top is and sight a lower angle which passes through part of the canopy edge, as illustrated.

Clinometer readings based on the percent scale assume that the measured distance from the tree to instrument location represents true horizontal distance. If slope exceeds 10%, use the procedure outlined in Appendix C to correct your distance from the tree base along the slope. For example, measuring a height from a 100 foot distance on a 20% slope requires a clinometer location of 100/.981 = 101.94 feet along the slope. You can also estimate the correction factor by interpolation if your exact slope value is not listed in Appendix C. Slope correction factors are applied identically in both up-hill and down-hill viewing situations.

4.7 Log form and defect

Form: Trees which have highly unusual form should be described in the notes section of your plot form. If there is significant volume in a separate trunk or branch, take extra measurements, and bring the data back to the office for discussion.

Defect: For every fifth tree of each species (" height" trees), visually separate the total height of the tree into 3 equal sections. Starting at the bottom third, record the amount of gross cubic

volume which is defective, or non-merchantable wood, rounded off to the nearest 5%. For example, if you estimate a particular section to have 13% defect, record 15 (no percent symbol needed). Record values for the middle and top thirds next. If a particular section is completely sound, you must record a 0 in the appropriate space. Use Appendix D as a guide to estimating defects.

Special condition: Though defect and height are typically measured on the fifth tree of each species, we need to record broken tops for **every** plot tree. Such trees are recorded separately from your normal defect tally. Broken top should be recorded when main stem diameter undergoes a significant change due to breakage or shearing. For these trees, measure the height to the break point, record this value, **and circle it**. Furthermore, try and visualize how tall the tree was originally, split the estimated total height into three sections and record defect for each section. For example, a 14 inch ES tree is broken at 60 feet, but otherwise has no defects. The stand around it is about 120 feet tall. Record height as 60 and circle it. Defect values should be approximated at 0/45/100. Half of the middle third is gone, but the bottom half remains, containing a little more than half the total cubic volume of that section. If regrowth above the break contains at least one 12" diameter log which is 16' in length, record it as a separate tree and make a record of this condition in the notes section. All smaller regrowth should be disregarded.

4.8 Plot data form

The first page of the plot data form should be filled out immediately after plot center has been established. Record stand and plot number, the object used as the starting point, and date. List aspect, slope, and all crew initials - circle initials of crew member who is the cruiser on that particular plot. List the species code for the three most dominant tree species in the stand (within a few hundred feet of the plot), in order of decreasing abundance. Type class categories will be defined for each particular project site. List the species code for the three most dominant understory and groundcover species in the stand (again, within a few hundred feet of the plot). Species codes are provided in Appendix A. Circle the appropriate weather code as follows:

Code	Description
1	Clear/Sunny
2	Overcast
3	Light rain
4	Heavy rain

If a plot straddles two forest types, a sketch map of the plot is required in the notes section of the plot data form. Draw a circle, sketch in at which two points the forest type line crosses the plot perimeter, along with azimuth to those points from plot center. Sketch in the shape of the type boundary within the plot, and record other features such as streams, roads, or buildings. Use the same plot data form to record tree and plant related information for the two different forest types, but be absolutely certain to note which main- and sub-plot tree stems are in each type. Crew

leaders are also requested to take notes on changes in forest types through the course of the work day. Use sketches, and approximate distances when recording notes, and transfer the information to the base map each afternoon. The project coordinator should periodically collect this information to update the project forest maps.

For the sub- and main-plot tally sections, follow the procedure outlined in section 3. For main-plot trees, crown class codes are defined as follows:

Class	Description
1	**Dominant** - Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, with crowns well developed but possibly somewhat crowded on the sides.
2	**Codominant** - Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with medium-size crowns but more or less crowded on the sides.
3	**Intermediate** - Trees shorter than class 1 or 2, but with crowns either below ore extending into the crown cover formed by class 1 or 2 trees, receiving little direct light from above and none from the sides; usually with small crowns considerably crowded on the sides.
4	**Overtopped** - Tress with crowns entirely below the general level of the crown cover, receiving no direct light either from above or from the sides.

These are crown class descriptions as defined in Forest Measurements by T. E. Avery, and H. E. Burkhart, 1983.

4.9 Vehicle operation and maintenance

Each project should provide procedures for vehicle operations, maintenance, and repairs.

4.10 Soil classification

Some projects may require collection of basic soils data. If so, a specific data collection format should be provided by the project coordinator. Some general soils background is provided here.

A'a and Pahoehoe: A'a has an angular cobble layer over dense blue rock; landscapes have complex slopes. Pahoehoe has a smooth surface and generally consists of many thin (less than one foot thick) layers; landscapes have simple slopes. Soils developed in A'a generally have more than 35% coarse fragments; those in Pahoehoe generally have less than 35% coarse fragments.

Horizon: Horizons are soil "layers" that form through specific processes. O horizons consist primarily of organic materials on or near the soil surface. Organic soils have O horizons formed mainly in organic materials. Topsoil consists of A horizons that are zones of organic matter accumulation in a mineral soil. B horizons occur below A horizons and show signs of weathering (reddish color). C horizons are below B horizons and have minimal weathering. A'a clinkers are considered C horizon material. R horizons are solid rock, know as "parent material."

Depth: The average depth of each horizon.

Range: The range in depth observed for each soil horizon.

Color: Soil color can be determined by using Munsell Soil Color charts. Color can indicate organic matter accumulation, degree of weathering, drainage conditions and other properties.

Texture: The percent sand, silt and clay in the soil, which can be estimated by feel at different moisture states. Higher amount of organic matter makes texture feel like soil has more silt. Sand feels gritty, silt feels slick or buttery, and clay fells sticky and plastic.

SECTION 5

GENERAL SURVEY GUIDELINES

Safety: Conditions for timber cruising in Hawaii can be extremely challenging. All crew members should wear sturdy boots, hard hats, safety glasses, and carry rain gear at all times. Rushing in this type of terrain will inevitably lead to injury. Crew leaders should exercise caution in committing crews to starting a new cruise line late in the afternoon to avoid unnecessary rushing. Be watchful of twigs and branches which may cause eye injury - especially when stepping up to trees which retain their dead small branches. Crew leaders should post which plots (in order) are to be cruised each morning, on a crew job board at the office. High quality insect repellent may be useful. Each crew should carry a basic first aid kit in the field, as well as a hand radio. In the unusual event that a crew is caught in the woods after dark, select a spot to wait for daylight. Traveling through mountainous forests at night is dangerous and disorienting.

Equipment maintenance: An inventory of all equipment should be maintained by crew leaders. This should include two complete sets for cruising, as well as backup equipment. Dry off all equipment after returning from wet field conditions, and oil metal pieces. Report all damaged equipment **immediately** to the project coordinator.

Quality control: The total area of all plots measured in this survey methodology represents a very small fraction of the total forest area. For this reason, the effect of a single error on one plot could have a heavy impact on the accuracy of the survey as a whole. It is clear that reliable answers to questions regarding forest management require precise measurements by capable people to keep field errors to a minimum. A program of field checks should be implemented to insure that field work is being performed accurately. This program will help

1) to obtain uniform and consistent interpretation and application of field instructions by all field crew members
2) to hold technique errors to a minimum
3) to reveal inadequacies in the instructions and in the training program.

To meet these goals, the project coordinator should selectively accompany crews to monitor and assist in improving field techniques. With the assistance of crew leaders, the coordinator should also conduct random inspections by remeasuring completed inventory plots to identify items in error or potential disagreement. Such items should be analyzed and discussed with the crew involved, and measures taken to prevent recurrence in the future.

APPENDIX A: Timber inventory tree and plant list. Last updated 1/21/99

IMPORTANT COMMERCIAL TIMBER SPECIES

Latin genus and species	Common name	Species code
Acacia Koa	Koa	AK
Eucalyptus camaldulensis	Red river gum	EU
Eucalyptus citriodora	Lemon-scented Gum	EC
Eucalyptus crebra	Narrow-leaved red ironbark	EA
Eucalyptus deglupta	Mindanao Gum	ED
Eucalyptus globulus	Blue Gum	EB
Eucalyptus grandis	Rose Gum	EG
Eucalyptus microcorys	Tallow-wood	EM
Eucalyptus paniculata	Grey Ironbark	EN
Eucalyptus pilularis	Blackbutt	EP
Eucalyptus robusta	Swamp Mahogany	ER
Eucalyptus rudis	Western Australian flooded gum	EI
Eucalyptus rostrata	Red River Gum	EO
Eucalyptus saligna	Sydney Blue Gum	ES
Eucalyptus sideroxylon	Red Ironbark	EE
Eucalyptus mixed	Mixed Eucalypts	EX
Flindersia brayleyana	Queensland Maple	FB
Fraxinus uhdei	Tropical Ash	FU
Grevillia robusta	Silk Oak	GR
Lophostemon confertus	Brushbox	LC
Metrosideros polymorpha	Ohia	MP
Pinus elliottii / caribaea	Slash Pine	PE
Pinus pinaster	Cluster Pine	PP
Pinus radiata	Monterey Pine	PR
Pinus taeda	Loblolly Pine	PT
Pinus mixed	Mixed Pines	PX
Toona ciliata	Australian Red Cedar	TC

OTHER TREE SPECIES

Latin genus and species	Common name	Species code
Acacia melanoxylon	Blackwood	AM
Agathis robusta	Kauri	AR
Albizia saman	Monkey Pod	AS
Aleurites moluccana	Kukui	AO

Latin genus and species	Common name	Species code
Alnus nepalensis	Nepal Alder	AN
Alphitonia ponderosa	Hawaiian Kauila Tree	AP
Araucaria bidwillii	Bunya Bunya	AB
Araucaria excelsa	Norfolk Island Pine	AE
Calophyllum inophyllum	Kamani	CI
Cardwillia sublimes	Australian bull oak	CW
Casuarina cunninghamiana		CC
Casuarina equisetifolia	Ironwood	CE
Cedrela odorata	Spanish Cedar	CO
Chamaecyparis lawsoniana	Port Orford Cedar	CL
Cordia subcordata	Kou	CS
Corynocarpus laevigata	New Zealand Laurel	CR
Cryptomeria japonica	Sugi	CJ
Cunninghamia lanceolata	China fir	CL
Cupressus macrocarpa	Monterey cypress	CM
Eriobotrya japonica	Loquat	EJ
Ficus spp.	Figs	FIG
Liriodendron tulipifera	Yellow poplar	LT
Mangifera indica	Mango	MI
Melaluca quinquenervia	Paper Bark	MQ
Parasarianthes falcataria	Molucca Albizia	PF
Persea americana	Avocado	PA
Podocarpus neriifolius	Podocarpus	PN
Pritchardia spp.	Loulu	LOULU
Quercus suber	Cork Oak	QS
Santalum spp.	Sandalwood	SL
Schinus terebinthifolia	Christmas berry	ST
Sequoia sempervirens	Redwood	SS
Spathodia campanulata	African Tulip Tree	SC
Syzygium cumini	Java Plum	SY
Syzygium jambos	Rose Apple	SJ
Terminalia myriocarpa	Jhalna	TM
Thespesia populnea	Milo	TP
Thuja plicata	Western Red Cedar	TJ
Trema oriantalis	Gunpowder Tree	TO
Zanthoxylum dipetalum	Kawa’u	ZD

COMMON UNDERSTORY SPECIES

Latin genus and species	Common name	Species code
Acacia confusa	Formosa Koa	AC
Acacia mearnsii	Black Wattle	AW
Broussaisia arguta	Kanawao	BA
Cecropia obtusifolia	Trumpet Tree	CT
Cheirodendron trigynum	Olapa	CH
Cibotium spp.	Hapu'u, Tree Ferns	HAPUU
Clermontia spp.	'Oha wai	OHA
Clidemia hirta	Koster's Curse	CA
Gouldia affinis	Manono	MANONO
Ilex anomala	Kawa'u	KAWAU
Leucaena leucocephala	Haole koa	LL
Melochia umbellata	Melochia	MU
Olea europaea	Olive	OE
Pelea clusiifolia	Alani	ALANI
Perrottetia sandwicensis	Olomea	OLOMEA
Psidium spp.	Waiawi 'ula'ula, Strawberry Guava	WAIAWI
Psychotria spp.	Kopiko	KOPIKO
Sadleria cyatheoides	Amu'u	AMU'U
Schefflera actinophylla	Octopus Tree	SA
Tibouchina urvilleana	Lasiandra	TU

COMMON GROUNDCOVER SPECIES

Latin genus and species	Common name	Species code
Ageratum spp.	Maile Hohono	AA
Angiopteris spp.	???	AG
Cuphea spp.	???	CC
Desmodium spp.	Tick Clover	DD
Dicranopteris linearis	Uluhe	ULUHE
Dodonea viscosa	A'ali'i	DV
Freycinetia arborea	Ie'ie	IE'IE
Lantana camara	Lantana	LAN
Melastoma spp.	Melastoma	MEL
Melinis minutiflora	Molasses Grass	MM
Mimosa pudica	Sensitive Plant	MIM
Nephrolepis spp.	Sword Fern	SWORD
Oplismenus hirtellus	Basketgrass	OH

Orchidaceae	Orchid Family	ORCHID
Styphelia tameiameiae	Pukiawe	STY
Latin genus and species	Common name	Species code
Rubus spp.	Raspberry, Blackberry	RR
Setaria palmifolia	Palm Grass	SP
Stachytarpheta or Verbena ???	O'i	OI
Waiwaiole ???	Fern ???	WW

APPENDIX B: Slope correction values for borderline trees.

For 1/5 acre plots, where 0% = 52.66

Slope in Percent	Feet along slope	Slope in Percent	Feet along slope	Slope in Percent	Feet along slope
5	52.73	14	53.17	26	54.41
6	52.76	15	53.25	28	54.69
7	52.79	16	53.33	30	54.98
8	52.84	17	53.42	35	55.79
9	52.87	18	53.51	40	56.72
10	52.92	19	53.60	45	57.75
11	52.98	20	53.70	50	58.88
12	53.04	22	53.92	55	60.10
13	53.10	24	54.16	60	61.41

For 1/10 acre plots, where 0% = 37.24

Slope in Percent	Feet along slope	Slope in Percent	Feet along slope	Slope in Percent	Feet along slope
5	37.28	14	37.60	26	38.47
6	37.30	15	37.65	28	38.67
7	37.33	16	37.71	30	38.88
8	37.36	17	37.77	35	39.45
9	37.39	18	37.83	40	40.10
10	37.42	19	37.90	45	40.83
11	37.46	20	37.97	50	41.63
12	37.50	22	38.13	55	42.50
13	37.55	24	38.29	60	43.42

APPENDIX C: Slope correction factors for height tree determination.

Distance from tree along slope = desired horizontal distance / correction factor

Slope in percent	Correction factor	Slope in percent	Correction factor
10	0.995	24	0.972
12	0.993	26	0.968
14	0.990	28	0.963
16	0.987	30	0.958
18	0.984	35	0.944
20	0.981	40	0.928
22	0.977	45	0.912

APPENDIX D: Defect types and explanations.

Record defect deductions as percentage of section total, for bottom, middle, and top third of tree.

Code	Type	Notes
A	Butt swell	Often severe defect in koa or ohia, but minor in other species
B	New trunk scar	Surface related - usually less than 10% defect
C	Old trunk scar	Likely to have traveled from surface into center of log - major
D	Newly broken/dead top	Broken within last year, deduct no volume below break
E	Old broken/dead top	Broken one or more years ago, deduct volume below break
F	Crook or sweep	Deduct 5-20% of section if bucking won't help, more if severe
G	Fork	No deduction if sound, unless merch. length reduced below 8'
H	Fork with vegetation	Minor deduction for most species, major for koa and ohia
I	Fork with exudate	Minor deduction
J	Seams	Bark overgrown and tight, no deduction, otherwise up to 20%
K	Dead sucker limbs	Deduct percentage equivalent to approximately 4' of length
L	Rotten branch or hole	Deduct 1-10% depending on diameter of scar
M	Live branch/sound knot	No deduction
N	Conks	Deduct percentage equivalent to approximately 16' of length
P	Flutes	Deductions applied only if flutes cut into merch. cylinder

APPENDIX E: Daily checklist for timber inventory crew.

Plot data sheets

Tatum

Pencils, permanent markers

Galvanized pipe (1 for each plot plus one)

Hammer

Flagging rolls (2)

Diameter tape (2)

100 foot tape (2)

Compass (2)

Clinometer

Machete and sheath (1)

Pick

Shovel

Paint cans (3-4)

Photos and maps in plastic sleeves

Scaled ruler

Calculator

Inventory manual

Day pack (2)

Cruisers vest (2)

Saw

Radio and batteries

Matches and lighter

Flashlight and batteries

First aid kit

Water, lunch and rain gear

APPENDIX F: Forest inventory work sequence.

1. Plan route to plots day before: Use maps and aerial photos to evaluate road access routes, walking access routes, and forest/terrain type.

2. Collect gear: Use checklist before leaving office to make sure you bring all needed items. Check fuel/oil in vehicle.

3. Check out: Post work plan on crew job board at office daily.

4. Travel to starting point: Drive as near to plot as practical, using good judgement concerning poor roads, gates, alternate routes, etc. Pace and tape your way to cruise line starting point. At starting point compare photo and ground conditions to determine if you are in the right place.

5. Travel to plot: Select and mark starting point. Tape and traverse from starting point to plot. Two people compass and tape - lead person reads compass course, rear person checks course and keeps track of total distance traveled. Both people frequently call out distances traveled.

6. Work on plot: Check field location on photos. Establish and mark plot center. Recorder stays at plot center and helps pass radius measuring tape to cruisers as work progresses. Cruiser measures trees in a clockwise direction starting from due North. As cruisers measure trees and call out tree information, the recorder **must** read back the information while writing on the plot data sheet. This is an important step in reducing error during data collection.

7. Leave plot: Before leaving plot, carefully inventory your equipment! Check plot data form to see that **all information** is complete. Continue to next plot, or exit field and return to office at end of day. Check back in on crew job board at office. Clean, dry or oil equipment before leaving for day.

PLOT DATA FORM

Stand / Plot ID	/
Starting point	
Date	/ /
Aspect / Slope	/
Crew initials	

Overstory	/ /
Type class	
Understory	/ /
Groundcover	/ /
Weather	1 2 3 4

SUB-PLOT TREE TALLY

Notes:

Species	1.6-3.5"	3.6-5.5"	Species	1.6-3.5"	3.6-5.5"

Notes:

MAIN PLOT TREE TALLY

No	Spp	Cc	DBH	Ht	Low/Mid/High	No	Spp	Cc	DBH	Ht	Low/Mid/High
1					/ /	16					/ /
2					/ /	17					/ /
3					/ /	18					/ /
4					/ /	19					/ /
5					/ /	20					/ /
6					/ /	21					/ /
7					/ /	22					/ /
8					/ /	23					/ /
9					/ /	24					/ /
10					/ /	25					/ /
11					/ /	26					/ /
12					/ /	27					/ /
13					/ /	28					/ /
14					/ /	29					/ /
15					/ /	30					/ /

MAIN PLOT TREE TALLY - SUPPLEMENTARY PAGE

Stand / Plot ID	/

No	Spp	Cc	DBH	Ht	Low/Mid/High	No	Spp	Cc	DBH	Ht	Low/Mid/High
31					/ /	63					/ /
32					/ /	64					/ /
33					/ /	65					/ /
34					/ /	66					/ /
35					/ /	67					/ /
36					/ /	68					/ /
37					/ /	69					/ /
38					/ /	70					/ /
39					/ /	71					/ /
40					/ /	72					/ /
41					/ /	73					/ /
42					/ /	74					/ /
43					/ /	75					/ /
44					/ /	76					/ /
45					/ /	77					/ /
46					/ /	78					/ /
47					/ /	79					/ /
48					/ /	80					/ /
49					/ /	81					/ /
50					/ /	82					/ /
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55					/ /	87					/ /
56					/ /	88					/ /
57					/ /	89					/ /
58					/ /	90					/ /
59					/ /	91					/ /
60					/ /	92					/ /
61					/ /	93					/ /
62					/ /	94					/ /