INVENTORYING FOREST RESOURCES

STANDARD OPERATION PROCEDURES

Wrangell-St. Elias National Park and Preserve

Glennallen, Alaska 99588

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prepared by Kathryn Anna Beck

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INTRODUCTION

The purpose of these standard operating procedures is to establish a basic forest resource inventory methodology for future inventories as well as to provide instruction for those unfamiliar with forest inventory procedures. Furthermore, the outlining of considerations and procedures used in planning a forest inventory allows other inventory designs or methodologies to be employed to accomodate specific data needs and unique forest resource areas.

Important factors to be considered in planning and organizing a forest resource inventory include, the length of the season available to do fieldwork, types of access required, and the estimated project cost. The number of personnel needed for the project should be considered as well as the level of experience these individuals should possess. Equipment necessary for sampling should be available and in good repair.

The approximate size of the area to be sampled needs to be determined. The use of a clear dot grid placed over a map or photo can help estimate timber stand acreage. The objectives of the study, inventory and statistical methodology, the parameters to be estimated and the precision desired should be clearly identified and stated before fieldwork begins. Eg.: The objective of the inventory is to determine volume, current annual productivity and density of the Batzulnetas timber stand with a 80 % level of confidence. The study population should be defined. Is the timber to be inventoried considered one stand of trees or would the study area be more appropriately divided into several strata or timber types. If the variation among stands within timber types is less than the variation among stands that are not in the same type, the population estimate will be more precise than if the sampling is done at random over the entire population. An examination of aerial photographs with a stereoscope may be helpful in determining whether a timber stand should be divided in to one or several strata. If possible, visit the area and perform some practice timber plots, especially if field personnel are unfamiliar with timber cruising methodology. Decide what criteria the differentiation of timber stands into strata or types will be based upon (canopy cover, species composition, volume, location, etc.).

Decide what data is to be collected and which measurement techniques will be used to collect this data. (Eg.: Age, 10-year increment, height, DBH and bark thickness measurements are required to determine current annual productivity.) All timber sampling within a strata or stand must be done with the same basal area factor (BAF). A preliminary trip to the field may be required to practice field techniques, identify problems and decide which basal area factor is most appropriate. Stands with similar density and volume which have already been surveyed could be used as a guide to determine which BAF is most ppropriate. Other local land management agencies may be contacted to find out what BAF was used by field crews for similar timber stands.

In determining the sample size; area size, number of strata, variance within the population and the desired level of statistical confidence must be considered. Appendix 1 contains some guidelines on sample size selection. Appendix 2 includes definitions of several commonly used forestry terms.

Sampling units need to be defined and a method of selecting sample units in the field must be chosen. A clear plot grid can be used to systematically or randomly locate plots throughout the sample area on either an aerial photograph or on a topographical map. If more points have been located on the map than the number of plots required for sampling at a certain level of statistical significance, a method for randomization of plots should be employed. Appendix 9 includes a random numbers table for use in sample site selection.

A methodology for locating plots in the field must be determined. The location of systematically arranged plots is often considered to be easier and less expensive than randomly placed plots because azimuths and spacing between plots is consistent. Field plot location by pacing in chains is explained in the field procedures section.

Recommended field equipment and supplies are listed below:

Tatum and tatum aids
Plot sheets and #2 lead pencil
Relaskop (WRST has a metric Relaskop)
Clinometer (with a % slope scale and a topographic scale to calculate tree height)
Compass (check declination)
DBH tape (in inches or cm, to the nearest 1/10" or mm)
50' or 75' measuring tape
Tree borer (a 10" borer is usually sufficient)
Extra tree borer extractors (in case of breakage)
Tree borer bit sharpening kit
Straws and masking tape (for storing extracted tree cores)
Handlens (for counting age of tree cores)
Small ruler
Camera and extra camera battery (a wide angle lens is preferable)
Several rolls of film (ASA 200 film is preferable in darker situations found beneath stands with dense canopy cover)
Chalkboard and plot pole
Chalk
USGS 1:63,360 topographical maps
Aerial photographs with plastic covers
A roll of brightly colored flagging

Personal gear:

shotgun and shells
field vest
bug dope
raingear
lunch and water
radio
first aid kit
emergency food and clothing
rubber or hip boots for wet lowland areas and creek crossings

FIELD PROCEDURES

Establishing Plot Location:

Because it is important to accurately establish plot locations, a system of pacing in chain lengths should be employed. Pacing also allows for an unbiased determination of plot center in the field. A chain is a standard length of measurement 66 feet long. Because there are 80 chains to mile, the number of chains to be traversed is easy to determine with a ruler and a topographical map or aerial photograph. Prior to, and intermittently during the field season, each crew member should determine their individual rate of pacing per chain length on different types of terrain. After marking a 66 foot length on the ground with a tape measure, count the number of normal, comfortable strides required to traverse a chain length. More steps may be needed to traverse a chain on tussocks, rough or steeply sloped terrain.

With a topographical map or aerial photograph, determine the compass bearing and number of chains to be paced from the starting location to the plot location. While pacing, occasionally check the compass for accuracy of direction. It is helpful to align the compass sight with a distinctive landmark or a particular tree and then pace toward it. The last pace of the last chain is where the plot center is to be located.

Once the plot center has been determined, the Timber Inventory Data Sheet is to be completed (Figure 1). Laminated plastic sheets (tatum aids) with applicable codes and explanations are available to help fill out the data sheet (Appendix 4).

Figure 1: Timber Inventory Data Sheet

TIMBER INVENTORY DATA SHEET

Point No.:________ Rank:______-______-______

T:_______R:_______S:_______,_______1/4,_______1/4

Map:________-____ Aerial Photo #:________ Date:________________

Observers:__________________________________ BAF:_______________

Elevation:____________ Slope:_____________ Aspect:_____________

Drainage:_________ Veg. Type:_____________ Photo #'s:__________

Tree Spp.	Tree Hist	DBH in.	Ht. ft.	Crown Ratio	Crown Class	Brk & 10 year inc	Tree Age	Damage Class	Use Class

Figure 1 cont.:

Comments:

Understory Species:

Wildlife:

WRST Photo #'s:

Timber Inventory Sheet Guidelines. Write "NA" in data sheet fields where information is not applicable.

Point No.: Fill in the point number.

Rank: If a random sampling of plots is being done, put random sample rank number here. If not, leave blank or delete from form.

T: R: S: Record township, range, section and quarters.

Map: Fill in the topographical quadrangle name and map number. Eg.: Nab A-3.

Aerial Photo #: This indicates the flight line and number of the color infrared aerial photograph on which the plot is located. Eg.: 99-4717

Date: Fill in current date.

Observers: List initials of the technicians. The initials of the person filling out the form should be first.

BAF: The basal area factor (BAF) is a constant used in variable plot cruising to estimate the basal area occupied by tree stems on a per acre or per hectare basis. Basal area is a measure of square feet or square meters of space occupied by the stem of a tree 4.5 feet from the ground. Eg.: a tree with a 7 inch DBH has a basal area of .2673 square feet. Basal areas are listed in [illegible] sample a timber stand is dependant on the size and density of trees in the stand. As a general rule, the BAF chosen should yield an average of between four and eight "in" trees per plot. Only one BAF is to be used in sampling a given population. Data collected with different BAF's may not be analyzed collectively. Past timber surveys in Nabesna and McCarthy areas have used a BAF of 2 1/4 if a metric scale Relaskop was used (American scale equivalent of 22.05), and 20 if an American scale Relaskop was used.

Elevation: Elevation is determined from 1:63,360 scale USGS topographical maps.

Slope: Record slope in percent either with the clinometer or the Relaskop. Obtain percent slope, first by looking upslope, then looking downslope and averaging the two values. Slope is usually very slight in forested lands in interior WRST.

Aspect: Record the general direction toward which the terrain slopes.

Drainage: Estimate site drainage using visible indicators (eg. wet site indicator plants, ground substrate condition and presense of standing water). Consider the past month's and current weather conditions when estimating site drainage. Code as follows:

1 Very poorly drained. Water table remains at or near the surface (above 45 cm or 18 in.) most of the year. Soils have a mucky or peaty surface horizon.

2 Poorly drained. Soil is wet much of the time, with water table seasonally near the surface for prolonged intervals. The water table is 45 - 90 cm (18 - 36 in.) and soils usually lack a mucky or peaty surface horizon.

3 Somewhat poorly drained. Soil is wet for significant periods, but not continuously, because of a slowly permeable layer or high water table (90 - 150 cm. or 36 - 60 in.). The soil has a very thick, dark A horizon due to the abundant growth of course grasses.

4 Moderately well drained. Soil is wet for a small but significant part of the year. The soil has a thick dark A horizon and indistinct mottling in the B horizon.

5 Well drained site. Water leaves the soil readily but not rapidly. The soil is intermediate in texture and lacks mottles.

6 Somewhat excessively drained site. Water leaves the soil rapidly. Soils may be shallow and sandy and very porous.

7 Excessively drained site. Water leaves the soil very rapidly. Soils are very porous.

Veg. Type: Vegetation type is keyed to the first four levels of the Viereck et al., 1986 Revision of the Alaska vegetation classification (Appendix 5). The area is determined to be forested or non-forested, to have open closed or woodland canopy coverage, coniferous, deciduous or mixed coniferous/deciduous composition, as well as which tree species are present. In attempting to estimate the percentage of canopy closure, visualize the amount of ground that would be covered by shadow from tree canopy cover, if the sun were directly overhead.

Photo #'s: Photo information may be included in the "Photo #'s" space provided at the top of the timber inventory sheet, if problems with future photo identification are anticipated.
To take photos, the photo board and plot pole are placed at plot center. Information on the photo board should include date, location and plot number or identification. When possible, exclude field gear and personnel from the photograph. Two photographs are then taken, the first to the north, the second to the south. A wide angle lens is preferable. It is helpful to take pictures of notable features and situations which occur in between plots. A photographic log should be kept.

Information on the grid portion of the timber inventory data sheet is collected on all trees 3.9" DBH or larger which are in the variable radius plot. "Tally trees" or trees determined to be "in" are selected by using an appropriate BAF and making a 360 degree sweep around the plot center, while holding the Relaskop directly over plot center. For more detailed instructions on using the Spiegel Relaskop, refer to Variable Plot Sampling by Dilworth and Bell, (1982 and 1984), The Relascope, by William Finlayson, or Appendix 6. Usually one crew member operates the Relaskop and fills out the data sheet while the other person gathers DBH and height information. If there is difficulty with remembering which trees are "in", chalk can be used to number trees on their bark. When the width of a tree at DBH is visually equal to the critical angle of a BAF, it is a "borderline" tree. A borderline tree is "in" if the distance between plot center and the tree is less than or equal to its limiting distance as determined by the DBH of the tree. For limiting distances of an English basal area factor of 22.05 (metric scale BAF of 2 1/4), refer to Appendix 7.

Seedling and sapling tally: Seedling and sapling densities are determined by tallying all seedlings and saplings growing within a fixed radius plot. Seedlings are defined as trees with a DBH less than one inch. Saplings have a DBH between one inch and less than four inches. The center of the variable radius plot is also used as the fixed radius plot center. The area of the fixed radius plot should equal that of the variable radius plot for a tree with a diameter at the cutoff point between a sapling and a tree, at its limiting distance for the BAF being used (Appendix 8). With a metric scale basal area factor of 2 1/4 (an American scale BAF equivalent of 22.05), all seedlings and saplings are tallied in a circular plot with a radius of 5.6 feet or 1.7 meters. Figure 2 indicates field data sheet information to be recorded for seedlings and saplings. When applicable, use damage class codes that pertain to seedlings and saplings: "02" - acceptable seedling or sapling, poor form; and "91"- layered seedling.

Figure 2. Field data sheet information to be recorded for seedlings and saplings.

	Tree Spp.	Tree Hist	DBH in.	Ht ft	Crown Ratio	Crown Class	10 yr & brk inc	Tree Age	Damage Class
Sapling	x	x	x	x	x	x			x
Seedling	x	x		x	x	x			x

<u>Tree Species</u>: Record tree species as a three digit code for all trees tallied. Important key identifying characteristics for each tree species listed below can be found in Appendix 9 and is included on the tatum aid sheets.

Code		
094	white spruce	<u>Picea glauca</u>
095	black spruce	<u>Picea mariana</u>
375	paper birch	<u>Betula papyrifera</u>
741	balsam poplar	<u>Populus balsamifera</u>
746	quaking aspen	<u>Populus tremuloides</u>
747	black cottonwood	<u>Populus trichocarpa</u>

<u>Tree History</u>: Record tree history for each tree tallied. To be tallied as a dead or mortality tree, trees must be four inches DBH or greater at time of death (dead seedlings and saplings are not tallied). In addition to dead and mortality trees which are standing upright, leaning and down trees should be tallied. Guidelines for estimating five year tree mortality is located in Appendix 10 and is included on the tatum aid sheets. Tree history codes are as follows:

Code

1 All live tally trees: Includes seedlings and saplings.

4 Salvable dead: Tree dead for more than five years, more than 50 percent sound on a cubic foot basis.

5 **Salvable mortality**: Dead less than five years, presently more than 50 percent sound on a cubic foot basis.

6 Non-salvable Mortality: Dead less than five years, presently less than 50 percent sound on a cubic foot basis.

7 Non-salvable dead: Dead more than five years, less than 50 percent sound on a cubic foot basis.

DBH: Record tree diameters to the nearest tenth of an inch or millimeter, at breast height (4.5 feet or 1.3 meters), on the uphill side of every tree tallied in the plot. DBH is also recorded for all saplings (1 " to 3.9 " DBH) in the fixed radius plot. Measure DBH by snugly wrapping a DBH tape around the tree at right angles to its lean, 4.5 feet from the ground. If the tree has an large irregularity (swelling, depression, branches, etc.) at DBH, measure diameter immediately above the irregularity at the place where the irregularity no longer affects stem form. If the tree forks at or above 4.5 feet, consider the tree as one tree and measure the DBH below the swell in the bole, if present. If the tree forks below 4.5 feet, consider it to be two trees and measure each fork as an individual tree. In either case, measure the diameter of the tree as near DBH (4.5 feet) as possible. Leaning trees are considered tally trees if they are within the limiting distance at breast height. For more detailed instructions on measuring DBH and on limiting distances, refer to Appendix 11 and 7, respectively.

Height: Height is recorded with a clinometer for every tallied tree and is measured to the nearest foot of the main stem top. On American scale clinometers, the left scale is percent and the right scale is usually topographic with a baseline distance of 66 feet. Refer to Appendix 12, for suggestions on taking accurate tree heights. If the tree is forked above DBH and has two full live tops, measure height of the tallest main stem top. If the tree forks below DBH, count as two trees and measure DBH and height for both. If the tree has live foliage and a dead or broken top, measure height of the dead or broken main stem top, even if a live lateral branch is taller than the main stem top.

<u>Crown Ratio</u>: Crown ratio, or percent live crown is related to vigor and growth of a tree. Crown ratio is expressed to the nearest 10 % of the total tree height supporting live crown, and is recorded as a 1-digit code. For trees with uneven crown growth or distribution, visually transfer the lower branches on the longer side to the short side to achieve a balanced crown. Eg: for a tree with a 48 % live crown, record "4".

1	0-19 %	4	40-49 %	7	70-79 %
2	20-29 %	5	50-59 %	8	80-89 %
3	30-39 %	6	60-69 %	9	90+

<u>Crown Class</u>: Determine crown class for each tally tree. Crown class is a description of the relative position of the tree crown with respect to competing vegetation that surrounds the tree.

1. <u>Open Crown</u>. Trees with crowns which have received light from above and all sides throughout most of their lives. Their forms or crown shapes have not been and are not likely to be influenced by other trees.

2. <u>Dominant</u>. Trees with crowns extending above the general level of the crown canopy and receiving full light from above and partly from the side; larger than the average trees in the stand, and with crowns dense, comparatively wide and long, but possibly somewhat crowded on the sides.

3. <u>Codominant</u>. Trees with crowns forming the general level of the crown canopy and receiving full light from above but comparatively little from the sides; usually with medium-size crowns more or less crowded in the sides.

4. <u>Intermediate</u>. Trees shorter than dominants or codominants, with crowns below or barely reaching into the main canopy, receiving little direct light from above and none from the sides, usually with small crowns considerably crowded in the sides.

5. <u>Overtopped</u>. Trees with crowns entirely below the general level of the crown canopy, receiving no direct light from above or from the sides.

<u>Tree Age</u> and <u>Bark & 10 Year Increment.</u>:

At least two dominant and/or codominant trees are bored at every plot. Not necessarily the largest or tallest trees in the plot, trees bored for age should as much as possible be free from disease and defect, of good form and vigor, not excessively limby and have at least 40 % live crown. Because not all plots have trees which fit these criteria, choose trees which best approximate the conditions stated above for coring. Avoid coring trees which have rot or excess sap on the bark. More trees are bored in plots which have a large number of "in" trees (more than 7 or 8), to account for a varied species composition and different size and age classes. The width of the bark/cambium layer is recorded in order to determine the diameter of the tree inside its bark and thus the volume of the tree minus the volume of the bark. Diameter outside bark is expressed as DOB.

Diameter inside bark is expressed as DIB. The width of the last ten year increment is recorded in order to calculate the current annual productivity of the timber stand.

Trees are cored at breast height, or 4.5 feet from the ground on the uphill side of the tree. Bore the corer to the center of the tree and insert the extractor spoon into the corer upside down. Turn the corer one rotation counterclockwise (or backwards) in order to break the tree core away from the inside of the tree and withdraw the extractor spoon with the tree core. To reduce the possibility of the corer getting stuck in the tree, remove it from the tree after extracting the extractor spoon prior to analyzing the tree core.

Once the core has been extracted, the width of the tree bark/cambium layer is measured and recorded in 1/20ths of an inch. Used by WRST field personnel, the Silva Ranger compass possesses an appropriately scaled ruler. The width of the most recent ten years of growth (the outermost ten annual growth rings) is also recorded in 1/20ths of an inch. The use of a handlens will greatly facilitate the counting of small or tight tree rings. The age of the tree is determined by counting all tree annual growth rings and adding seven years to the total, to account for the number of years it took the tree to reach breast height (USDA and Ak DNR, 1983). If the corer was off-center from the exact center of the tree, estimate the additional number of rings needed to reach the center of the tree from the innermost ring intersected by the borer. If tree age is to be counted in the office, count at least the 10 year increment in the field to minimize error due to shrinkage from the core drying. If the tree core is to be saved, place it in a straw, stopping both ends with masking tape and writing the plot number and tree number on the tape. If the core is too long for one straw, break it in half and place it in two straws. Once back in the office, unblock one of the straw ends in order to prevent mildew from forming on the core.

Damage Class: Record the presence or absence of serious damage or pathogen activity for all live trees and cause of death, if it can be determined, for all mortality trees (Figure 3). Record primary and secondary damage which refers to the relative time each damage occurred. If a tree was damaged by insects thus causing a dead top, record insect damage as the primary cause and the dead top as the secondary damage. If a tree has two unrelated damages, code the most severe as primary and the less severe as secondary. A general rule is to code damage only when something is wrong with the tree which will:

1. Prevent it from living to maturity, or surviving ten more years if already mature.
2. Reduce or has seriously reduced quality of the tree's products, i.e. houselogs and firewood (damage resulting from rot, lightning strike, etc.).

For more detailed descriptions of damage codes, refer to Appendix 13. Make special note of the presence of spruce beetles in the timber stand.

Figure 3. Damage class codes.

Code			Code		
01		No damage	50		Weather
02		Acceptable seedling or sapling, poor form		51	Wind
10		Insect damage		52	Lightning
	11	Bark beetles		53	Snow
	12	Defoliators		54	Frost
	13	Sucking insects		55	Flooding
	14	Tip and shoot borers		56	Earth movement
	15	Gall-forming insects	60		Suppression
20		Disease, unidentified	70		Unknown
	21	Rust		71	Leaning 15 % or more
	22	Rot		72	Forked
	25	Severe rot		73	Broken top
	26	Witches-brooms		74	Dead top
				75	Uprooted
30		Fire		76	Bole split
				77	Sweep Crook
40		Animal caused		78	Abrasion
	41	Domestic animal		79	Unhealthy foliage
	42	Porcupine			
	43	Rabbit	80		Logging damage
	44	Beaver			
	45	Big game	90		Cull or offsite tree
	46	Human		91	Layered seedling

Use Class: This is an optional category used to indicate the suitability of the tree for use as a houselog or firewood. If in some future timber survey, information on another criteria is to be gathered (ie. cubic or surface defect), the heading of this column can be altered.

Comments:

Although they are sometimes tedious to fill out in the field, comments written on the back of the form can later prove to be an invaluable source of information about specific or unusual observations and general stand trends, etc. that are not necessarily or obviously reflected by the numeric parameters recorded on the front of the form. Written observations can also qualitatively interpret and reinforce the physical setting and general conditions evident in or near the plot vicinity. Observations made in between plots can be written here as well.

Understory Species:

List all of the major understory species observed in the plot area. In general, the most dominant species are listed first. Use of plant species codes (the first three letters of both the genus and species names) is an efficient way of recording understory species. Eg.: Vaccinium uliginosum is "VACULI". In the case where only genus has been determined, use the first five letters of the genus name. Eg. Equisetum is "EQUIS". Vascular plant nomenclature follows Hulten, 1968.

Wildlife

Here space is provided for comments pertaining to wildlife observations (animal sightings, presence of a cavity nest, etc).

WRST Photo #'s

Space is provided to later fill in official eleven digit WRST photo numbers once these numbers have been assigned to individual plot photographs. Information is provided in Appendix 14 concerning the proper labeling of slides.

Eg.: 05-01-108-0288

"05" indicates association with the Resource Management program.

The third and fourth digits indicate the WRST district in which the photo was taken. In this case, "01" means the Nabesna district.

"108" indicates the photo was taken in conjunction with the Forest Products program.

The last four digits indicate the particular sequential number assigned to each individual slide.

Information and equipment maintenance chores should be performed in the office after every trip to the field in order to prepare for the next field outing and to avoid an accumulation of incomplete data forms. Exposed film should be prepared for processing. Field equipment should be maintained or turned in for repair (tree borer sharpening instructions, Appendix 15). The field supply of items like field data forms and straws should be replenished. Field plots should be mapped onto 1:63,360 maps. Field data forms should be organized and information such as elevation and township and range etc., should be filled in. It is important to write down field notes describing unusual observations, problems, inconsistencies and questions before they are forgotten.

OFFICE PROCEDURES

Once all of the field data has been collected, data calculations can be started. Several good sources of information on statistics, basal area computation, the construction of V-Bar tables and stand tables, etc. are listed in the references section as well as in Appendix 16. The park/preserve presently has a computer program called "Basica Crude", which statistically computes gross timber volume and dead timber volume by species per acre using V-Bar tables, basal area and appropriate timber volume equations (see Figure 4). The appropriate timber volume tables can be found in Haack, 1963 and Gregory and Haack, 1964.

Tree density per acre and DBH size class distribution tables are constructed using appropriate stand table factors (Appendix 17). Tally the number of trees in the stand in each size class, divide each total by the number of plots, then multiply by the appropriate stand table factor for each DBH size class. Odd DBH size classes with intervals of two inches, starting with the five inch (4 to 5.9") DBH size class are used. Dead and mortality tree densities and species composition of the stand are computed similarly. Steps for computing current annual productivity (cubic feet per acre) are listed in Figure 4. Also refer to Hush et al., 1972; p. 314.

Figure 4. Steps for Computing Current Annual Productivity. Numbers in brackets refer to column number of the stock table on page 27.

[1] DBH size class midpoint, eg.: DBH size class 7 includes trees between 6.0" and 7.9" DBH.

[2] The Stand Table Factor indicates the number of trees per acre represented by each "in" tree tallied during variable plot cruising. Decreasing with increasing DBH, each DBH size class has a different stand table factor. Stand table factor = the Basal Area Factor (BAF in this case = 22.04) divided by the basal area (sq. ft.) of the midpoint DBH class.

[3] Present Stand Table (live trees/acre): Tally the total number trees in each DBH size class from the data sheets. Divide each total by the number of plots, then multiply by the appropriate Stand Table Factor [2] for each DBH size class.

[4] Average Bark Thickness (in): computed by averaging bark thickness measurements for each DBH size class from original data sheets and doubled to obtain diameter measurement.

[5] Present DBH diameter inside bark (DIB): subtract [4] from [1] for each size class. This is the diameter of the tree minus the diameter of the bark.

[6] 10 year increment (in): compute by averaging 10 year increment measurements for each DBH size class from original data sheets and doubled to obtain the diameter of the 10 year increment.

[7] Estimated future DBH (in) DIB: Add [5] and [6] for an estimate of the DBH of each size class in 10 years.

[8] Divide 2.0 inches (the number of inches in each DBH size class) by [6] to compute the average estimated number of 10 year periods required for trees in each DBH size class to advance to the next DBH size class.

[9] Determine average height (feet) for trees in each DBH size class from the original data sheets.

[10] Compute the height difference between each DBH size class [9] and the next larger DBH size class.

[11] Estimated 10 year height increment (feet): Divide [10] for each DBH size class by [8] to compute how much each DBH size class grows in a 10 year period.

[12] Estimated future height (feet): add [9] and [11] for each DBH size class.

[13] Present average volume (DIB) (cu. ft./tree): with Ave. Est. Ht./tree [9] and present DBH (DIB) (in) [5], use the volume equation for trees of interior Alaska for the appropriate tree species to compute Ave. Est. tree volume (cu. ft./tree) for trees in each DBH size class.

Alaska white spruce, Smalian's Formula, NOR-5*
$V = -.69934 + .0021294646D^2H$

Interior aspen, Smalian's Rule, NOR-6, 4" top**
$V = -.5553 - .02216D^2 + .00246D^2H$

Interior paper birch, Smalian's Rule, NOR-6, 4" top**
$V = -2.5767 + .9524D - .10446D^2 - .03303H + .00282D^2H$

Haack, 1963* and Gregory and Haack, 1964**

[14] Average Estimated Future Volume (DIB) (cu. ft./tree): use Ave. Est. future DBH [7] and Ave. Est future height [12] and the appropriate volume equation to compute Ave. Est. future volume/tree.

[15] Present Stock Table (cu. ft./acre): multiply [3] and [13] to compute estimated volume (cubic feet/acre) for each DBH size class.

[16] Estimated Future Stock Table (cu. ft./acre): multiply [3] and [14] to compute the estimated future volume (cu. ft./acre) for each DBH size class.

[17] Estimated Current Annual Productivity (cu. ft./acre/year): Subtract [15] from [16] for each DBH size class and divide by 10. Sum this column to compute the total amount of current annual volume productivity for an acre in the stand (cu. ft./acre/year).

Figure 4 cont.: Stock table used to derive the current annual timber productivity for the Chisana timber stand.

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
DBH Class (in)	Stand Table Factor (22.04)	Present Stand Table (T/A)	Bark Thick-ness (in)	Present DBH (DIB) (in)	10 Year Inc. (in)	Est. Fut. DBH (in)	DBH Class Inc. Rate	Ave. Tree Ht. (ft)	DBH Class Ht.Inc. (ft)
5	161.58	130.80	0.30	4.70	0.26	4.96	7.7	30.00	10.43
7	82.45	149.20	0.40	6.60	0.18	6.78	11.1	40.43	6.16
9	49.89	97.40	0.46	8.54	0.26	8.80	7.7	46.60	7.72
11	33.39	58.53	0.56	10.44	0.30	10.74	6.7	54.32	2.48
13	23.91	22.77	0.46	12.54	0.34	12.88	5.9	56.80	2.70
15	17.96	13.68	0.56	14.44	0.34	14.78	5.9	59.50	0.00
17	13.98	2.00	0.90	16.10	0.20	16.30	10.0	50.33	0.00
19	11.19	1.60	(0.52)	18.48	--	(18.48)	--	59.33	--

[1]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
DBH Class (in)	Est. 10 Yr. Ht. Inc. (ft)	Est. Fut. Ht. (ft)	Present Vol/Tree (DIB) (cu.ft.)	Est. Fut. Vol/Tree (DIB) (cu.ft.)	Present Stock (cu.ft./ acre)	Est. Fut. Stock (cu.ft./ acre)	Curr.Ann. Vol.Prod. (cu ft./ acre/yr.)
5	1.36	31.36	0.63	0.84	81.89	109.87	2.80
7	0.55	40.98	2.82	3.07	421.18	458.04	3.69
9	1.00	47.60	6.10	6.67	593.93	649.66	5.57
11	0.37	54.69	11.14	11.92	655.47	701.25	4.58
13	0.46	57.26	17.16	18.30	390.83	416.69	2.59
15	--	59.50	24.11	25.30	329.88	346.10	1.62
17	--	50.33	25.39	26.05	50.79	52.10	0.13
19	--	59.33	39.82	--	63.71	(63.71)	0.00
Total							20.98

Seedling and sapling densities are computed by tallying the total number of seedlings and saplings present in the stand, then by multiplying by the ratio of the size of an acre to the size to the fixed radius plot and finally by dividing each total by the number of plots.

Ex.: For a stand with a total of 28 seedlings in 12 plots with a fixed radius of 5.6 feet. (There are 442 plots with a radius of 5.6 feet in an acre.) 28 x 442 / 12 = 1031.33 seedlings/acre.

A simple T-test can be used to determine variance and confidence intervals of seedling and sapling densities per acre.

Once densities, volumes, current annual productivity, etc. have been determined, they should be incorporated and written into results and discussion narratives, in conjunction with comments recorded in the field. Papers previously written for the park, eg., the Inventory of Forest Resources of Wrangell St. Elias National Park and Preserve, and the Inventory of Forest Resources at the Chisana Stand, may be used as guidelines. In addition, pertinent forest resource literature and references in the park/preserve library may be reviewed for background information. The results should be discussed in light of park values and management goals and concerns. A recommended forest resource management strategy(s) chosen from an array of feasible management alternatives should be identified. Specific guidelines on how this strategy is to be implemented should accompany the narrative/discussion.

compensate for the vertical angle without having to use an abney or other device.

Establishing Plots and Determining Tree Counts

Number of sample plots. Sample plots or points are located in a manner similar to that used for fixed-radius plot cruising. Mechanical or random sampling patterns may be used with single points or plot clusters. The use of clusters decreases travel time and tends to minimize costs in achieving a prescribed sampling error. The cluster represents an observation and the "n" of sample size in the formula below represents the number of clusters or single points, whichever sampling method is used.

The statistical formulas for determining the number of sample plots are essentially the same as for fixed-radius plots. If the points are close enough that with the prism to be used there will be an overlap of plots, then the formula for an infinite population is used. The same formula would be used for large areas.

$$n = t^2C^2/A^2$$

If there is no chance of overlap and the area being sampled is small, the formula for a finite population is:

$$n = \frac{Nt^2C^2}{NA^2+t^2C^2}$$

When:

- n = number of sampling points or observations
- N = possible number of plots in area to be sampled[1]
- C = estimated coefficient of variation (based on previous variable plot cruises of similar stands)
- A = allowable error (standard error of the mean) in percent
- t = number of standard errors (expression of confidence limits)

[1]The possible number of plots will vary with the BAF used and the diameters of the trees. One approach in determining N is to estimate the diameter of the average tree and imaginary plot size for such a diameter. For example, the plot size of a 30-inch diameter using a BAF 25 prism is about 1/5-acre which indicates N is 5 per acre of the total area being sampled.

The Washington Department of Natural Resources takes 40 points for the first 40 acres, 20 points for the second 40, 10 points per forty for the next 120 acres, and uses the formula when over 200 points are required.

Types of Sample Plots or Points

Full plots (360 degrees) are used on level to moderately steep terrain. **Semi-circular** or half plots are taken when the slopes are steep. The reason for using semi-circular plots is to eliminate the necessity of having to sight uphill with the large vertical angles involved. This is particularly true if the point of measurement used is the top of the first 16-foot log, which is commonly the case. Full and semi-circular plots are not used together. The cruiser must decide in advance to use one or the other in a given stand, but not both.

Semi-circular plots are established in the following manner:

1. The point location is determined as described above. Plot centers are usually marked for future reference.

2. In laying out the plot, the compassman stands at the point facing downhill. He then picks out a reference tree to his left that is on contour with the point. A stake may be set if a reference tree is not available. If the re-establishment of the point is at all likely, the reference tree or stake is marked in an appropriate manner.

3. The establishment of the plot is completed by extending an imaginary line from the reference point through and beyond the center point far enough to complete the uphill boundary of the semi-circular plot.

4. All trees on the downhill side of this boundary are potential "in" trees.

When semi-circular plots or half points are used, a prism of one-half the normal BAF is used to maintain the same tree count as is considered desirable on a full plot. In addition, the tree count obtained on the half point is doubled in obtaining the stem basal area per acre.

Appendix 2. Definitions of some common forestry terms.

Basal area (BA): A measure of square feet of space occupied by the stem of a tree at breast height, 4.5 feet.

Basal area factor (BAF): The BAF is a constant for a given critical angle and varies with the size of the critical angle. It gives the basal area per acre for each tree intercepted from a sampling point.

Board foot-basal area ratio (V-BAR): The ratio between the volume of the tree and its basal area.

Density: The size of a population expressed on a per acre or hectare basis. Density can be broken into diameter size classes.

DOB and DIB: Diameter outside bark and diameter inside bark.

Diameter size classes: A classification of trees according to mid-point diameter size classes.

Gross volume: The total volume of a tree, including all defects and rot.

MAI or mean annual increment: the increase in diameter for a given number of years divided by that number of years.

Net volume: The gross volume of a tree less deductions for rot, sweep or other defect affecting its use for wood products.

Plot radius factor (PRF): For a given critical angle, the plot radius factor is the distance per unit of tree diameter from the sampling point to a point at which the tree would be a borderline tree. The plot radius factor times a tree diameter is the maximum distance at which a tree would be counted and is used to determine whether borderline trees are "in" or "out".

Site index: A measure of site productivity based upon the height of trees at a given base age. Site index classes are height classes represented by a graphed curve of height over age for each class.

Variable radius plot: A plot on which a predetermined critical angle is projected from a central point, and swept in a full circle, to determine the basal area, tree count and volume per unit of area. The radius of this plot is a function of tree basal area and is therefore variable.

V-Bar: The ratio of the tree volume to the basal area.

Appendix 3. Random Numbers Table

TABLE D.45 Ten Thousand Random Digits

	00-04	05-09	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
00	22808	04391	45529	53968	57136	98228	85485	13801	68194	56382
01	49305	36965	44849	64987	59501	35141	50159	57369	76913	75739
02	81934	19920	73316	69243	69605	17022	53264	83417	55193	92929
03	10840	13508	48120	22467	54505	70536	91206	81038	22418	34800
04	99555	73289	59605	37105	24621	44100	72832	12268	97089	68112
05	32677	45709	62337	35132	45128	96761	08745	53388	98353	46724
06	09401	75407	27704	11569	52842	83543	[illegible]	03177	50511	15301
07	73424	31711	65519	74869	56744	40864	[illegible]	89866	96563	75142
08	37075	81378	59472	71858	86903	66860	63757	32723	54273	45477
09	02060	37158	55244	44812	45369	78939	08048	28036	40946	03898
10	94719	43565	40028	79866	43137	28063	52513	66405	71511	66135
11	70234	48272	59621	88778	16536	36505	41724	24776	63971	01685
12	07972	71752	92745	86465	01845	27416	50519	48458	68460	63113
13	58521	64882	26993	48104	61307	73933	17214	44827	88306	78177
14	32580	45202	21148	09684	39411	04892	02055	75276	31831	85686
15	88796	30829	35009	22695	23694	11220	71006	26720	39476	60538
16	31525	82746	78935	82980	61236	28940	96341	13790	66247	33839
17	02747	35989	70387	89571	34570	17002	79223	96817	31681	15207
18	46651	28987	20625	61347	63981	41085.	67412	29053	00724	14841
19	43598	14436	33521	55637	39789	26560	66404	71802	18763	80560
20	30596	92319	11474	64546	60030	73795	60809	24016	29166	36059
21	56198	64370	85771	62633	78240	05766	32419	35769	14057	80674
22	68266	67544	06464	84956	18431	04015	89049	15098	12018	89338
23	31107	28597	65102	75599	17496	87590	68848	33021	69855	54015
24	37555	05069	38680	87274	55152	21792	77219	48732	03377	01160
25	90463	27249	43845	94391	12145	36882	48906	52336	00780	74407
26	99189	88731	93531	52638	54989	04237	32978	59902	05463	09245
27	37631	74016	89072	59598	55356	27346	80856	80875	52850	36548
28	73829	71651	50141	76142	72303	06694	61697	76662	23745	96282
29	15634	89428	47090	12094	42134	62381	87236	90118	53463	46969
30	00571	45172	78532	63863	98597	15742	41967.	11821	91389	07476
31	83374	10184	56384	27050	77700	13875	96607	76479	80535	17454
32	78661	85645	13181	08700	08289	62956	64439	39150	95690	18555
33	47890	88197	21368	65254	35917	54035	83028	84636	38186	50581
34	56238	13559	79344	83198	94642	35165	40188	21456	67024	62771
35	36369	32234	38129	59963	99237	72648	66504	99065	61161	16186
36	42934	34578	28968	74028	42164	56647	76806	61023	33099	48293
37	09010	15226	43474	30174	26727	39317	48508	55438	85336	40762
38	83897	90073	72941	85613	85569	24185	08247	15946	02957	68504
39	82206	01230	93252	89045	25141	91943	75531	87420	99012	80751
40	14175	32992	49046	41272	94040	44929	98531	27712	05106	35242
41	58968	88367	70927	74765	18635	85122	27722	95388	61523	91745
42	62601	04595	76926	11007	67631	64641	07994	04639	39314	83126
43	97030	71165	47032	85021	65554	66774	21560	04121	57297	85415
44	89074	31587	21360	41673	71192	85795	82757	52928	62586	02179
45	07806	81312	81215	99858	26762	28993	74951	64680	50934	32011
46	91540	86466	13229	76624	44092	96604	08590	49705	03424	48033
47	99279	27334	33804	77988	93592	90708	56780	70097	39907	51006
48	63224	05074	83941	25034	43516	22840	35230	66048	80754	46302
49	98361	97513	27529	66419	35328	19738	82366	38573	50967	72754

Appendix 3: cont.

TABLE D.45 (cont.) Ten Thousand Random Digits

	00-04	05-09	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
50	27791	82504	33523	27623	16597	32089	81596	78429	14111	68245
51	33147	46058	92388	10150	63224	26003	56427	29945	44546	50233
52	67243	10454	40269	44324	46013	00061	21622	68213	47749	76398
53	78176	70368	95523	09134	31178	33857	26171	07063	41984	99310
54	70199	70547	94431	45423	48695	01370	68065	61982	20200	27066
55	19840	01143	18606	07622	77282	68422	70767	33026	15135	91212
56	32970	28267	17695	20571	50227	69447	45535	16845	68283	15919
57	43233	53872	685[illegible]	70013	31395	60361	39034	59444	17066	07418
58	08514	23921	166[illegible]	89184	71512	82239	72947	69523	75618	79826
59	28595	51196	96108	84384	80359	02346	60581	01488	63177	47496
60	83334	81552	88223	29934	68663	23726	18429	84855	26897	94782
61	66112	95787	84997	91207	67576	27496	01603	22395	41546	68178
62	25245	14749	30653	42355	88625	37412	87384	09392	11273	28116
63	21861	22185	41576	15238	92294	50643	69848	48020	19785	41518
64	74506	40569	90770	40812	57730	84150	91500	53850	52104	37988
65	23271	39549	33042	10661	37312	50914	73027	21010	76788	64037
66	08548	16021	64715	08275	50987	67327	11431	31492	86970	47335
67	14236	80869	90798	85659	10079	28535	35938	10710	67046	74021
68	55270	49583	86467	40633	27952	27187	35058	66628	94372	75665
69	02301	05524	91801	23647	51330	35677	05972	90729	26650	81684
70	72843	03767	62590	92077	91552	76853	45812	15503	93138	87788
71	49248	43346	29503	22494	08051	09035	75802	63967	74257	00046
72	62598	99092	87806	42727	30659	10118	83000	96198	47155	00361
73	27510	69457	98616	62172	07056	61015	22159	65590	51082	34912
74	84167	66640	69100	22944	19833	23961	80834	37418	42284	12951
75	14722	88488	54999	55244	03301	37344	01053	79305	94771	95215
76	46696	05477	32442	18738	43021	72933	14995	30408	64043	67834
77	13938	09867	28949	94761	38419	38695	90165	82841	75399	09932
78	48778	56434	42495	07050	35250	09660	56192	34793	36146	96806
79	00571	71281	01563	66448	94560	55920	31580	26640	91262	30863
80	96050	57641	21798	14917	21836	15053	33566	51177	91786	12610
81	30870	81575	14019	07831	81840	25506	29358	88668	42742	62048
82	59153	29135	00712	73025	14263	17253	95662	75535	26170	95240
83	78283	70379	54969	05821	26485	28990	40207	00434	38863	61892
84	12175	95800	41106	93962	06245	00883	65337	75506	66294	62241
85	14192	39242	17961	29448	84078	14545	39417	83649	26495	41672
86	69060	38669	00849	24991	84252	41611	62773	63024	57079	59283
87	46154	11705	29355	71523	21377	36745	00766	21549	51796	81340
88	93419	54353	41269	07014	28352	77594	57293	59219	26098	63041
89	13201	04017	68889	81388	60829	46231	46161	01360	25839	52380
90	62264	99963	98226	29972	95169	07546	01574	94986	06123	52804
91	58030	30054	27479	70354	12551	33761	94357	81081	74418	74297
92	81242	26739	92304	81425	29052	37708	49370	46749	59613	50749
93	16372	70531	92036	54496	50521	83872	30064	67555	40354	23671
94	54191	04574	58634	91370	40041	77649	42030	42547	47593	07435
95	15933	92602	19496	18703	63380	58017	14665	88867	84807	44672
96	21518	77770	53826	97114	82062	34592	87400	64938	75540	54751
97	34524	64627	92997	21198	14976	07071	91566	44335	83237	24335
98	46557	67780	59432	23250	63352	43890	07109	07911	85956	62699
99	31929	13996	05126	83561	03244	33635	26952	01638	22788	26393

Appendix 3. cont.

TABLE D.45 (cont.) Ten Thousand Random Digits

	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
00	53330	26487	85005	06384	13822	83736	9[illegible]876	71355	31226	56063
01	96990	62825	97110	73006	32661	63408	0[illegible]893	10333	41902	69175
02	30385	16588	63609	09132	53081	14478	50813	22887	03746	10289
03	75252	66905	60536	13408	25158	35825	10447	47375	89249	91238
04	52615	66504	78496	90443	84414	31981	88768	49629	15174	99795
05	39992	51082	74547	31022	71980	40900	84729	34286	96944	49502
06	51788	87155	13272	92461	06466	25392	22330	17336	42528	78628
07	88569	35645	50602	94043	35316	66344	78064	89651	89025	12722
08	14513	34794	44976	71244	60548	03041	03300	46389	25340	23804
09	50257	53477	24546	01377	20292	85097	00660	39561	62367	61424
10	35170	69025	46214	27085	83416	48597	19494	49380	28469	77549
11	22225	83437	43912	30337	75784	77689	60425	85588	93438	61343
12	90103	12542	97828	85859	85859	64101	00924	89012	17889	01154
13	68240	89649	85705	18937	30114	89827	89460	01998	81745	31281
14	01589	18335	24024	39498	82052	07868	49486	25155	61730	08946
15	36375	61694	90654	16475	92703	59561	45517	90922	93357	00207
16	11237	60921	51162	74153	94774	84150	39274	10089	45020	09624
17	48667	68353	40567	79819	48551	26789	07281	14669	00576	17435
18	99286	42806	02956	73762	04419	21676	67533	50553	21115	26742
19	44651	48349	13003	39656	99757	74964	00141	21387	66777	88533
20	83251	70164	05732	66842	77717	25305	36218	85600	23736	06629
21	41551	54630	88759	10085	48806	08724	50685	95638	20829	37264
22	68990	51280	51368	73661	21764	71552	69654	17776	51935	53169
23	63393	76820	33106	23322	16783	35630	50938	90047	97577	27699
24	93317	87564	32371	04190	27608	40658	11517	19646	82335	60088
25	48546	41090	69890	58014	04093	39286	12253	55859	83853	15023
26	31435	57566	99761	77250	43165	31150	20735	57406	85891	04806
27	56405	29392	76998	66849	29175	11641	85284	89978	73169	62140
28	70102	50882	85960	85955	03828	69417	55854	63173	60485	00327
29	92746	32004	52242	94763	32955	39848	09724	30029	45196	67606
30	67737	34389	57920	47081	60714	04935	48278	90687	99290	18554
31	35606	76646	14813	51114	52492	46778	08156	22372	59999	43938
32	64836	28649	45759	45788	43183	25275	25300	21548	33941	66314
33	86319	92367	37873	48993	71443	22768	69124	65611	79267	49709
34	90632	32314	24446	60301	31376	13575	99663	81929	39343	17648
35	83752	51966	43895	03129	37539	72989	52393	45542	70344	96712
36	56755	21142	86355	33569	63096	66780	97539	75150	25718	33724
37	14100	28857	60648	86304	97397	97210	74842	87483	51558	52883
38	69227	24872	48057	29318	74385	02097	63266	26950	73173	53025
39	77718	56967	36560	87155	26021	70903	32086	11722	32053	63723
40	09550	38799	88929	80877	87779	99905	17122	25985	16866	76005
41	12404	42453	88609	89148	85892	96045	10310	45021	62023	70061
42	07985	27418	92734	80000	58969	99011	73815	49705	68076	69605
43	58124	53830	08705	20916	46048	30342	86530	72608	93074	80937
44	46173	77223	75661	57691	24055	27568	41227	58542	73196	44886
45	13476	72301	85793	80516	59479	66985	24801	84009	71317	87321
46	82472	98647	17053	94591	36790	42275	51154	77765	01115	09331
47	55370	63433	80653	30739	68821	46854	41939	38962	20703	69424
48	89274	74795	82231	69384	53605	67860	01309	27273	76316	54253
49	55242	74511	62992	17981	17323	79325	35238	21393	13114	70084

Appendix 3. cont.

TABLE D.45 (cont.) Ten Thousand Random Digits

	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
50	03674	36059	46810	58367	82676	15051	57977	49410	02971	05797
51	26136	80623	96505	91089	02309	54743	15831	45538	96456	87272
52	61716	80405	84735	12997	86386	61606	75091	84996	76070	54923
53	67051	63246	99547	81223	52485	90333	24697	06266	07388	70389
54	17284	60347	87314	30218	87983	45426	84153	10569	64042	95618
55	12543	23999	95777	28105	66073	35174	67706	05181	35176	85558
56	45494	93037	29209	70724	86438	65354	71209	27969	85321	10216
57	39262	15415	93940	41615	43605	95675	53916	29580	07048	95838
58	29094	58703	92144	14287	50165	85661	95749	61118	36668	96852
59	77988	03222	57805	00725	91543	80021	16442	63360	33620	39324
60	02758	86823	52423	32355	96707	47448	06453	59430	43952	16775
61	46702	37467	66803	49344	59519	92717	97110	82087	36785	00880
62	61759	95153	80090	60626	55917	92812	63544	82295	50729	20116
63	82316	11402	28078	75325	43963	63105	99294	30285	61473	53613
64	32754	74241	14315	49697	61979	66711	61707	81589	53936	82115
65	37907	24080	31741	86653	81460	32304	99590	56644	41521	91172
66	16619	75264	12279	18996	16716	81959	65722	10058	91522	65410
67	66640	06195	84416	32836	53178	93810	36766	59778	26612	69017
68	45208	58525	07714	77126	67986	73140	12026	75550	84912	64691
69	00910	40237	91035	29125	03534	47246	64698	00608	39537	71755
70	19965	46945	59357	15551	20335	03145	21519	37882	99146	70161
71	37538	05747	54982	00494	51866	86172	82679	04152	56369	20356
72	38571	69663	03287	28101	46753	55715	93527	30508	19722	02072
73	76711	02864	00880	85518	25834	52317	48070	51582	03374	19540
74	07128	44400	48015	41449	21109	38948	21816	52089	64529	21510
75	00882	89357	80906	76476	58420	95793	34043	00991	38937	39859
76	96160	18580	40549	46562	45106	53768	76097	60504	85273	63076
77	13443	22235	46210	47755	05802	00311	15171	23818	89870	47578
78	99494	35395	71411	48281	92151	84465	63651	15969	61345	13324
79	90647	11809	96365	52409	17977	05971	35835	03889	43733	66100
80	33050	48785	92200	59319	36977	41111	28002	51580	10573	21763
81	21257	15066	72630	23206	03106	53140	50292	64012	83184	81304
82	45362	94324	81800	83980	97244	09691	08435	66723	06150	54972
83	93322	58684	95695	19096	98108	47678	98061	87193	99992	82870
84	20374	61803	62508	83696	54449	53649	86447	66115	90857	69114
85	00715	13209	17080	06890	38022	76469	27696	30778	31836	96676
86	85519	93677	90186	09579	98760	50320	98077	46048	79700	81431
87	71948	15871	84502	41330	46675	51342	93431	55566	90819	68923
88	43427	95500	02004	51802	59668	17806	87605	33010	20991	76269
89	64854	28815	74959	03531	77051	51807	89005	18898	23716	45862
90	62195	29095	23982	75883	41561	25897	43595	92703	86676	32038
91	61186	54041	60984	61602	18482	57941	59657	35924	21738	30646
92	88585	40218	69965	74354	62274	38948	44813	31558	40625	22477
93	15598	21389	79016	92151	21926	49901	16835	88055	30545	60306
94	27097	89653	21558	72731	66694	36703	92172	46129	32660	91356
95	40537	85697	78182	39711	59270	21934	78647	94801	78832	37287
96	74828	06544	13078	59528	31100	11132	91256	85899	72492	18200
97	43297	83195	66218	65838	63255	72093	38976	44892	96861	97848
98	32663	58127	73258	09220	49701	92357	43700	37214	56844	02048
99	45551	31330	08152	23712	23963	58274	94583	03761	73429	47328

Table D.45 was prepared using an algorithm for the IBM 360 computer (International Business Machines, 1968: 77).

Appendix 4. Tatum Aids

DAMAGE/CAUSE OF DEATH (CONT.)

Code		Damage/Cause of Death
01		No damage
02		Acceptable seedling or sapling, poor form
10		Insect damage
	11	Bark beetles
	12	Defoliators
	13	Sucking insects
	14	Tip and shoot borers
	15	Gall-forming insects
20		Disease, unidentified
	21	Rust
	22	Rot
	*25	Severe rot
	26	Witches-brooms
30		Fire
40		Animal caused
	41	Domestic animal
	42	Porcupine
	43	Rabbit
	44	Beaver
	45	Big game
	46	Man
50		Weather
	51	Wind
	52	Lightning
	53	Snow
	54	Frost
	55	Flooding
	56	Earth movement
*60		Suppression
70		Unknown
	71	Leaning 15° or more
	72	Forked
	73	Broken top
	74	Dead top
	*75	Uprooted
	76	Bole split
	77	Sweep crook
	78	Abrasion
	79	Unhealthy foliage
80		Logging damage
*90		Cull or offsite tree
	91	Layered seedling

SITE DRAINAGE

1 very poor
2 poor
3 somewhat poor
4 moderately well
5 well drained
6 somewhat excessive
7 excessive

TREE HISTORY (ALL POINTS)

On both estimated and measured points, record a 1-digit tree history code for each tree using the following standard codes:

Code	Definition - New Sample locations
1	**All live tally trees** (Includes seedlings, saplings, poletimber, and sawtimber trees).
4	**Salvable Dead** Dead for more than 5 years Equal to or greater than 10 cm. DBH Standing or down More than 50 percent sound on a cubic foot basis
5	**Salvable Mortality** Dead less than 5 years Equal to or greater than 10 cm. DBH Standing or down Not rough or rotten tree class at time of death Presently more than 50% sound on a cubic foot basis.
6	**Non-salvable Mortality** Dead less than 5 years Equal to or greater than 10 cm. DBH Standing or down Not rough or rotten tree class at time of death Presently less than 50% sound on a cubic foot basis
7	**Non-salvable Dead** Dead more than 5 years Equal to or greater than 10 cm. DBH Standing or down Less than 50 percent sound on a cubic foot basis.

CROWN CLASS

	Code
Open grown	1
Dominant	2
Codominant	3
Intermediate	4
Overtopped	5

GUIDES FOR ESTIMATING FIVE YEAR MORTALITY

Died within past 5 years	Species	Dead more than 5 years
Some foilage remaining 30% or more of twigs remain 50% or more of branches remain Little sloughing of bark	Spruce (wh & bl)	No foilage Less than 50% branches remaining. Large limbs falling. Less than 30% of twigs remaining. Considerable bark sloughing
50% or more of bark still attached to bole in some degree.	Populus Sp.	No foilage Bark fallen completely free of bole, or less than 50% attached in any degree.
A few persistent leaves remaining. 50% or more of branchlets remaining. Occassional secondary branch falling.	Birch	No foilage Less than 50% of secondary branches remaining. Bark shows abnormal curling
Some needles remaining 25-50% or more of branchlets remaining. Tight bark (particularly on hemlock). But few secondary branches falling.	Sitka spruce & Western hemlock	25% or less of branchlets remaining. Secondary and primary branches falling. Bark sloughing Sporophores of _Fomes pinicola_ and other fungi common.

094 White Spruce (_Picea glauca_)

leaves	4-angled, sharp-pointed, stiff needles, whitish lines, short stalks, grow singly on all sides of twig.
twigs	slender, hairless, orange-brown, become rough from peglike stalks of leaves, pungent odor when crushed.
bark	thin, grey to brown, smooth to scaly plates, whitish inner bark.
cones	nearly stickless shiny light brown, thin, papery, smooth-edged, scales.
habitat	well drained soils, south slopes, seldom where permafrost is near surface.

095 Black spruce (_Picea mariana_)

leaves	short stalked, 4-angled needles, stiff, pointed, purplish hue, grow singly on all sides of twig.
twigs	slender, hairy, purplish hue, become brown and rough.
bark	thin, grey to black scales with brown beneath, inner bark yellowish with brown spots.
cones	short stalked, pendant, 15-31mm., dull grey to black, clustered in tree top, scales rigid, brittle, rounded, and slightly toothed.
habitat	cold, wet, flats, muskegs, north slopes, lake margins.

[illegible] forest ([illegible] canopy)

A. Spruce-birch -- [illegible] in cool, wet sites [illegible] spruce is present in the mixture; white spruce favors forest warmer, drier sites. The type is found primarily in interior and south-central Alaska and, to a lesser extent, in nortwest and southwest Alaska.

B. Spruce-birch-poplar (cottonwood) -- reported from the Susitna Valley in south-central Alaska

C. Spruce-birch-aspen -- reported from interior Alaska.

D. Aspen-spruce -- is an intermediate successional stage, with spruce as the eventual climax. Aspen generally occurs with white spruce on warm , well-drained sites. The type is most common in interior and south-central Alaska.

E. Poplar-spruce -- is an intermediate successional stage leading to white spruce climax on flood plain sites in interior, south-central, southwestern, and northwestern Alaska.

1C2 Open mixed forest (25-60% canopy)

A. Spruce-birch -- occurs on a variety of upland sites in interior, south-central, southwestern and northwestern Alaska.

B. Aspen-spruce -- reported from the Porcupine River area in interior Alaska.

C. Birch-Poplar (cottonwood)-spruce -- reported from the Susitna Valley, southcentral Alaska.

D. Spruce-poplar (cottonwood) -- reported from the Susitna Valley, soutncentral Alaska.

1C3 Mixed woodland (10-25% canopy)

A. Spruce-birch -- reported from the Susitna Valley, south-central Alaska.

B. Spruce-poplar (cottonwood) -- reported from the Susitna Valley, soutacentral Alaska.

C. Spruce-birch-poplar (cottonwood) -- reported from the Susitna Valley south-central Alaska.

1B1 Closed broadleaf forest (60-100% canopy)

A. Red alder -- occupies moist sites and distrubed areas in southeastern Alaska

B. Black cottonwood -- is generally found along streams in southeastern and south-central Alaska.

C. Balsam poplar -- occurs most frequently on river flood plains in interior, south-central, and southwestern Alaska, although there are several isolated clumps on the north slope of the Brooks Range.

D. Paper birch -- occurs on a variety of upland sites, both with and without permafrost, in interior and south-central Alaska.

E. Aspen -- occurs on warm, well-drained upland soils in interior and south-central Alaska.

F. Birch-aspen -- found on moderately warm sites in interior and south-central Alaska and is generally replaced by white spruce.

G. Aspen-balsam poplar -- reported from the Porcupine River and in interior Alaska.

1B2 Open broadleaf forest (25-60% canopy)

A. Paper birch -- occurs on dry to moist sites in interior, southcentral, and western Alaska. On drier sites, lichens are important in the understory; on moist sites, shrubs are dominant.

B. Aspen -- occurs primarily on extremely dry sites on steep south slopes in interior and south-central Alaska.

C. Balsam poplar -- occurs as open clumps near tree line in interior, south-central, southwestern, and nortnwestern Alaska and as isolated groves on the north slope of the Brooks Range.

D. Paper birch-Poplar (cottonwood) -- reported from the Susitna Valley in southcentral Alaska.

1B3 Broadleaf woodland (10-25% canopy)

A. Paper birch - occurs on dry sites, such as old sand dunes and coarse gravel deposits, in northwest Alaska and the northern portion of interior Alaska.

B. Poplar (cottonwood) woodland -- reported from the floodplain of the Susitna River in southcentral Alaska.

C. Paper birch-poplar (cottonwood -- reported from the Susitna Valley south-central Alaska.

1A1 Closed needleleaf forest (60-100% canopy)

K. White Spruce -- is widespread in southcentral and int and extends to the limits of tree growth along rivers d Brooks Range. It generally occupies sites with well-dr permafrost-free soils.

L. Black Spruce -- generally occurs on poorly drained or often underlain by permafrost. It has wide distribution western, southwestern, northwestern, and south-central A

M. Black spruce-white spruce -- occurs in interior Alas northern and western limits of trees. It also occurs on at the base of south-facing slopes.

N. Tamarack-black spruce

- 45 -

1A2 Open needleleaf forest (25-60% canopy)

F. White spruce -- is similar to the closed white sp with more shrub cover because of the more open tree Found commonly on well-drained sites and near treeli interior, southwest, northwest, and south-central Al

G. Black spruce -- is extremely common on poorly dr sites in interior and south-central Alaska.

H. Black spruce-white spruce -- occurs mostly near interior, southwestern, western, northwestern, and Alaska.

1A3 Open needleleaf woodland (10-25% canopy)

C. White spruce -- is a very open, woodland type esp common at the northern limits of tree growth and at tree lines.

D. Black spruce -- is found on wet, boggy sites whe often grades into a sphagum bog, and on dry upland lichens are frequently important in the understory. in interior, south-central, southwest, and northwes

E. Black spruce-white spruce -- occurs in interior, south-central, southwest, and northwest Alaska, esp the northern, western, and altitudinal limit of tre

Appendix 5. 1986 Revision of the Alaskan Vegetation Classification (Viereck et al., 1986).

1a. Trees over 3 m in height present and with a canopy cover of 10 % or more........1 Forest........2

1b. Trees over 3 m in height absent or nearly so, with less than 10 % cover. (Dwarf trees, less than 3 m tall at maturity may be present and abundant)................................7

1 Forest

2a. Over 75 % of the tree cover contributed by needleleaf (conifer) species......1A Needleleaf Forest....3

2b. Less than 75 % of tree cover contributed by needleleaf (conifer) species................................4

3a. Tree canopy of 60-100 % cover.........................1A(1) Closed needleleaf forest

3b. Tree canopy of 25-59 % cover....1A(2) Open needleleaf forest

3c. Tree canopy of 10-25 % cover.......1A(3) Needleleaf woodland

4a. Over 75 % of tree cover contributed by broadleaf species..............1B Broadleaf Forest.....5

4b. Broadleaf or needleleaf species contribute 25-75 % of the tree cover.......1C Mixed Broadleaf/Needleleaf Forest.....6

5a. Tree canopy 60-100 % cover.....1B(1) Closed broadleaf forest

5b. Tree canopy 25-59 % cover........1B(2) Open broadleaf forest

5c. Tree canopy 10-24 % cover...........1B(3) Broadleaf woodland

6a. Tree canopy 60-100 % cover.........1C(1) Closed mixed forest

6b. Tree canopy 25-59 % cover............1C(2) Open mixed forest

6c. Tree canopy 10-24 % cover...............1C(3) Mixed woodland

7a. Vegetation with at least 25 % cover of erect to decumbant shrubs or with at least 10 % cover of dwarf trees (less than 3 m tall at maturity)...8

7b. Vegetation herbaceous (may have up to 25 % shrub cover)......................................1

Appendix 5 cont.

Alaskan Vegetation Classification to Level 3

Level 1	Level 2	Level 3
1. Forest	A. Needleleaf forest	(1) Closed needleleaf forest
		(2) Open needleleaf forest
		(3) Needleleaf woodland
	B. Broadleaf forest	(1) Closed broadleaf forest
		(2) Open broadleaf forest
		(3) Broadleaf woodland
	C. Mixed forest	(1) Closed mixed forest
		(2) Open mixed forest
		(3) Mixed woodland

Appendix 5 cont.

Alaskan Vegetation Classification to Level 4 (Forest)

1A1 Closed needleleaf forest (60 - 100% canopy)

K. white spruce - is widespread in southcentral and interior Alaska and extends to the limits of tree growth along rivers draining the Brooks Range. It generally occupies sites with well-drained, permafrost-free soils.

L. black spruce - generally occurs on poorly drained organic soils, often underlain by permafrost. It has wide distribution in interior Alaska.

M. black spruce-white spruce - occurs in interior Alaska near the northern and western limits of trees. It also occurs on terraces and at the base of south-facing slopes.

1A2 Open needleleaf forest (25 - 60% canopy)

F. white spruce - is similar to the closed white spruce type but with more shrub cover because of the more open tree canopy. Found commonly on well-drained sites and near treeline in interior Alaska.

G. black spruce - is extremely common on poorly drained cold sites in interior and south-central Alaska.

H. black spruce-white spruce - occurs mostly near treeline in interior, southwestern, western, northwestern and south-central Alaska.

1A3 Open needleleaf woodland (10 - 25% canopy)

C. white spruce - is a very open, woodland type especially common at the northern limits of tree growth and at elevational tree lines.

D. black spruce - is found on wet, boggy sites where it often grades into a sphagnum bog, and on dry upland sites where lichens are frequently important in the understory. It is common in interior, south-central, southwest and northwest Alaska.

E. black spruce-white spruce - occurs in interior, south-central, southwest and northwest Alaska, especially near the northern, western and altitudinal limit of trees.

Appendix 5 cont.

1C1 Closed mixed forest (60 - 100% canopy)

A. spruce-birch - tends to occur on cool, wet sites when black spruce is present in the mixture; white spruce favors forest warmer, drier sites. The type is found primarily in interior and south-central Alaska and, to a lesser extent, in northwest and southwest Alaska.

B. spruce-birch-poplar (cottonwood) - reported from the Susitna Valley in south-central Alaska.

C. spruce-birch-aspen - reported from interior Alaska.

D. aspen-spruce - is an intermediate sucessional stage, with spruce as the eventual climax. Aspen generally occurs with white spruce on warm, well-drained sites. The type is most common in interior and south-central Alaska.

E. poplar-spruce - is an intermediate successional stage leading to white spruce climax on flood plain sites in interior, south-central, southwestern and northwestern Alaska.

1C2 Open mixed forest (25 - 60% canopy)

A. spruce-birch - occurs on a variety of upland sites in interior, south-central, southwestern and northwestern Alaska.

B. aspen-spruce - reported from the Porcupine River area in interior Alaska.

C. birch-poplar (cottonwood)-spruce - reported from the Susitna Valley, south-central Alaska.

D. spruce-poplar (cottonwood) - reported from the Susitna Valley, south-central Alaska.

1C3 Mixed woodland (10 - 25% canopy)

A. spruce-birch - reported from the Susitna Valley, south-central Alaska.

B. spruce-poplar (cottonwood) - reported from the Susitna Valley, south-central Alaska.

C. spruce-birch-poplar (cottonwood) - reported from the Susitna Valley, south-central Alaska.

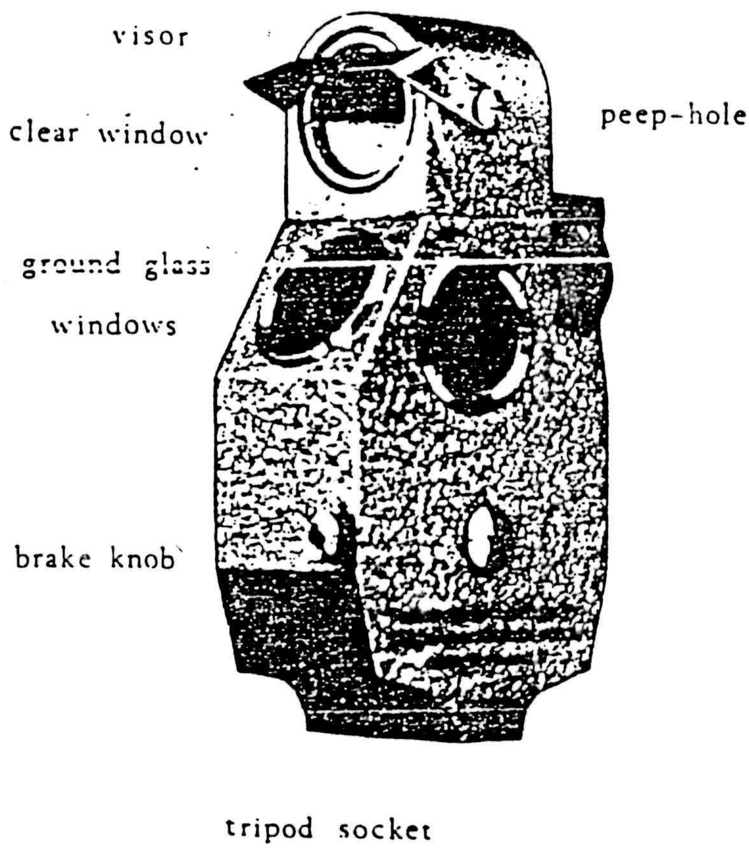


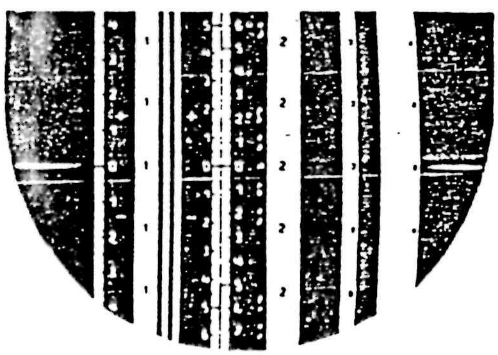
Fig. 1 — Spiegel Relaskop.

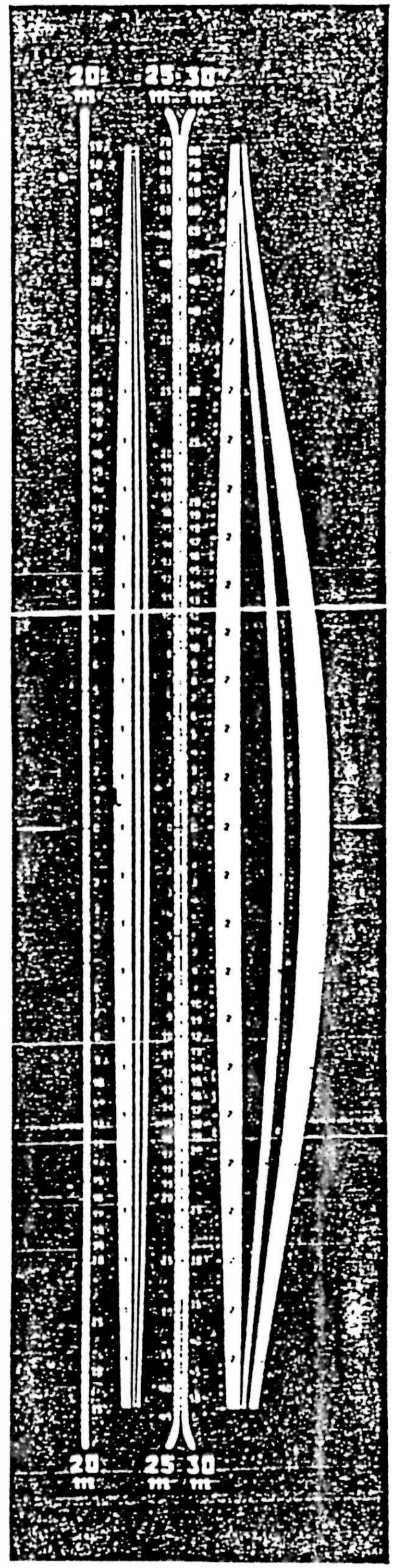
From the Relaskop, Finlayson

Appendix 6: cont.

Fig 2 (right)
Scales — full length.

Fig. 3 (below)
Scales – as seen.





Finlayson, no date. Relaskop Use.

SPIEGEL - RELASKOP

Inventor: W. W. Bitterlich

These instructions prepared by Dr. John F. Bell, School of Forestry, Oregon State University, Corvallis, Oregon, U.S.A.

INTRODUCTION:

The Spiegel-Relaskop is an instrument designed for use as an angle gauge in the Bitterlich angle method of forest sampling (also known as horizontal point sampling and variable plot sampling) for determining basal area in square feet per acre. The Spiegel-Relaskop can also be used to directly measure tree diameters to any height that stem visibility permits: to measure tree heights, to read slope in percent, topographic, and degree scales and to directly measure horizontal distances.

Three scale arrangements — American, Metric and Wide — are offered to fit different conditions and usages.

The Spiegel-Relaskop is a compact, ruggedly-constructed instrument. Weight 14 ounces.

Throughout the remainder of these instructions, *the instrument is referred to as* RELASKOP.

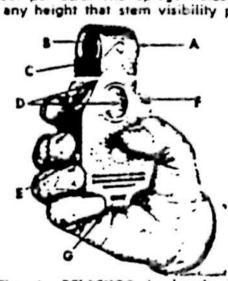


Fig. 1 RELASKOP in hand - held operating position.

OPERATION:

If hand-held, the RELASKOP should be positioned as per Fig. 1. For more precise work, mount it on a tripod (Fig. 2). One person, unassisted, can make accurate measurements with RELASKOP.

Looking through the small window "A" gives a clear, wide angle view through "B" in which is visible a series of black and white scales. A shade "C" is provided to permit use when facing bright light. In use, the 3 circular windows "D", beneath A and B should remain free of obstruction as they provide light to the scales. The button "E" releases the brake which holds the scale wheel in position between readings. The scale wheel operates on the pendulum principle but dampens very fast and brakes easily. There are 2 eyes "F" on which a strap is attached for carrying the instrument suspended from the neck, if desired.

The field of vision through A-B is divided into 2 halves, upper and lower, by a horizontal line which is the measuring "edge." No other point of reading is accurate. Through the upper half the RELASKOP user views the terrain and the trees. In the lower one-half the RELASKOP user will see against a dark background a series of bars and black and white bars and scales extending up to the measuring edge.

To take a reading, the user presses brake release button "E" and the scale automatically rotates to the angle the instrument is tilted when sighting at the point of measurement. Partial release of button "E" helps to bring the pendulum to a fast stop. The scales for the American (Standard) scale RELASKOP are illustrated in Fig. 3 and 3a and they are identified at the base of the scales when the instrument is tilted down 60°.

Fig. 2 RELASKOP on tripod mounting; shake-free for greater accuracy. Distance "a" is always measured from the eye of the observer.

Cosines of Slopes

2° - .999	14° - .970	26° - .899	38° - .788
4° - .998	16° - .961	28° - .883	40° - .766
6° - .994	18° - .951	30° - .866	42° - .743
8° - .990	20° - .940	32° - .848	44° - .719
10° - .985	22° - .927	34° - .829	46° - .694
12° - .978	24° - .914	36° - .809	48° - .669

If Girard and Bruce form class tables are being used, form class can be eliminated by observing the trees at the top of the first 16 foot log — see Dilworth and Bell (Reference No. 3) for procedure to use.

TO USE AMERICAN SCALE RELASKOP AS A RANGEFINDER

To find ranges of 33, 66 and 99 feet proceed as follows:
Hold the RELASKOP flat with scales locked as per Fig. 6.

3 feet are intercepted by "b" to "d" at a horiz. distance of 33 ft.
6 feet are intercepted by "b" to "d" at a horiz. distance of 66 ft.
6 feet are intercepted by "b" to "c" at a horiz. distance of 99 ft.
8 feet are intercepted by "b" to "c" at a horiz. distance of 132 ft.

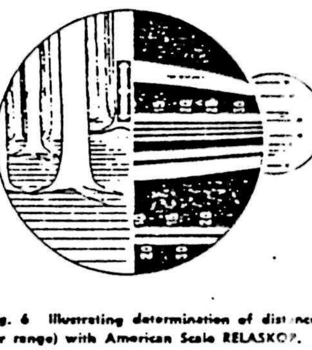


Fig. 6 Illustrating determination of distance (or range) with American Scale RELASKOP.

In using the instrument to establish horizontal distances from the tree to be measured, a staff exactly 6 feet long is held vertically (or leaned against the tree) at its central axis. From an estimated horizontal distance of 66 feet from the tree the slope is measured with the instrument and the scale fixed in position at this slope by setting the brake. The instrument is turned 90° and the staff should intercept the distance along the "measuring edge" from "b" to "d" if the 66 feet is estimated accurately. (Fig. 6) By moving forward or backwards the accurate point can be established. You can do the same with a staff 3 feet long and a horizontal distance of 33 feet.

TO MAKE SLOPE MEASUREMENTS WITH AMERICAN SCALE RELASKOP

DEGREE SCALE

Scale "D" to the left of "0" is graduated in degrees. See Fig. 3a. The range is from plus 70° to minus 60°.

PERCENT SCALE

Scale "P" to the left of Scale "D" is graduated in percent. See Fig. 3a. The range is from plus 270 percent to minus 170 percent.

TOPOGRAPHIC SCALE

Scale "T" to the right of "b" gives the topographic corrections to be applied in using the 2-chain tape with trailer. See Fig. 3a. The readings are the number of feet difference elevation per 1 chain horizontal distance. Range is between plus 180 feet and minus 120 feet.

The plus and minus direction of the instrument for scales "T", "D" and "P" are indicated only at the zero point.

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INSTRUCTIONS FOR METRIC SCALE RELASKOP

HOW TO MEASURE BASAL AREA WITH METRIC SCALE RELASKOP

In the Bitterlich method, a tree whose diameter is larger than the fixed critical angle of the Relaskop is a count tree (Fig. 4).

The angles with the counting factor 1 and 2 are the ones most frequently used. Both angles are illustrated by white stripes showing the continuous numbers 1 and 2 respectively (Fig. 8). In application, select a plot center, project the chosen angle (strip) of the scale to each tree at DBH that can be seen from the point, and count the number of trees greater in diameter than the angle used. If a stem is obscured by intervening trees, it is necessary to move to one side but maintaining the same distance from the tree, to view it. The number of trees counted times the angle's basal area factor equals the basal area in square meters per hectare in the plot. The effect of the slope of the terrain is automatically adjusted by the instrument when the brake is released and the scale comes to rest on a particular tree's DBH.

To the right of strip 1, the same width is divided into 4 bars (two dark and two light ones). Added to strip 1, they give an angle with the basal area factor 4, which is also used frequently.

Trees which seem to be of the same width in diameter as the angle used, have to be checked by measuring. In order to be counted, the tree diameter multiplied by the Plot radius factor must give an answer larger than the distance from the plot center to the stem. (Example: Basal Area Angle factor 4, having the Plot radius factor 1 :25; tree with measured DBH 36cm; the critical radius is 36 x 25 = 900 cm; tape measurement gives a distance of 897 cm. Tree has to be counted).

Basal area may be determined at any desired height. Measurements at different height give valuable information about the shape-factor of a particular stand. Using a colored 4 meter staff, it is easy to find the height where the diameter is of the same width as the angle used. (This point is called "Deckpunkt"). This staff, for example, is from 1,3 m blue, from 3,0-3,5m white, and from 3,5-4,0m red. If the "Deckpunkt" falls into the blue section, the stem has to be counted up to a height of 2,5 meters, but not at a height of 3,0 meters.

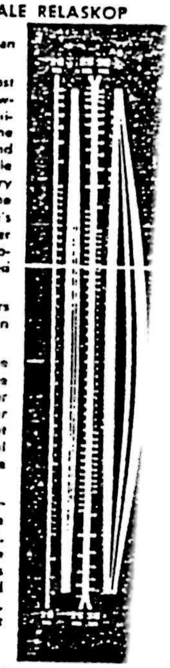


Fig. 7 Scales of Metric RELASKOP their full length varying width stripes illustrate the instrument for changes in From left to right gent scale for horizontal distance of 20 strip 1 with the ing dark and two bars, tangent scale horizontal distance 25 and 30 meters 2, and two strips different width range finder.

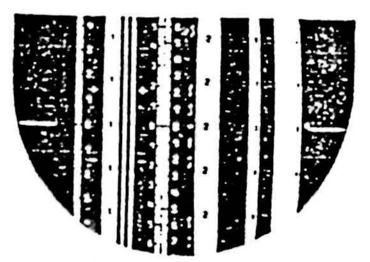
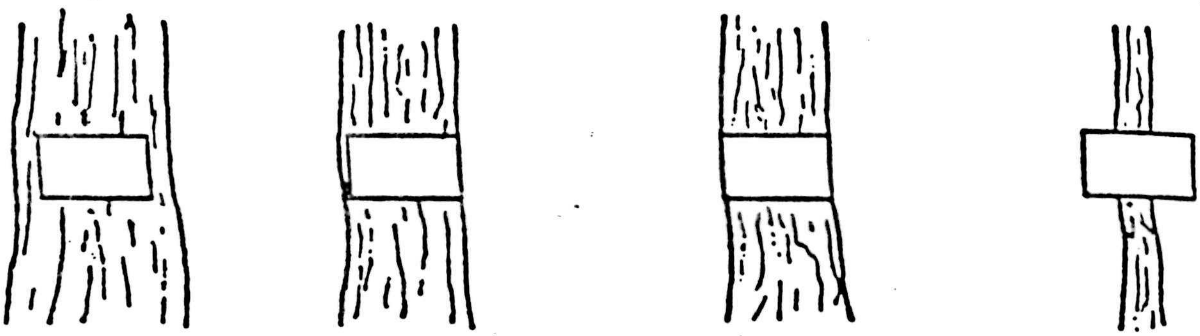


Fig. 8 Metric scales, close-up.

Relaskop use. Dilworth and Bell, 1982.

Use of Angle Gauge - The eye of the observer must be directly over the plot center. The angle gauge should be extended straight, and the cross arm sighted at DBH on the tree. Four possible angle gauge readings are illustrated below:



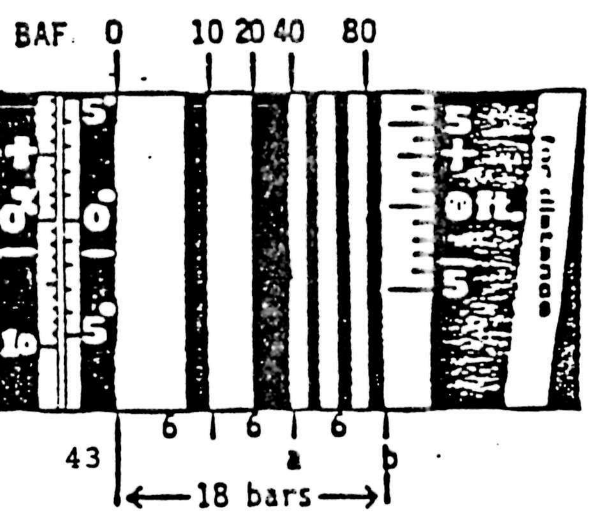
Record this Tree | Borderline Tree (check with tape) | Borderline Tree (check with tape) | Do not Record This Tree

Use of the Spiegel-Relaskop (American Scale) - The instrument is positioned over the sample plot center and the measuring edge is aimed so as to 'cut' the tree at DBH. To take a reading, the user depresses the brake release button and the scale rotates to the angle which the instrument is tilted. Releasing this button brings the scale to a stop. The curvature of the scale automatically compensates for any slope in terrain.

18 'bars' are represented on the scale. From the '0' edge to '10' equals 6 bars, '10' to 'a' equals 6 bars and 'a' to 'b' equals 6 bars (see diagram). Three Basal Area Factors (5, 10 and 20) are already imposed on the bottom of the scale and the instrument is adaptable for other BAF's using the following formula: BAF = 0.277 X (Number of bars)^2

Thus;

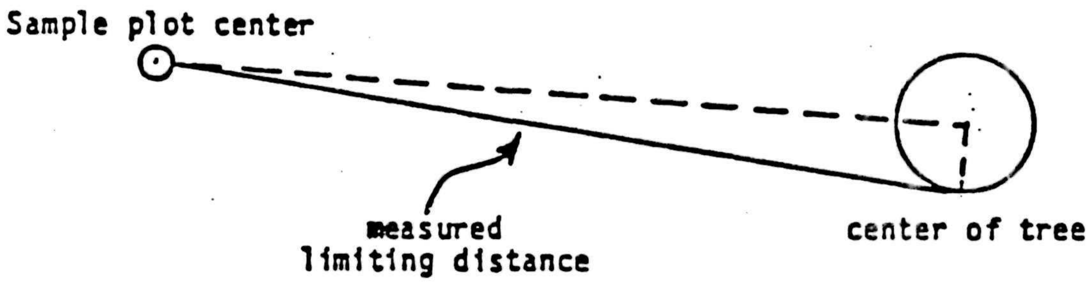
BAF	Number of Bars
10	6.01
20	8.49
40	12.01
80	16.99



The edge marked '0' is used as the common side for all BAF's and is positioned so that it lines up with the left side of the tree bole at DBH. Trees greater in diameter than the projected angle are 'in' or tallyable. Since the BAF's being used do not exactly correspond to an even number of bars, the observer must use caution and check the limiting distance of all questionable trees with a tape. The diagram above represents the scale viewed through the Spiegel-Relaskop.

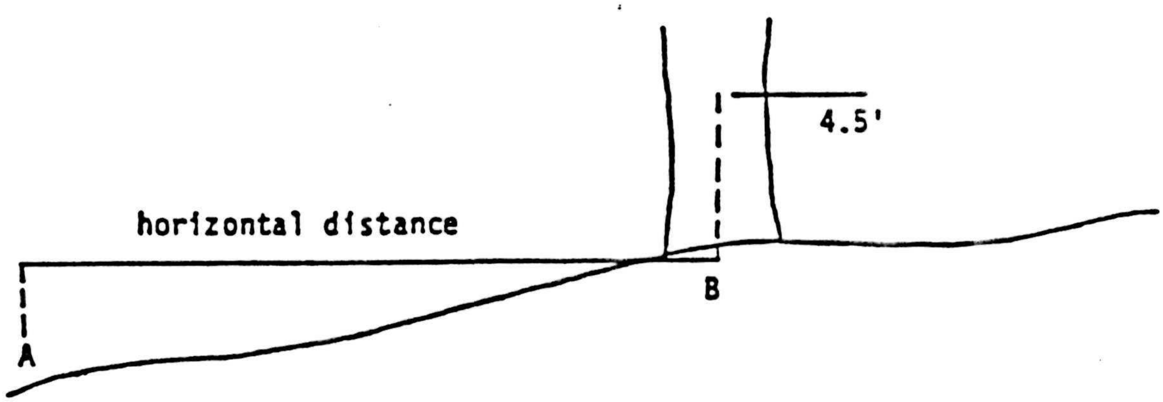
Trees with oblong, egg shaped or irregular boles should always be checked with a tape whenever questionable. The irregular shape of these boles does not give a true image of tree diameter.

The limiting distance to all questionable trees must be checked with a tape. Hold the tape at DBH at the "center of the tree", perpendicular to a line from the sample plot center to the tree.



Determine the limiting distance and compare it to the horizontal or slope distance from the sample plot center to the center of the tree by one of the following methods:

Direct horizontal distance measurement - Measure the horizontal distance from point A to point B as illustrated below, and compare to tree's tabular limiting distance (Table 2, page M9).



Appendix 7. Variable radius plot limiting horizontal distances (Dilworth and Bell, 1982 and 1984).

Horizontal limiting distance from plot center to the center of the bole at the point of diameter measurement. The distance in feet indicates the maximum distance at which at tree of a given diameter would be considered an "in" tree.

Metric scale BAF 2 1/4 or American scale equivalent of 22.05

Dia.	Dist. Feet	Dia.	Dist. Feet
3.0	5.6	12.0	22.2
3.5	6.5	12.5	23.1
4.0	7.4	13.0	24.1
4.5	8.3	13.5	25.0
5.0	9.3	14.0	25.9
5.5	10.2	14.5	26.8
6.0	11.1	15.0	27.8
6.5	12.0	15.5	28.7
7.0	13.0	16.0	29.6
7.5	13.9	16.5	30.5
8.0	14.8	17.0	31.5
8.5	15.7	17.5	32.4
9.0	16.7	18.0	33.3
9.5	17.6	18.5	34.2
10.0	18.5	19.0	35.2
10.5	19.4	19.5	36.1
11.5	21.3	20.0	37.0

Plot Radius Factor = 1.85

Limiting Distance = PRF x Dia.

For plot radius factors of other BAF's see Appendix F.

Appendix 8. Useful conversions.

Conversions
1 square mile = 640 acres
1 acre = 43,560 square feet
1 hectare = 2.471 acres
1 acre = 0.405 hectares
1 meter = 3.28 feet
1 square meter = 10.76 square feet
1 foot = 0.305 meters
1 square foot = .093 square meters
1 inch = 2.54 centimeters
1 centimeter = 0.394
10 square chains = 1 acre
1 mile = 80 chains
1 chain = 66 feet

acre	plot radius
1 acre	117.8 ft
1/10	37.2 ft
1/50	16.7 ft
1/100	11.8 ft
1/250	7.5 ft
1/442	5.6 ft*
1/500	5.3 ft

* Limiting distance for a 3 inch DBH at a American BAF of 22.05.

Appendix 8 cont.

Approximate conversions between the BAF's of Metric and Metric wide scale Relaskops and an approximate American scale equivalent.

Metric Scale		(BAF squared) (conversion)	Wide Scale Metric	American equiv.	Plot Radius Factor(ft)*
1.00 Band 1	(16/16)	(1.00)	1 RU	4.36	4.16
1.56 Band 1 + 1 narrow band	(25/16)	(2.44)		10.63	2.67
2.00 Band 2	(32/16)	(4.00)	2 RU's	17.42	2.08
2.25 Band 1 + 2 narrow bands	(36/16)	(5.06)	2 1/4 RU's	22.05	1.85
		(6.25)	2 2/4 RU's	27.2	1.67
		(7.56)	2 3/4 RU's	32.93	1.52
3.06 Band 1 + 3 narrow bands	(49/16)	(9.37)		40.08	1.37

*Plot Radius Factor: For a given critical angle, the plot radius factor is the distance per unit of tree diameter from the sampling point to a point at which the tree would be a borderline tree. The plot radius factor is determined once for every BAF.

The limiting distance (the plot radius factor times the diameter) is the maximum distance at which a tree of a given diameter is counted "in".

Eg.: The limiting distance for a 3" diameter tree when the BAF is metric scale 2 1/4 (or 22.05 American scale equivalent) is:

3.0 x 1.85 = 5.55 ft., or 1.7 meters

For limiting distances of other diameters, refer to Appendix B.

Appendix 9. Key characters for major tree species (USDA and Ak DNR, 1983)

094 white spruce (*Picea glauca*)

leaves: 4-angled, sharp-pointed, stiff needles, whitish lines, short stalks, grow singly on all sides of twig.

twigs: slender, hairless, orange-brown, become rough from peglike stalks of leaves, pungent odor when crushed.

bark: thin, grey to brown, smooth to scaly plates, whitish inner bark.

cones: nearly stalkless, shiny light brown, thin, papery, smooth-edged scales.

habitat: well drained soils, south slopes, seldom where permafrost is near surface.

095 black spruce (*Picea mariana*)

leaves: short stalked, 4-angled needles, stiff, pointed, purplish hue, grow singly on all sides of twig.

twigs: slender, hairy, purplish hue, become brown and rough.

bark: thin, grey to black scales with brown beneath, inner bark yellowish with brown spots.

cones: short stalked, pendant, 15-31 mm., dull grey to black, clustered in tree top, scales rigid, brittle, rounded, and slightly toothed.

habitat: cold, wet, flats, muskegs, north slopes, lake margins.

Appendix 9 cont.

373 paper birch (<u>Betula papyrifera</u>)

leaves: slender stalked, ovate, pointed at tip, rounded at base, coarsely and double toothed, dark green and hairless above, light yellow-green and may be slightly hairy below.

twigs: slender, hairless, red-brown, small, whitish dots, raised, half-round leaf scars.

bark: smooth, white to coppery brown, separates into thin, papery layers, inner bark orange.

fruit: conelike, 25-50 mm., slender stalked, pendant.

habitat: interior, rolling benchlands to 800 feet elevation.

741 balsam poplar (<u>Betula balsamifera</u>)

leaves: finely hairy, slender stalked, ovate to broadly lance-shaped, long pointed at apex, rounded at base, many small rounded teeth, nearly hairless, shiny dark green above, light green and brown below.

twigs: red-brown and hairy when young, becoming grey with raised leaf scars.

bark: light to dark grey, smooth becoming rough, thick, and deeply furrowed.

habitat: interior river valleys and flood plains, found to 3,500 feet elevation.

746 quaking aspen (<u>Populus tremuloides</u>)

leaves: slender, flattened stalks, nearly round, short-pointed at apex, rounded at base, many small rounded teeth, hairless, shiny green above, paler beneath.

twigs: slender, reddish, and slightly hairy when young, becoming grey with raised leaf scars.

bark: whitish to greenish-grey, smooth, thin, curved scars and black knots, furrowed at base on older trees.

habitat: south slopes, well-drained benches, creek bottoms up to 3,000 feet elevation.

Appendix 10. Guide for estimating five year mortality (USDA and Ak DNR, 1983)

Died within past 5 years	Species	Dead more than 5 years
Some foliage remaining 30% or more of twigs remain 50% or more of branches remain Little sloughing of bark	Spruce (wh & bl)	No foliage. Less than 50% branches remaining. Large limbs falling. Less than 30% of twigs remaining. Considerable bark sloughing.
50% or more of bark still attached to bole in some degree.	Populus Sp.	No foliage. Bark fallen completely free of bole, or less than 50% attached in any degree.
A few persistent leaves remaining. 50% or more of branchlets remaining. Occasional secondary branches falling.	Birch	No foliage. Less than 50% of secondary branches remaining. Bark shows abnormal curling.

Appendix 11. DBH Taking Suggestions

Why "Diameter at Breast Height"?

There are a number of practical and expeditious reasons why diameter is measured at breast height (4.5 feet above ground on the high or uphill side of the tree).

- A person of average height can comfortably measure the tree in a normal standing position without having to stoop over or pack along a stepladder.

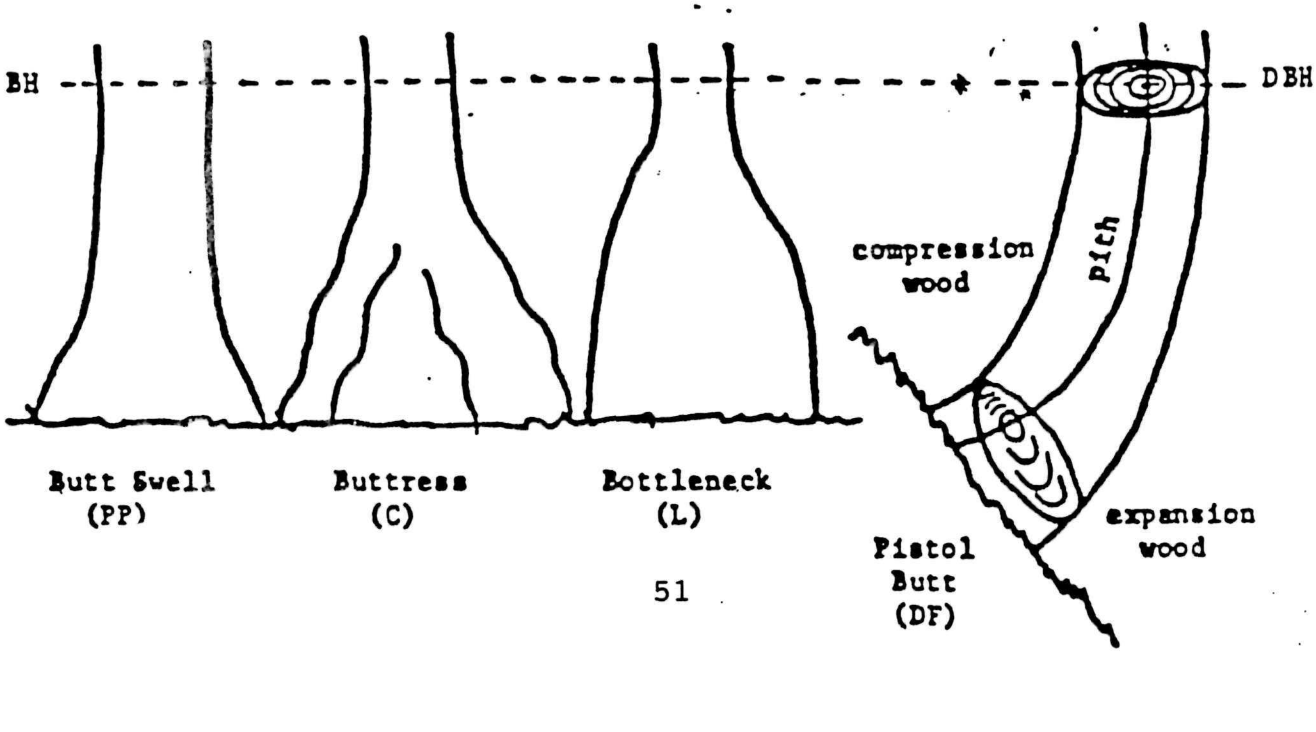
- The tree bole is often quite asymmetrical at ground level, stump height, and until it reaches breast height. By 4.5 feet, the bole is usually quite symmetrical. The pith is more likely to be located in the center at breast height, rather than off-center as is often the case at stump, particularly in "pistol-butt" trees.

- Rot at stump height (from fire damage, root injuries, etc., which permit pathogens to enter) very often does not extend to breast height. Therefore, it is often possible in such trees to obtain age at breast height when it cannot be obtained at stump height.

- These considerations support the reasoning for obtaining age and growth by increment boring at breast height. It would be difficult, or at least inconvenient, to get an increment boring at stump height.

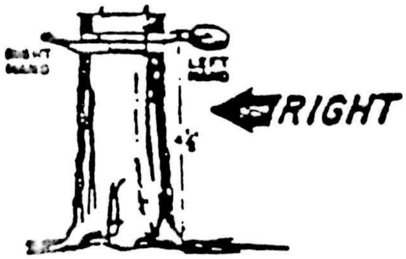
- When diameter, growth, and age are all measured at the same place (breast height), a correlation between these factors can be statistically established.

Asymmetrical Conditions at Stump Height which are not usually present at Breast Height:

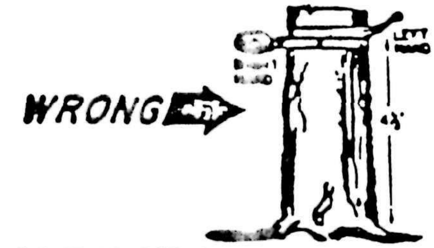


Appendix 11. cont.

USE OF A DIAMETER TAPE

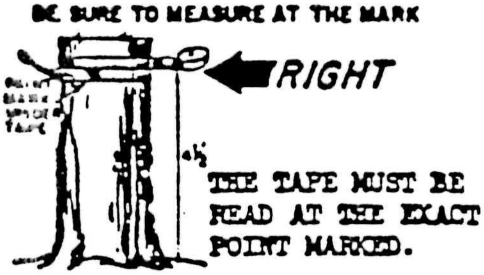


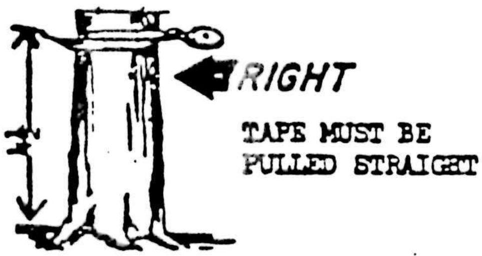
LEFT HANDED— Right hand crossed under.



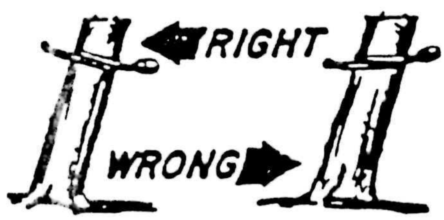
RIGHT HANDED— Left hand crossed over.

BE SURE TO MEASURE AT THE MARK

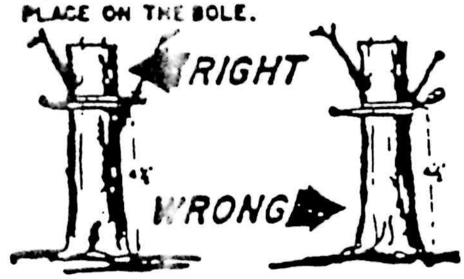




THE TAPE MUST BE AT RIGHT ANGLES TO THE LEAN OF THE TREE.

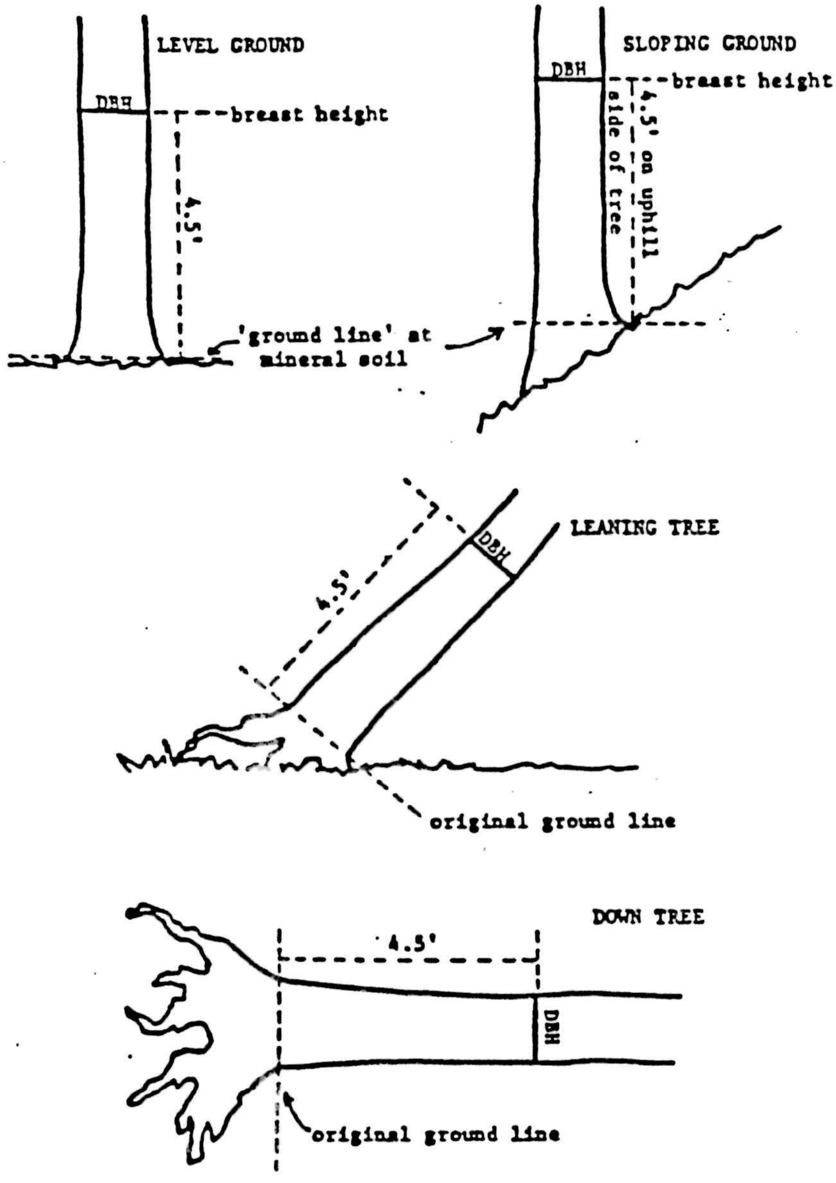


DON'T PLACE TAPE AT AN ABNORMAL PLACE ON THE BOLE.



Appendix 11. cont.

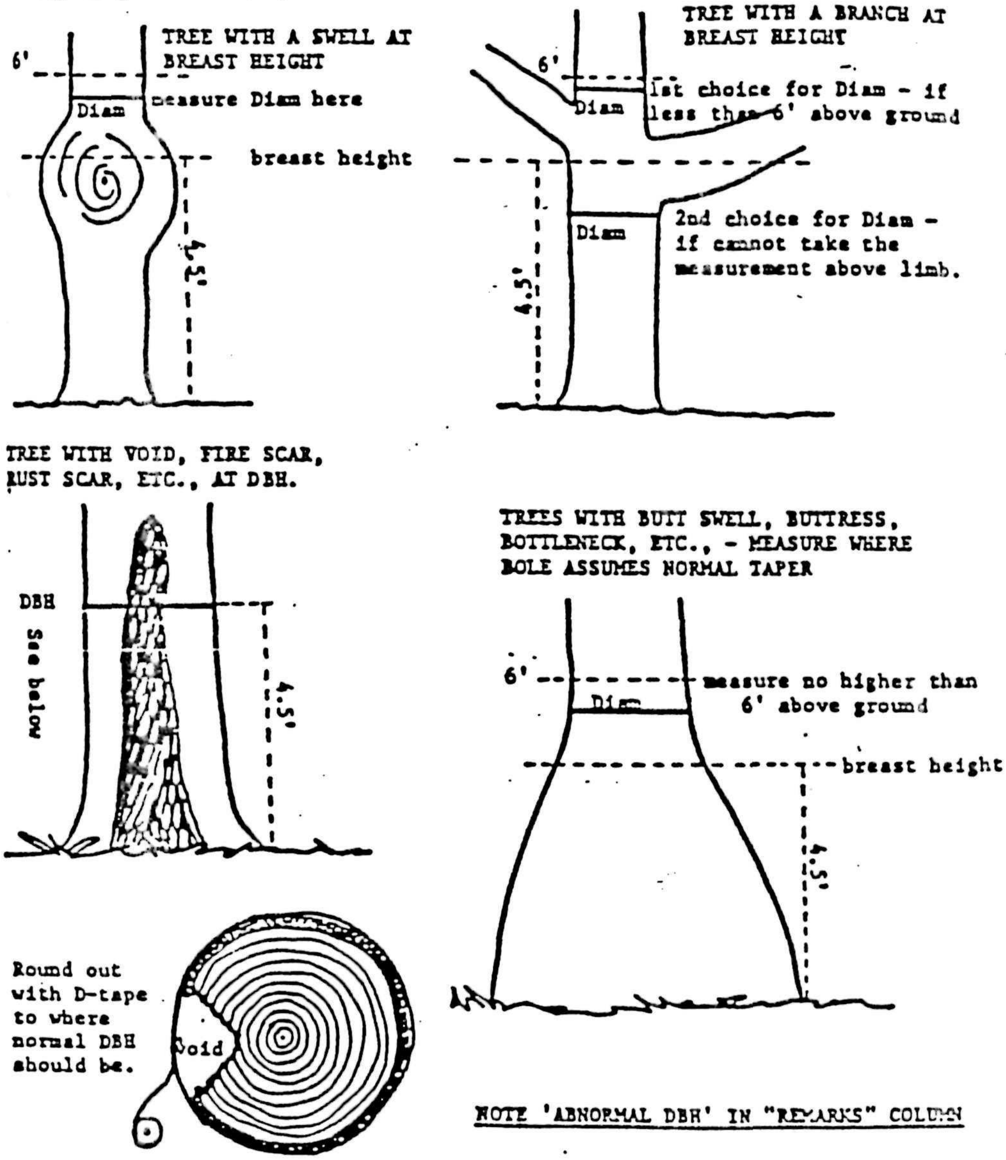
DBH of trees with Normal or Average Boles at 4.5 feet above ground:



Appendix 11. cont.

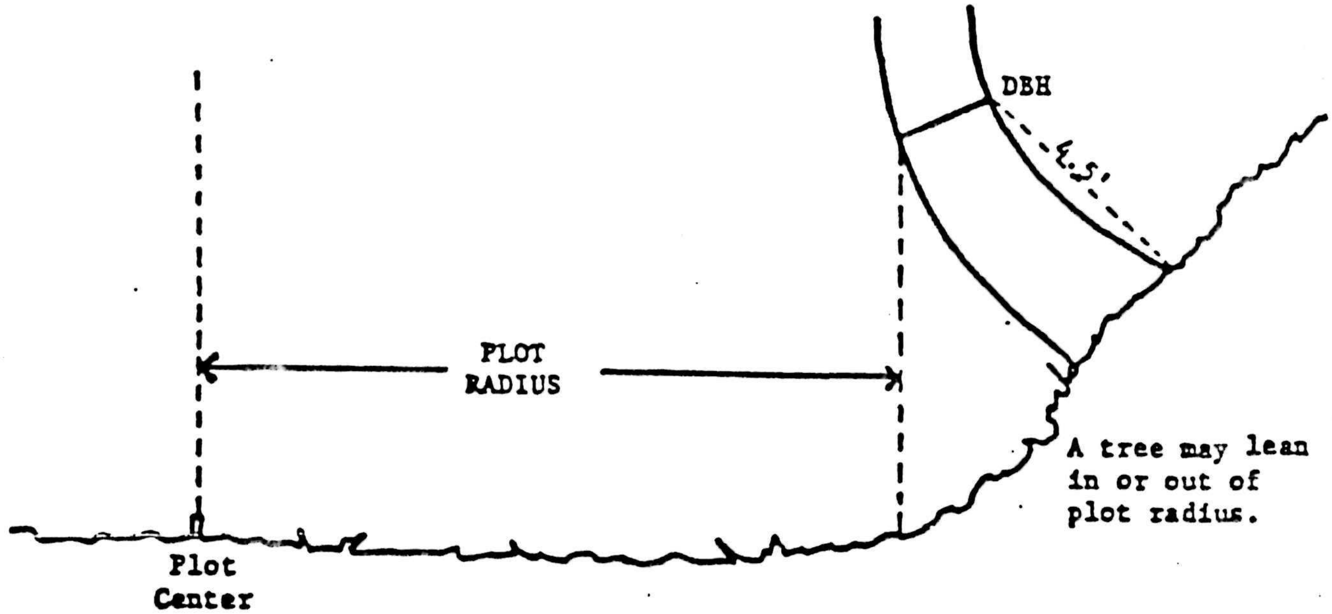
Diameter of Trees with Bole Abnormalities at Breast Height (4.5 feet above ground).

Measure diameter as close as possbile to the standard 4.5 feet above ground. For practical reasons, at a height no higher than 6 feet above ground; and preferably, no lower than 3 feet above ground. Try to get the best possible diameter for the tree.

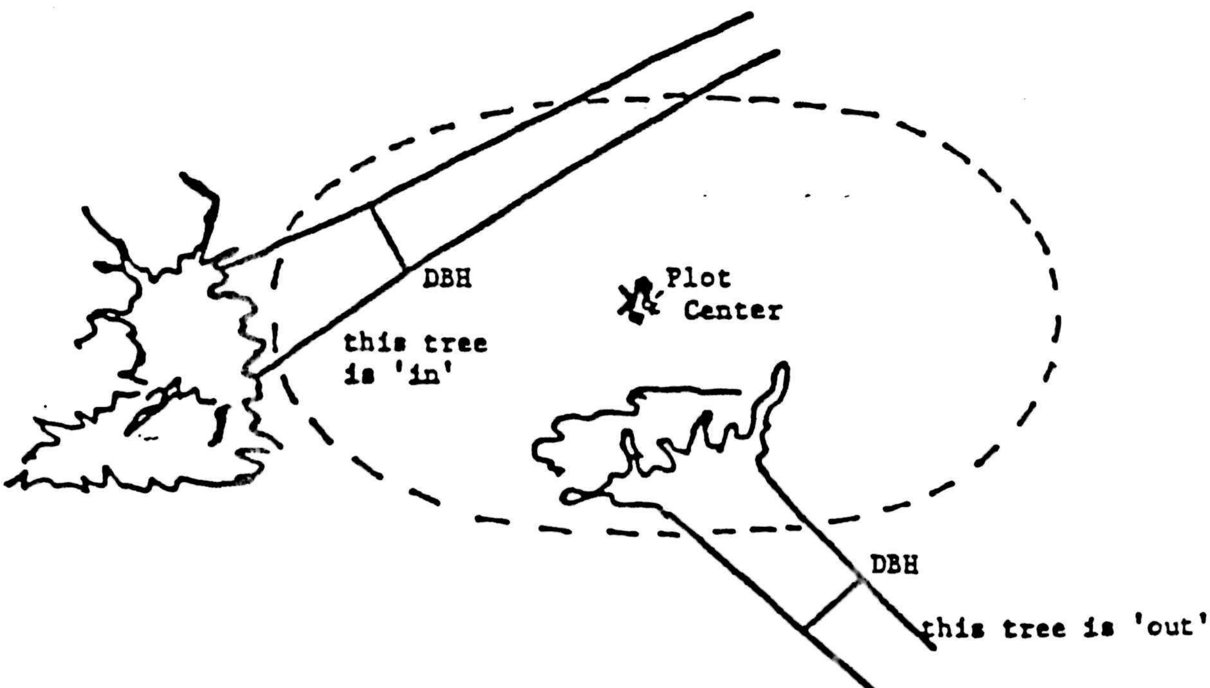


Appendix 11. cont.

Measuring DBH in Various Situations:



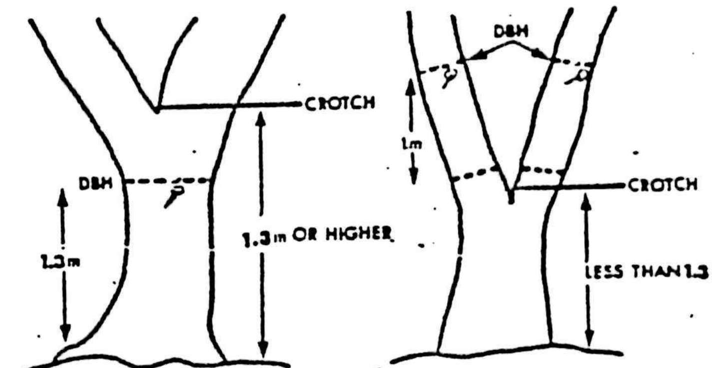
Down Trees are 'in' or 'out' of plot radius based upon where the DBH now lies, not upon where the tree once stood.



Appendix 11. cont.

Leaning trees will be considered as tally trees if they are within the limiting distance at breast height. Measure diameter 1.3 meters from ground level along the lean of the tree.

If the tree forks at or above 1.3 meters the open crotch of the fork is at or above 1.3 m.), consider the tree as one tree and measure the DBH below the swell as near 1.3 meters as possible. If the tree forks below 1.3 meters consider it two trees. Measure the diameter as near to 1 meter above the fork as possible. Record the height of measurement in remarks. In all cases, place a nail 5 cm. below the point of measurement.



FORKED 1.3m OR HIGHER   FORKED BELOW 1.3m

11 TOTAL HEIGHT (ALL POINTS)
12

On measured points, first estimate, then measure total height to the last decimeter on all growth sample and site trees. Height on trees should be estimated to the nearest decimeter. On estimated points, record Item 6-19, estimated height, do not record measured height.

On trees that fork above DBH, measure length along the longest section.

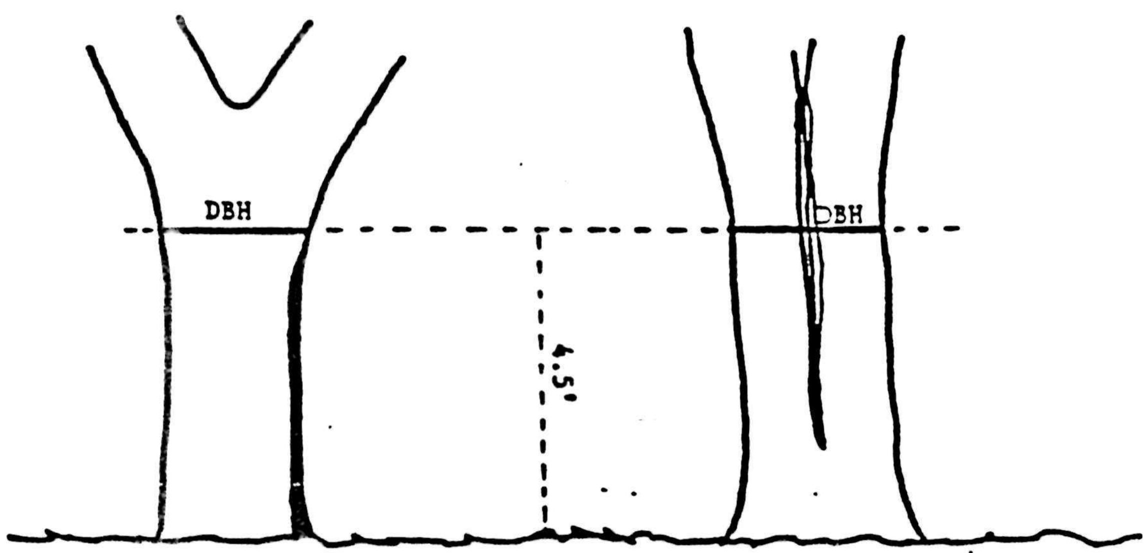
Appendix 11. cont.

Tally Rules for Forked Trees, continued.

Forked Trees in Stand Population Statistics

Forked trees should be regarded as a separate population. They should not be used as Site Trees or Growth Sample Trees unless they are charateristic of the general stand population or unless the forking is a natural genetic function of a species to be featured in management. Height should be recorded for each tree because heights computed from prognosis would not be realistic for these trees or forks.

A. For trees which fork above 4.5 feet above ground.



This tree forks above 4.5 feet.

This tree forks below 4.5, but the forks cannot be measured individually.

1. Measure DBH at 4.5 feet or as close as practical.

2. Record it as one tree. It may be a GST or a Tree Class 1 but not a Site Tree, unless this is a tree typical of those to be featured in management for this stand.

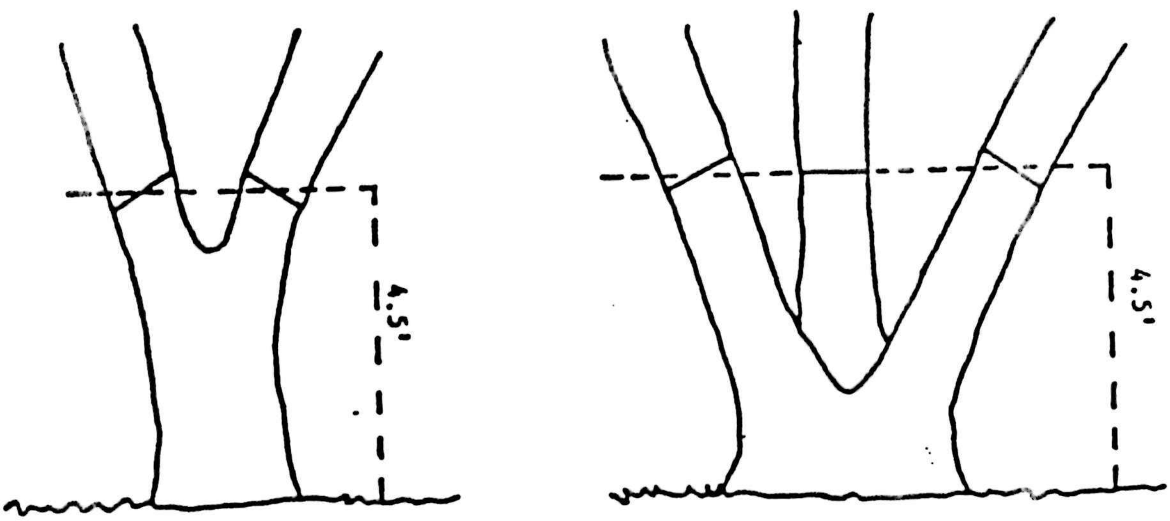
3. Record height of the tallest fork.

4. Record forked tree Damage Code 98.

Appendix 11. cont.

Tally Rules for Forked Trees, continued.

B. For trees which fork below 4.5 feet above ground.



1 Determine where DBH will be measured for each fork. Fork diameters should be measured as close as practical to 4.5 feet above ground.

2. Determine whether the fork is 'in' or 'out' of the plot radius.

3. Tally the 'in' plot forks. Record each fork as an individual tree. It may be a GST or a Tree Class 1, but not a Site Tree unless this is a tree typical of those to be featured in management for this stand.

4. Record height for each fork.

Appendix 12. Tree Height Suggestions

TOTAL HEIGHT (CONT.)

The ensuing steps should be followed to produce accurate tree height data when measuring tree height with a clinometer.

1. When using the clinometer check which scale you are using - they are labeled and can be seen by sighting the top or bottom of the scale. On the English unit instruments, the right scale is normally topographic and the left scale is percent however this varies from instrument to instrument. On the metric instrument the 1/20 scale is on the left and the 1/15 scale is on the right.

2. Always take tree height measurements from a horizontal distance 1 to 1 1/2 times the height of the tree being measured.

3. When using the percent scale, it is recommended that the distance at which tree height is measured is a multiple of 10 (10, 20, 30, etc.). This allows easier calculations for tree height. When using the metric clinometer heights are determined directly at distances of 15 or 20 meters, and by halving the 1/20 scale readings at a distance of 10 meters.

4. Whenever possible, take tree height measurements standing on a plane approximately even with the base of the tree or standing on a plane above the base of the tree.

5. If the tree is leaning, stand perpendicular to the lean of the tree and then measure tree height.

6. For trees with broken tops, measure or estimate the height of the standing portion and add on the measured or estimated height of the missing top. Be sure to code this broken top as damage. Note in remarks the actual height of the standing portion and that the total height is estimated.

7. The estimator will shout lower and upper clinometer readings to the recorder who will shout them back to make sure he heard them correctly.

8. The recorder <u>and</u> estimator will do the calculation necessary to determine total tree height. They will then compare their calculations by calling out their calculated tree heights to each other.

9. The formula for determining tree height with the PERCENT SCALE of a clinometer is:

   UR = upper reading (tree top)
   LR = lower reading (tree base)
   D = horizontal distance from the tree

   $$(UR-LR) * \frac{D}{100} = \text{tree height}$$

   (The metric clinometer is simply UR-LR at the correct distance of 15 or 20 meters)

Appendix 12. cont.

19 TOTAL HEIGHT (CONT.)

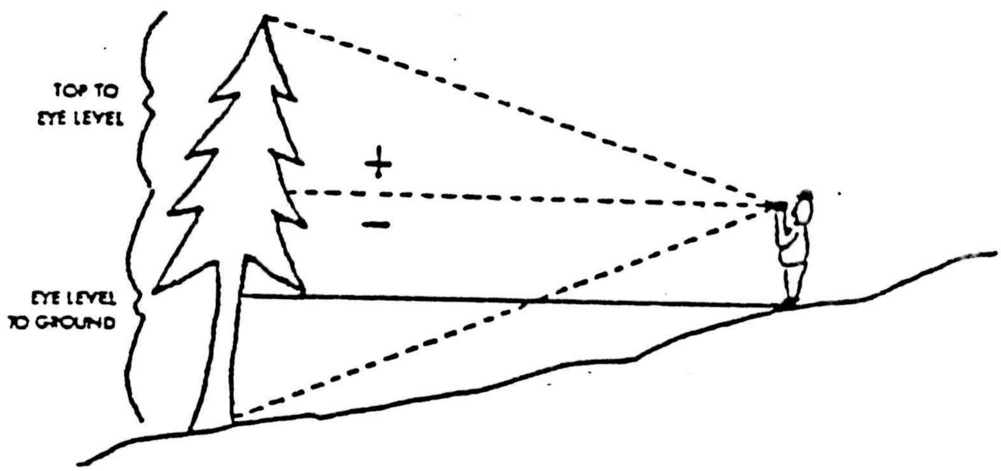
to illustrate:

UR = +34
LR = -29[1]
D = 50 meters

$$(UR - LR) * \frac{D}{100} = \text{tree height}$$

$$34 - (-29) * \frac{50}{100} = 31.5 \text{ meters total height}$$

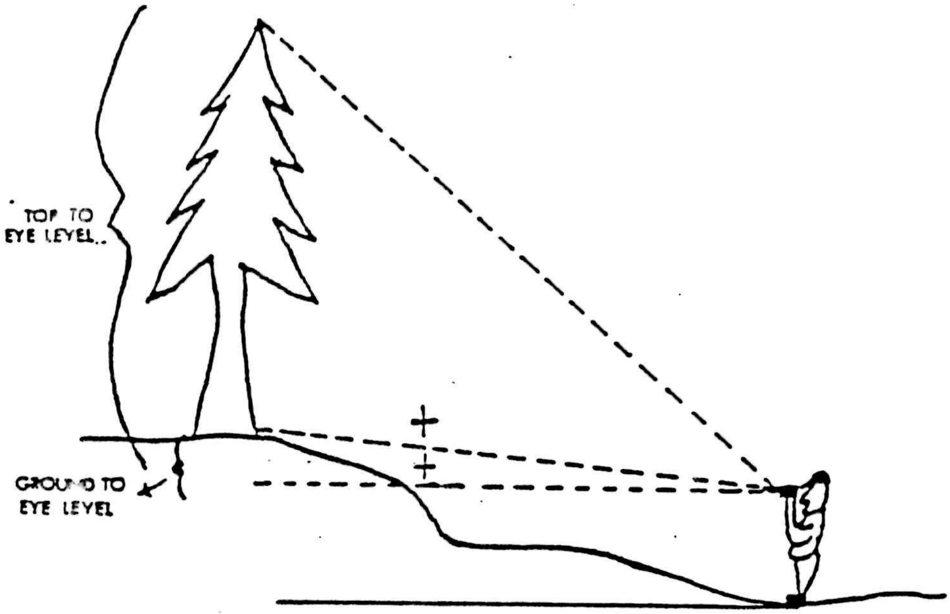
[1]The lower reading may be a positive or a negative number depending on whether you are looking up or down at the base of the tree. If you are looking up at the base of the tree, the reading will be positive and should be subtracted from UR. If you are looking down, the reading will be negative and should be added to UR.



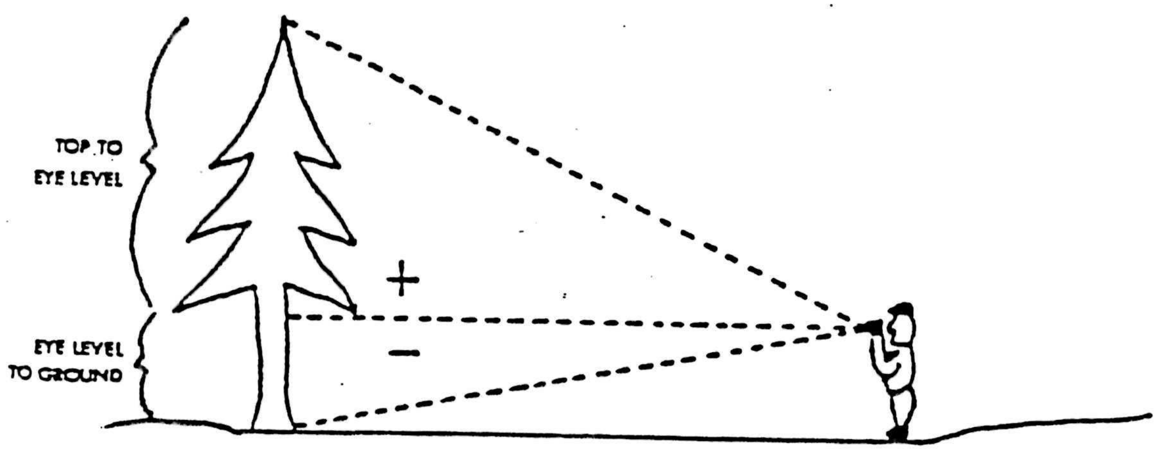
Taking tree height measurements standing on a plane above the base of the tree. The lower reading will be negative because you are looking down at the base of the tree. The two readings must be added to obtain total tree height.

Appendix 12. cont.

TOTAL HEIGHT (CONT.)

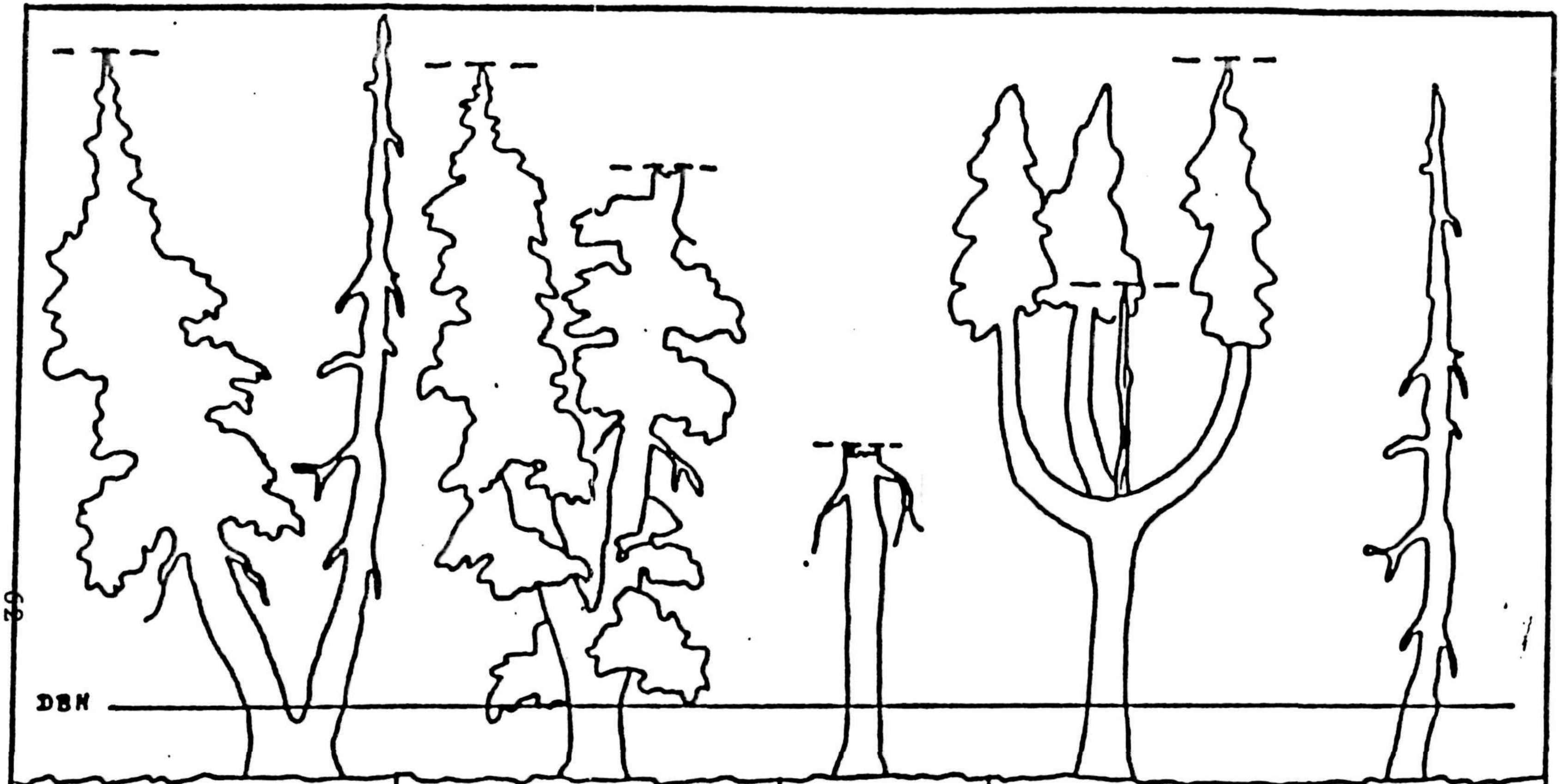


If you are standing on a plane that is far enough below the base of the tree, the lower reading will be positive. It is not desirable to determine tree height with readings that have the same sign. The two numbers must be subtracted to obtain total height.



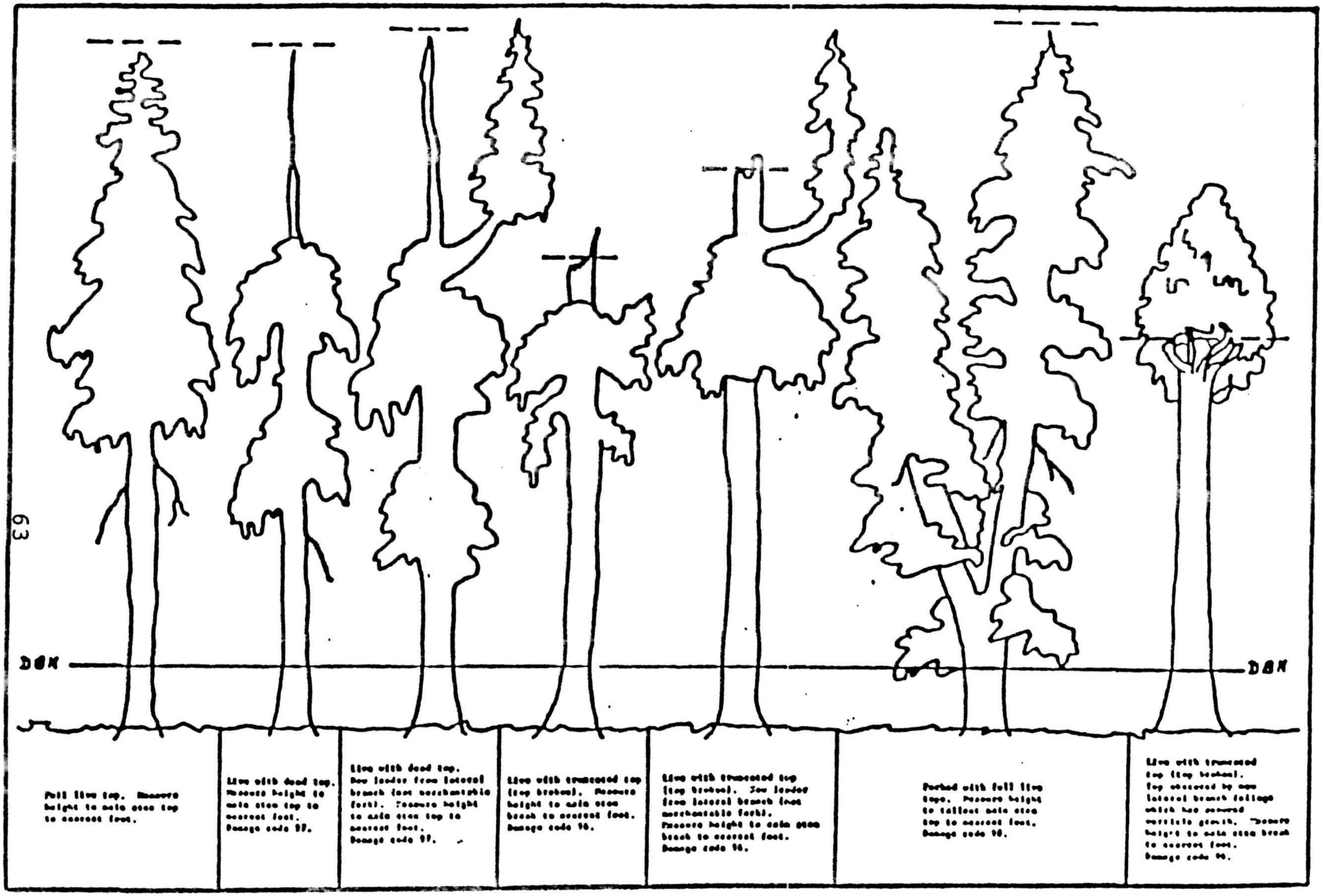
Taking tree height measurements standing on a plane approximately even with the base of the tree.

HEIGHT MEASUREMENT ILLUSTRATIONS

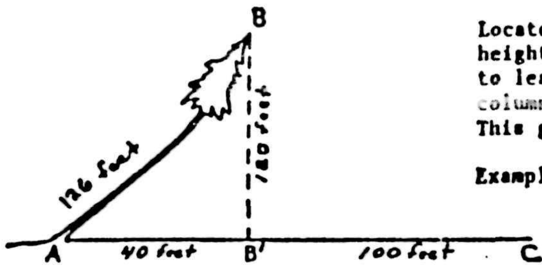


Forked below dbh so tally as two trees. Full live top - measure height to main stem top to nearest foot. Dead tree - do not measure height unless top is broken.	Forked with one main stem forked. Measure and record height of the fork with the main stem intact and record damage code 98. If the fork with intact main stem is not merchantable and the other fork is, then measure and record the truncated height of the fork with the broken main stem and record damage. code 96 and 98.	Dead with broken top. Measure height to main break to nearest foot. Damage code 96.	Multiple forks, some or all may be merchantable. If any merchantable, measure height to main stem top to nearest foot for the tallest fork and code damage 98. If no forks merchantable, measure height to top of dead top and code damage 97.	Dead with intact main stem. Do not need to measure and record height.

HEIGHT MEASUREMENT ILLUSTRATIONS



Measuring Height of Leaning Tree



Locate point on ground directly under tip of leaning tree. Measure height B B' from either C or C' which are 100' out at right angle to lean. Measure horizontal distance A B'. Look up B B' in left column of table, follow across to column headed by distance A B'. This gives true height of tree.

Example: Measured height B B' = 120'
Horizontal distance A B' = 40'
Corrected tree height = 126

Horizontal Distance; tip to center of bole at ground. (A B')

Measured Height	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
40	40	41	43	45														
50	50	51	52	54	56													
60	60	61	62	63	65	67												
70		71	72	73	74	76	78											
80		81	81	82	84	86	87	89										
90		91	91	92	94	95	97	98	101									
100		101	101	102	103	104	106	108	110	112								
110			111	112	113	114	116	117	119	121	123							
120			121	122	123	124	125	126	128	130	132	134						
130			131	131	132	133	135	136	138	139	141	143	145					
140			141	141	142	143	144	146	147	149	150	152	154	157				
150			151	151	152	153	154	155	157	158	160	162	164	166	168			
160			161	161	162	163	164	165	166	168	169	171	173	175	177	179		
170			171	171	172	173	174	175	176	177	179	180	182	184	186	188	190	
180			181	181	182	183	183	184	186	187	188	190	191	193	195	197	199	201
190				191	192	192	193	194	195	196	198	200	201	203	204	206	208	210
200				201	202	202	203	204	205	206	208	209	211	212	214	215	217	219

FORKED TREES

By definition, a tree is typically a large woody perennial with a single well-defined stem (bole). Trees with forks in the stem of species which normally have a single stem are referred to as "forked trees" in Region 6.

The difference between a fork and a branch:

- A branch assumes lateral growth.

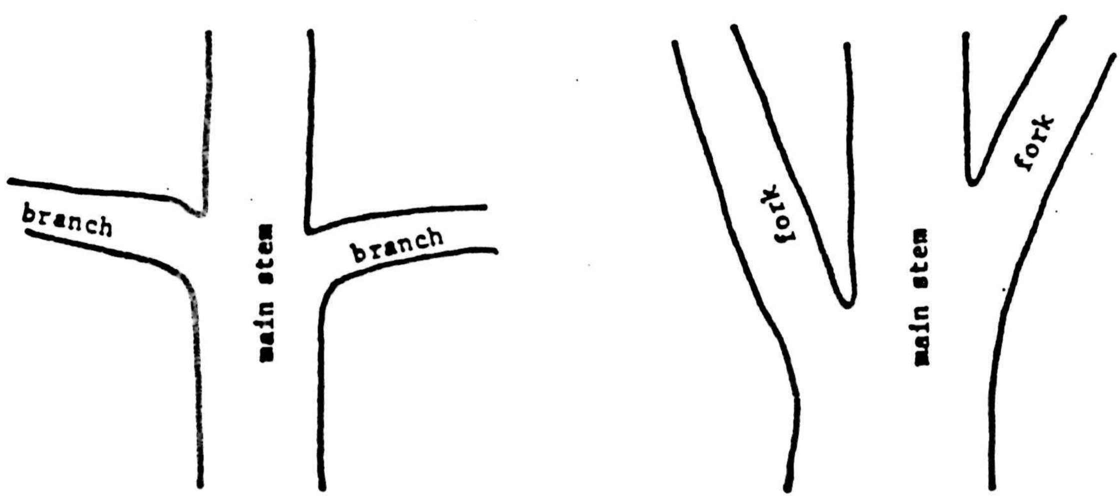
- A fork assumes vertical growth.

Forks are extensions from the main stem which, in time, assume a main stem growth pattern (vertical) and often become merchantable stem or bole wood products.

Forks are tallied because they have the potential to become products. Branches do not normally have the potential to become "products."

TALLYING FORKED TREES

Is it a fork or a branch?



Branches assume 'lateral' growth   Forks assume 'vertical' growth

For trees of commercial species which normally have a single well-defined stem: When the top is damaged, the lateral branches often compete for top dominance. When this happens, the branch growth becomes vertical. One or more leaders may result. In time, one or more of these branches may become forks. During the transition phase, it could be difficult to classify this as branch or fork growth.

Appendix 13. Damage Codes

DAMAGE/CAUSE OF DEATH (CONT.)

15 Gall-forming insects

Signs are abnormal swellings or galls on twigs and small branches or leaves. On spruces, the growing tips may be greatly swollen into spiny structures resembling small pineapples, which at a casual glance may be mistaken for cones.

20 Disease, Unidentified

The specific case of the disease cannot be identified.

21 Rust

Code only if the cankers deform the bole, cause open wounds, or threaten to girdle the tree.

22 Rot

Use this code for trees which are still marketable. Use for sapwood staining fungus before conks appear.

25* Severe rot

Record severe rot damage if conks are present or the tree is too defective to be marketable. Conks are the fruiting bodies of wood rotting fungi. They may occur on the limbs or bole of a tree; or on the ground near the base of the tree indicating root rot. All conks indicate serious damage.

26 Witches Broom

All witches broom should be coded whether of rust, mistletoe or insect origin. This information is for flying squirrel habitat study by Robert Maurey of INF.

30 Fire

Serious fire scars have killed the inner bark more than half way around the tree. Fire damage which has killed the upper third of the crown is also serious. However, the lower part of the crown may be killed without seriously damaging the tree.

40 Animal Caused

Use only when the type of animal causing damage is unknown.

41 Domestic animal

Domestic animal damage is usually confined to seedlings and saplings. Damage is serious when trees become so deformed that it is unlikely they will develop into marketable products.

42 Porcupine

Porcupines eat the inner bark of trees. This type of damage is usually seen on the upper stems of trees where the porcupines climb to nibble on the tender, succulent, (delicious) young bark. Damage is serious when the inner bark is killed more than halfway around the tree (girdling). This will kill the top and deform the tree.

43 Rabbit

Rabbit damage usually occurs near the base of seedlings or at the point of deepest snow. Rabbits eat the bark of trees when food is scarce and can girdle a tree by eating the inner bark around the stem.

44 Beaver

This damage code is used only for damage or death caused by gnawing. Trees killed by flooding are coded 55.

45 Big game

Big game damage occurs when trees are browsed, trampled, clawed or rubbed by antlers. Damage is serious when the tree is so deformed that it is unlikely it will develop into a marketable product.

46 Man

Man-caused damage other than logging damage. (See damage code 80). This includes damage from recreation (trampling, soil compaction, etc.), mining etc., where the tree has not been cut but is damaged in some other way (bulldozing etc.).

50 Weather damage

Use only when the specific weather damage agent cannot be determined.

DAMAGE/CAUSE OF DEATH (CONT.)

51 Wind

Blowdowns and broken tops are serious wind damage. (Blowdowns should be recorded as mortality or dead in tree history.) Trees with broken tops are often weakened by rot so check for rot indicators.

52 Lightning

Lightning can shatter the wood or create an open wound through which infection can enter. Scars caused by lightning tend to spiral around the tree.

53 Snow

Damage occurs as breakage due to heavy loads of snow or bending (usually seedlings or saplings). On steep side slopes only the base of trees may be bent. Bent over trees, however, seldom recover and damage is serious. Breakage is serious if main stem is broken or if broken branches have left large wounds in the bole.

54 Frost cracks

Frost cracks are generally vertical and occur most often near base of the tree. (Lightning cracks are spiral and extend from top to bottom.) Frost cracks are formed by the outside of the tree cooling or warming faster than the inside. They often heal over but can be serious because they provide avenues for infection as well as initial wood damage.

55 Flooding

Damage caused by natural flood or by water backed up behind a beaver dam.

56 Earth movement

Damage caused by slides or earthquakes.

<u>60*</u> <u>Suppression</u>

Suppression is caused by shading or nutrient competition (black spruce) in overstocked conditions. Suppressed trees are characterized by extremely short or nonexistant internodes; twisted, snarled stems; short, flat crowns forming "umbrella shaped" trees; or, an extreme sparseness of foliage. This code should be used for scruffy looking black spruce with no commercial value.

Appendix 13. cont.

DAMAGE/CAUSE OF DEATH (CONT.)

<u>70</u> <u>Unknown</u>

71 Leaning tree (more than 15°)
Tree leaning more than 15° from the vertical.

72 Forked

73 Broken top

74 Dead top

75* Uprooted

76 Bole split
Caused by other than frost action or lightning.

77 Sweep - Crook

78 Abrasion
Use code 80 for trees damaged by logging

79 Unhealthy foliage
Code only if the condition appears to threaten survival of the tree.

<u>80</u> Logging damage
This includes trees scarred or broken as well as trees actually cut and left.

<u>90</u>* Cull or offsite tree
Tree has rough appearance and is not capable of producing a 3.75 meter (12-ft.)log now or prospectively. This code should used primarily for trees found outside their range. For rough black spruce, use code 60.

91 Layered seedling

---

rees with this code will be classed as tree class rough (30) rotten (40).

PARASITIC DISEASES OF THE
MAJOR INTERIOR ALASKA TREE SPECIES

Tree	Disease	Location	Visible Indicators	Entrance Port
Spruce	Fomes pinicola (Red belt fungus)	Confined mostly to butt or lower bole of dead trees or dead portions of live trees.	hoof-shaped conk, gray to black above with red margin.	Seams, fire scars, mechanical wounds.
	Polyporus Schweinitzii	Mostly in butt portion and roots of live trees.	Velvety brown conk near base of tree or on the ground.	Fire scars, or basal wounds and seams.
	Fomes pini (White speck; red ring rot; conk rot).	Any location in main bole of the tree.	Shell-shaped conk, rich-brown to grayish-brown color--swollen knots and branch stubs.	Seams, mechanical wounds, or branch stubs.
	Chrysomyxa arctostaphylli (Yellow witches broom).	Witches brooms on main branches adjacent to main bole.	Yellow or brown-yellow broom, dwarfing and yellowing leaves of infected branch.	Rust alternates between infected tree and kinnikinnick and/or bearberry.
Aspen	Fomes ignarius (White trunk rot).	Any location in main bole of tree.	hoof-shaped conk; grayish-black above, brown below.	Branch stubs or open wounds; fire scars.
	Pholiota adiposa (Yellow cap fungus).	Confined to butt portion of tree.	Mushroom type fruiting bodies at base of tree.	Fire scars, butt seams or wounds.

Appendix 13. cont.

DAMAGE

	Disease	Location	Visible Indicators	Entrance Port
n	Armillaria mellea (Honey mushroom or shoestring root rot).	Confined to butt portion of tree.	Toadstools, honey-yellow to brown in color, at base of tree coming up from infected roots.	Rhizomorphs originating infected trees, penetrate unbroken bark of healthy tree and infect them
ch	Fomes ignarius	Any location in main bole of tree.	Hoof-shaped conk, grayish-black above, brown below.	Branch stubs wounds or fire scars.
	Poria obliqua (heart or saprot).	Any location on main bole of tree.	Black warty rough clinker-like sterile conk issuing from canker wound, or knot.	Knots, wounds, and cankers caused by fungus.
	Fomes applanatus	Confined to root or buff portion of dead or live trees.	Shelf like conk gray-black above, white below.	Fire scars basal wounds.
tonwood	Fomes ignarius	Any location in main bole of tree.	Hoof-shaped gray-black above, brown below.	Branch stubs wounds or fire scars
	Pholiota adiposa	Confined to butt portion of tree.	Mushroom at base of tree.	Fire scars butt seams or wounds.
	Fomes applanatus (Shelf fungus or artist's conk).	Confined to root or butt portion of dead or live trees.	Shelf-like conk; gray to grayish-black above, fresh white below issuing from wounds.	Fire scars, basal wounds.

Appendix 13. cont.

GUIDES FOR IDENTIFICATION OF WEATHER DAMAGE (Code 80-88)

Wind (Code 81). Wind damage usually occurs as blowdowns, where trees are uprooted and blown over. This may occur in residual stands after logging. It may also occur as a result of widespread windstorm or due to a phenonema of jetstream touchdown, which sometimes hits areas of 4-20 acres, creating a real havoc in which trees are broken up as well as blown down (rare). Tops may be broken out of trees, but often where this happens it is due to weakness from rot.

Snow (Code 82). Snow damage occurs as breakage due to heavy loads of snow which break off limbs, or bend over the trees in the case of seedlings and saplings. Such bent over trees seldom recover, and the damage is serious.

Frost Crack (Code 82). Frost cracks occur usually during extremely low temperatures, especially when there is a sudden drop in temperature. The inside of the tree is warmer than the outside. The outside shrinks faster causing a split to occur. These cracks provide avenues for infection as well as damage to the wood, but often frost cracks will close and heal over, and the tree may remain sound. Frost cracks tend to run up and down on the same side of the tree.

Frost Damage (Code 83). Frost damage to foliage usually occurs when a warm spell is followed by a cold snap. The foliage appears blighted, turns red, "red belting" and frost damage is known mostly by its occurrence in a given area at a given time. Generally only the needle tips are tinged. It is serious if 2/3 or more of the foliage is affected beyond recovery.

Drought (Code 86). Moisture deficiency.

Lightning (Code 88). Lightning can sometimes kill the tree as well as shattering the wood, creating an open wound through which infection can enter, retarding growth, etc. Lightning scarred trees almost always have some kind of defect. Lightning scars tend to spiral around the tree.

Other Natural Phenomenon. Earthquake, avalanche, slides, flood.

Appendix 14. Photograph Labeling

RESOURCE MANAGEMENT SLIDE
CATALOG SYSTEM

General	
Resource Management Activities	51
Vegetation	52
Mammals	53
Birds	54
Amphibians	55
Resource Management Projects	
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Road Inventory	103
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Research Projects	
ATV Impact Study	501
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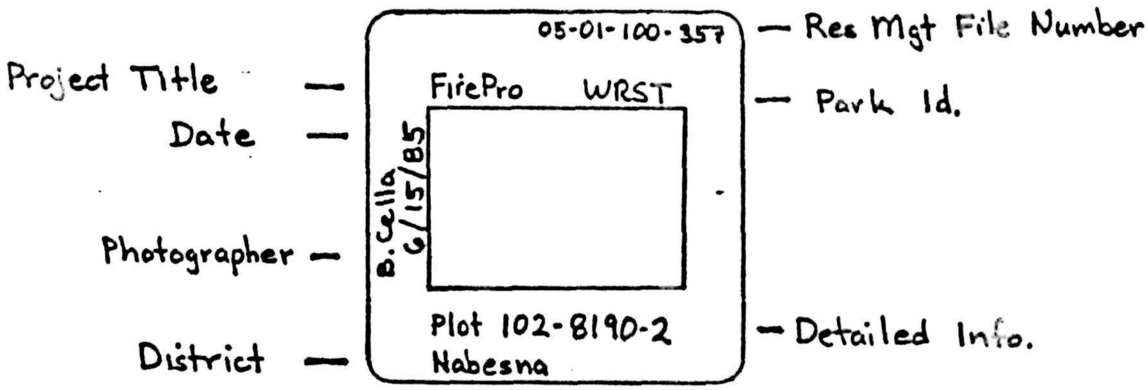
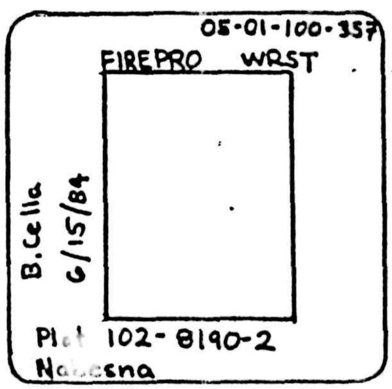
Appendix 14. cont.

Slide Label Format Examples





TO TAKE AN INCREMENT CORE, FOLLOW THESE INSTRUCTIONS, STEP-BY-STEP. . .

1. Remove the borer bit and extractor from inside the handle. Place the extractor in a pocket of your cruiser vest for convenience and protection of the extractor.

2. Assemble the handle and borer bit by:
   a. pushing the locking latch away from the handle with your thumb,
   b. inserting the square end of the borer bit into the handle, and then
   c. returning the locking latch completely around the borer bit "collar". You're now ready to start boring;
   however, we suggest you apply beeswax to the threads and shank before you do. (See below)


Fig. 1

3. Align the borer bit and the handle so that the bit will penetrate through or towards the center of the tree and at right angles to the tree. In any other alignment, the annual growth rings seen in the extracted core will be distorted and could result in erroneous growth rate analysis. RIGHT WRONG

4. Place the borer bit threads against the tree (Fig. 1), preferably in a bark fissure where the bark is thinnest. Hold the threads in place with one hand. With your other hand push forward on the handle and simultaneously turn it to the right until the bit threads penetrate the wood enough to hold the bit firmly in place.


Fig. 2

5. Then place both hands, palms open, on the ends of the handle and turn the handle to the right until the bit reaches the desired depth. (Fig. 2)


Fig. 3

6. With the bit at the desired depth insert the full length of the extractor, concave side up like this "⌒". (Fig. 3) Then turn the handle one-half turn to the left to break the core from the tree and also to turn the extractor concave side down like this "◡".


Fig. 4

7. Pull the extractor from the borer bit. (Fig. 4) The core will be resting in the channel and held in place by the small "teeth" at the tip of the extractor. Before examining the core sample, promptly remove the borer bit from the tree, clean it (See "Clean with WD-40" below), and place it and the extractor back in the handle.

CARE AND MAINTENANCE OF INCREMENT BORERS

Here are a few suggestions Forestry Suppliers, Inc. feels will be helpful in maintaining the efficiency and extending the life of increment borers. We welcome any additional suggestions.

LUBRICATE WITH BEESWAX

Forestry Suppliers, Inc. provides a block of beeswax with every increment borer sold. Penetration and removal of the borer bit will be easier if beeswax is liberally applied to the threads and shank before each boring.

CLEAN WITH WD-40

WD-40 is an excellent cleaner and rust preventative for an increment borer. It will also prevent sap acid-etching of the borer. Spray it on and inside the bit and on the extractor at the end of each working day. Wipe clean.

BE QUICK

Obtain your core samples as rapidly as possible. It's best to remove the bit from the tree even before examining the core sample. This will reduce the possibility of the bit becoming stuck or locked in the tree.

AVOID COMPRESSION - TENSION WOOD

Never bore into suspected compression or tension wood. To explain: a tree leaning towards the North will have compression wood on the North side. If you bore into compression wood, the bit could be locked into the tree by the force of the "compressed" wood. If you bore into the South side, you are boring into "tension" wood, where the ring width may not be representative. We recommend boring on the East or West side or, if possible, select another tree.

Appendix 15. cont.

INCREMENT BORER SHARPENING

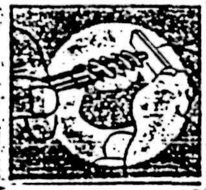
Increment borers become dull or nicked with use. A borer is dull if it does not easily engage the wood and if it will not cut a clean-edged hole when rotated on a sheet of paper.

HERE'S HOW YOU DO IT

NOTE: see back page "Increment Borer Sharpening Kit" for sharpening stones described here.

1. True Cutting Edge Using Pocket Stone

If cutting edge is uneven when placed lightly against a flat surface, it needs to be trued up. Place a few drops of oil on wide face of pocket stone. Hold borer bit steady on cork rest and pass stone back and forth across cutting edge, turning bit slightly after each pass. Repeat till true.



2. Sharpen Cutting Edge Using India Stone

Holding bit in left hand and India stone in right hand, slowly rotate bit away from you and against stone while holding stone parallel to and firmly on beveled edge of bit. Continue until sharp. If nicks are present, use pocket stone to work them out, then follow with India stone.

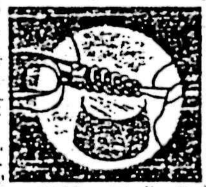
3. Hone Inside of Cutting Edge Using Conical Stone

Put a few drops of oil on conical stone and insert tip of stone into cutting end of bit until it occupies about ¾ths of core hole. Very lightly rotate stone against inside of cutting edge, keeping flat edge of stone parallel to long axis of bit.

4. Hone Outside Beveled Portion of Cutting Edge Using Conical Stone

Hold borer bit with threads on cork rest and place just the tip of conical stone on and parallel to bevel. Use very light strokes back and forth over a small arc of beveled edge. Turn bit and repeat until entire edge has been honed.

Test by cutting circular holes in paper sheet.



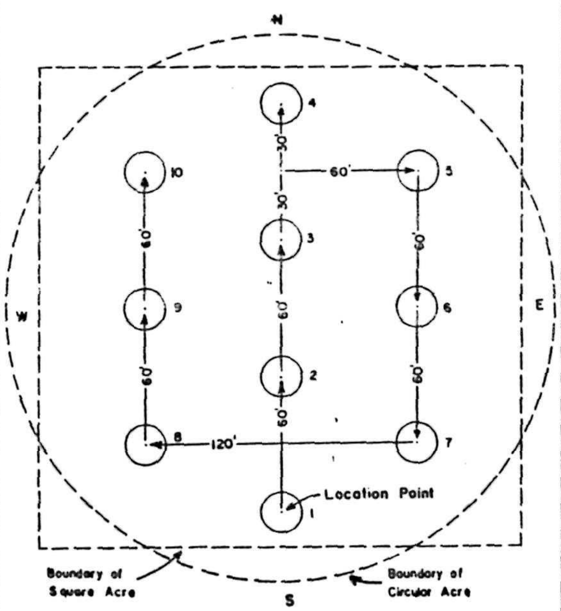
PROFESSIONAL INCREMENT BORER REPAIR SERVICE

For more than just touch-up sharpening. Have all cutting edges and threads machine sharpened, nicks and some minor broken threads removed — repaired, all professionally done.

63001	For bit diameters up to .200" (5mm) and 4" to 8" long bits	$12.95
63011	For bit diameters .500" (12mm)	15.95

Send your entire increment borer (handle, extractor and bit) to Forestry Suppliers, Inc., Box 8397, Jackson, MS 39204.

Figure 16. Ten-point sampling design.



The Pacific Northwest station also uses the 10-point field plot to obtain volume data.

L.R. Grosenbaugh[1] suggests the following procedures for permanent sample points.

1. A field plot that contains a cluster of 2-5 sample points is used. Measure approximately 100-500 field plots per ownership.
2. The bearing and distance to each "in" tree from the point center is recorded.
3. At the time of remeasurement, work only with the previous "in" trees plus any trees that are now "in" trees that were below breast height at the time of the previous measurement. This is based on the fact that each "in" tree represents the same number of trees throughout the life of the sample point. Trend data are determined from these observations.
4. After several remeasurement periods, it will be necessary to include all trees at each sample point that have grown enough to become "in" trees. This will constitute a new base and then proceed as outlined in item 3 above.

OFFICE PROCEDURES

BASAL AREA DETERMINATION

The average tree count per point times the basal area factor gives the average basal area per acre outside bark.

For example: Twenty points are taken on a "forty" with a total tree count on the plots of 97. The wedge-prism factor is 25.

Average tree count $= \frac{97}{20} = 4.850$ (take to three decimal places)

$4.850 \times 25. = 121.25$ square feet (basal area per acre outside bark)

[1] Based on occasional paper 145 (9) and personal discussion.

The 121.25 square feet represents the basal area per acre at the vertical level at which the tree count observations were made (i.e., DBH or 16 feet). If the trees were observed at the top of the first 16-foot log, the stem area per acre at DBH can be determined by dividing the stem area per acre inside bark (i.b.) at 16 feet by form class squared. For example:

Stem area per acre (o.b.) at 16′ = 121.25 sq. ft.
Bark Thickness Ratio Squares (Table IX) .812
Stem area per acre (i.b.) at 16′ = 121.25 x .812
= 98.455 sq. ft.

Form class at 16′ .70
Basal area per acre (o.b.) at

$$\text{DBH} = \frac{98.455}{(.70)^2}$$
$$= 200.93 \text{ sq. ft.}$$

Table IX.- Mean squared bark thickness ratios for top of 16-foot logs. 1/

Species	BT Ratio Squared		
	Oregon	Western Washington	Alaska
Ponderosa pine	.820		
Western larch	.810		
Sugar pine	.780		
Concolor fir	.805		
Incense cedar	.699		
Douglas-fir			
(25-50 years)	$\sqrt{.85} = .922$		
(Over 50 years)	.812		
Western hemlock	.891	.885	.86
Western red cedar	.903	.895	.88
Sitka spruce	.925	.937	.90
Lodge pole pine		.899	
White pine		.933	
Noble fir		.902	
Red alder		.890	
Alaska cedar			.90

1/ Ratios are merely guides since variation is found from county to county. Sources: Alaska, U.S.F.S.; Washington, Department of Natural Resources; Oregon, Mason, Bruce and Girard, and Oregon State University.

To illustrate this relationship between basal or stem area and form class, the following example is provided.

Form class = .70
DBH = 40″ DBH basal area = 8.7266
Dib at 16′ = 28″ Dib 16′ basal area = 4.2761

$$\frac{4.2761}{X} = 8.7266 \qquad X = \frac{4.2761}{8.7266} = .49 = FC^2$$

If separate plot data were kept by species, windfalls, snags, or size classes, the data for each group will be handled in the same manner indicated in the above example.

VOLUME DETERMINATION

Gross Volume. Gross volume for each species, or other tree classifications such as snags or windfalls, is determined as follows:

1. Determine V-BARs for all volume-sample trees recorded in the field.

2. Compute the average V-BAR per tree.

3. Compute the number of square feet of stem area per acre as previously explained.

4. When tree counts are made outside bark and the volume table is based on d.i.b., multiply the stem area o.b. by the mean squared bark thickness $(BTR)^2$, as illustrated in Table IX to obtain the area inside bark. The BTR represents the ratio between the basal areas of wood and wood plus bark at the point of measurement (i.e., 16 feet).

5. The gross volume per acre is computed by multiplying the stem area per acre from Step 4 times the average V-BAR from Step 2.

Net volume. The net volume per acre is computed the same as described above for gross volume, except that the V-BAR is adjusted for defect and breakage. If the defect and breakage is computed individually by trees, then each V-BAR will have to be adjusted. However, if the deduction is to be made on a stand basis, the sum of the V-BARs can be reduced percentage-wise.

Volume by log grade. Volumeby log grade is determined by applying the appropriate percentages of each log grade to each V-BAR and then computing in the same manner as for gross volume.

The following formulas combine the above five steps, except for grade considerations:

If all plots are volume plots—

Volume per acre

$$= \frac{(\text{Sum V-BARs})(\text{tot. tree count})(\text{BAF})(\text{BTR})^2}{(\textit{number of plots})(\textit{tot. tree count})}$$

This formula can be simplified to—

$$\text{Volume per acre} = \frac{(\text{Sum V-BARs})(\text{BAF})(\text{BTR})^2}{\text{number of plots}}$$

$$= \frac{(3{,}038)(25)(.812)}{20} = 3{,}083 \text{ Dec. C}$$

If the volume control data were taken on a portion of the plots, the volume per acre determined by the above equation would be multiplied by a factor determined by dividing the tree count on all plots by the tree count on the volume plots.

Assume in the above example that an additional 20 tree count plots were taken giving a total of 40 plots of which 20 were measured.

$$\frac{\text{Tree count on all plots}}{\text{Tree count on V-BAR plots}} = \frac{98}{50} \approx 1.96$$

$$\text{Volume per acre} = \frac{(3{,}038)(25)(.812)}{40} \times 1.96 = 3{,}022 \text{ Dec.C}$$

Computation Guide for a Variable-Plot Cruise Using a Desk Calculator

Assumptions:

1. Diameter inside bark on V-BAR trees; and tree count taken at top of first 16-foot log.

2. Log length is 32′.
3. Composite V-BAR Table IV is used to determine the ratio of board feet in the tree to square feet of stem area at top of first 16-foot log.

Procedure:

A. V-BAR points or plots.

1. Work with each species separately according to outline below.
2. Construct a computation table as follows:

Gross V-BAR	Net V-BAR	Net V-BAR distributed among log grades					
		1P	2P	3P	2S	3S	Other

3. Determine the proper V-BAR from the V-BAR table for each tree tallied on the volume points. This is the gross V-BAR.
4. Subtract the defect and breakage[1] percentage from each gross V-BAR. This is the net V-BAR.
5. Distribute each net V-BAR among the different log grades that are in the tree. This is done by using the same percent volume table that was used for making defect deductions in the field. For example: the gross V-BAR of a 26″3 log tree is 447 bd.ft./sq.ft. A three log tree has 50 percent of volume in 1st log, 33 percent in the 2nd, and 17 percent in the 3rd. If the first log is a 3P then .5 x 447 or 223 is recorded in the 3P column. If the 2nd log is 2S, then

[1]When breakage is determined for the individual tree in the field.

148 is recorded in the 2S column. This leaves 76 bd.ft./sq.ft. for the top log whatever its grade.

6. Add up the gross V-BAR column in the above table.
7. Divide by the total number of trees tallied on the **V-BAR points**. This is the average gross volume per sq. ft. of stem area inside bark at the top of the first 16-foot log. It is usually referred to as the "gross V-BAR."

B. Stem basal area per acre.

1. Determine the total number of trees recorded on all points. This will include V-BAR and count points.
2. Divide the number of trees by the number of points.
3. Result: Average number of count trees per plot.
4. Multiply (B3) by the basal area factor.
5. Result: Stem basal area per acre outside bark. The prism cannot "see" inside the bark to get the measurement corresponding to your estimate on V-BAR points.
6. Correct stem basal area estimate for inside bark dimensions. Multiply by bark ratio squared. The bark ratio had been determined in the field or an average used.
7. Result: Stem basal area per acre inside bark.

C. Volume per acre.

1. Multiply stem basal area per acre inside bark. (From B7 above by the average gross V-BAR in bd. ft. per sq. ft. i.b. (from A7 above). This is the gross volume per acre in board feet.
2. Determine the net volume per acre.
   (a) Divide total net V-BAR (from table in item A2) by total gross V-BAR (also from table in item A2).
   (b) Multiply this ratio times the gross volume per acre (from item C1) which gives the net volume **per acre in board feet.**

D. Determine the log grade percent on a net volume basis.

Determine what percent of the total net volume is in each log grade. The total net V-BAR in each log grade is divided by the total net V-BAR (of all log grades) and multiplied by 100.

SAMPLE PROBLEM A:[1]

The problem below follows the same order as the preceding steps.

The sample size is smaller than normal so that the calculations can be followed more readily by the reader.

Figure 17 shows how the data were recorded in the field. Note that half points were taken.

The assumptions already listed for this problem apply. All sample trees are Douglas-fir.

Procedure:

Construct a computation table as followed, from the data shown on the field summary sheet (Figure 17) following steps 3 through 6.

Step 7. Average gross V-BAR $= \frac{11,064}{23.5} = 470.8$

[1]The basic data and results of this problem will be used in all subsequent problems presented in this book.

6 - Basal Area per ha: the Relascope Principle

The relascope as such was invented for one particular measurement - estimating the basal area per ha. This was Professor Bitterlich's mathematical discovery.

Recall that the basal area of a tree is its sectional area at 1.30 m above ground level. The basal area per ha is the sum of the basal areas of all the trees on one ha.

The basal area per ha is in itself a measure of the density of the stand. It is also a factor to be used in one method of estimating the volume of stands, as in Section 10.

The use of the relascope for this purpose is very simple. Standing at one point, the observer makes a "sweep" of the surrounding trees. He compares the breast height diameter of each tree with, let us say, band 1. If a tree appears to be bigger than band 1, it is counted. The number of trees counted is the basal area in m^2 per ha.

If band 2 is used, the number counted has to be multiplied by 2, and if band 4 is used, by 4.

In theory, at least, other bands may be used:-

- with one narrow band, multiply by 1/16
- with two narrow bands, by 1/4
- with three narrow bands, by 9/16
- with band 1 plus 1 narrow band, by 25/16
- with band 1 plus 2 narrow bands, by 9/4
- with band 1 plus 3 narrow bands, by 49/16

This remarkable method of estimation may be explained in quite simple arithmetical terms. Suppose all the trees have the same diameter. Suppose e... they are all 60 cm. If we compare them with band 1, those which appear the same size must be at a distance of 60 cm x 50 = 30 m. Those which appear smaller than band 1 will be further away. Those which appear bigger will be within this distance. We can say that if we count all the trees which appear bigger than band 1, we have counted all those within a circle of 30 m radius.

Suppose we count 13 such trees.

Their total basal area is:-

$$(13 \times \pi/4 \times 0.60^2)\ m^2$$

The area of the circle is:-

$$(\pi \times 30^2)\ m^2$$

$$= (\pi \times 30^2 \div 10\ 000)\ ha$$

The basal area per ha is the basal area of the 13 trees divided by the area of the circle i.e.:-

$$\left(\frac{13 \times \pi/4 \times 0.60^2}{\pi \times 30^2 \div 10\ 000}\right) m^2 \text{ per ha}$$

$$= 13\ m^2 \text{ per ha}$$

This figure of 13 is the same as the number of trees counted.

The same calculation can be repeated for all the different sizes of trees, and in all cases the basal area per ha will be found to be the same as the number counted.

In practice, the trees will be of many different sizes. Each size can be considered separately. The total estimate will be the sum of the estimates for all the different sizes. I.e. in an ordinary relascope sweep, the total basal area per ha will be the same as the total number counted.

Similar calculations lead to the multiplying factors given for the different bands. In working these out, note that the ratio of distance : object for band 2 is $50/\sqrt{2}$: 1.

A striking feature is that the estimate is not based on a plot of any given size. Small trees near the observer are counted and trees further away are counted if they are bigger. Hence expressions such as "plotless cruising". We speak generally of sampling points rather than of plots.

Further developments of the basic idea depend on this feature, that the chance of a tree being counted increases in proportion to its diameter. Another way of putting it is that we automatically get a correctly weighted sample, giving more importance to bigger trees, and including relatively few small ones.

The early relascopes were very simple. Indeed, the thumb at arm's length can be used instead of "band 1", "band 2", etc., and the correct multiplication factor calculated from length of arm and width of thumb.

The Spiegel Relaskop, however, is the only one constructed to give an automatic correction for slope. It is therefore the only practical, accurate type of relascope for use in mountainous country and, in spite of its high cost, it is widely used for this reason. In addition, its ingenious set of scales gives it subsidiary advantages over simpler instruments.

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To obtain the automatic slope correction, it must always be used with the brake freed.

The choice of band should be such that the count gives about 20 - 30 trees. Counts of less than 20 trees are said to be particularly unreliable. Suppose band 1 is tried, and gives 12 trees. This result should be rejected and another count made with three narrow bands. It will not necessarily give a result very close to 21 trees!

Trees which are obscured by intervening trees must be observed by stepping to one side, keeping the correct distance, and then stepping back again to continue the sweep. Care must be taken that only one tree is viewed at a time. A slight movement of the head to one side will immediately show if a "tree" is really the left side of one and the right side of another.

For borderline cases, first check that the observation is really being directed exactly to breast height. An assistant should have a 1.30 m stick. If there is still doubt, count the tree as a half, i.e., using band 1, count it as ½ m^2 per ha. If a tripod is used, there will be very few such cases.

Note. For large important surveys, Professor Bitterlich recommends deciding doubtful trees by measuring diameter and distance from observer. E.g. when using band 1, if the distance is less than 50 times the diameter, the tree is counted. A tape may be prepared, marked with the limiting diameter corresponding to appropriate distances.

Appendix 17. Stand Table Factors*

Metric scale BAF 2 1/4 or
American scale BAF equivalent of 22.05

Mid pt. Diam. in.	Trees per Acre	Mid pt. Diam. in.	Trees per Acre
3	499.08	14	20.63
4	252.58	15	17.97
5	161.66	16	15.79
6	112.33	17	13.99
7	82.49	18	12.48
8	63.16	19	11.20
9	49.91	20	10.11
10	40.43	21	9.17
11	33.41	22	8.35
12	28.07	23	7.64
13	23.92		

* Stand table factor indicates the number of trees per acre each "in" tree represents. Stand table factor times tree count per point in a diameter class equals number of trees per acre in that diameter class.

Stand Table Factor = BAF divided by the basal area of the mid-point value of the diameter class.

For basal area in square feet from given diameters of 0.1 to 60.0 inches, refer to Dilworth and Bell, 1984; p. 107 or Dilworth and Bell, 1984; p. 438.

For additional stand table factors for American scale BAF's, refer to Dilworth and Bell, 1982; p. 267.

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