



# Northern California Forest Yield Cooperative

Department of Forestry and Resource Management

University of California, Berkeley, Ca. 94720

Research Note No. 6

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## Stem analysis procedures for use in obtaining time series forest growth data.

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### Introduction

California's forest economy has been changing as the land base of young-growth trees has burgeoned. Along with the increased land base of young-growth trees has emerged the need for more precise knowledge concerning the amount as well as rate of forest growth. In 1978 the Northern California Forest Yield Cooperative was formed to keep pace with this trend. These models are needed to predict development of forest stands under alternative management regimes and to assess the impact of legal regulation on forest production.

Data requisite for construction of empirical models of forest growth include multiple measurements over time to obtain growth estimates of diameter, height and crown development. When it is not feasible to wait to remeasure trees for growth, whole tree stem analysis may be employed. In this technique individual trees are felled and sections rounds are cut at equal intervals throughout the stem. From age and radial increment measurements taken on each round the prior growth development (height, and taper) can be constructed. However, a major drawback to this technique is that it is expensive and labor intensive. Many methods have been proposed to reduce the bulk of materials to be taken from the woods for further laboratory analysis. This paper documents an alternative method of recording the data (age and growth) from the section rounds based upon photographing the rounds and digitalizing the ring locations from the resulting photographs. This method provides reliable and accurate measurements of age and growth on individual sections. In addition there are dramatic reductions in the time for field data collection, elimination of bulk transfer of wood to the laboratory and associated problems of shrinkage and molding, and the photographic transparencies provide a long term record that is readily accessed should the section require reanalysis.

This method has received extensive field testing by forest industries in northern California and takes approximately 13.5 man-days per cluster.

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This document incorporates adaptations evolving from the field trials at Blodgett Forest and Champion International in the Fall of 1979. In addition, the definition of site index trees has been reconsidered and refined subsequent to consultation with the select committee. This document is mainly comprised of materials previously circulated under the title "Expended Stem Analysis Procedures" from June 6, 1980.

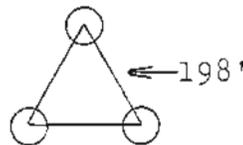
To aid in comparing the procedural text of this version with the previous one (12/19/79), we have added the symbols "A" or "C" to the right hand column to indicate that a sentence (or paragraph) has been added or changed. Minor text changes have not been marked, nor have changes to the data forms.

Plot selection The following criteria should be used to select plots.

1. The stand should be large enough to include a cluster of three  $1/5^{\text{th}}$  acre plots, (52.67 ft. in radius) each without edge effects.

The plot centers for each cluster should be located at the vertices of an equilateral triangle with side lengths equal to 198 feet (three chains).

C



2. Clusters are located to ensure being in only one distinct soil series. Other factors such as aspect and elevation should be uniform for any given cluster.
3. Each cluster will be located in a density, site, and size class of importance to the land holder. (Refer to letter dated April 16, 1980 concerning placement of stem analysis plots.)
4. Avoid plots thinned within the last ten years.
5. Within the chosen stand the clusters should be randomly placed.

A

Plot measurements

1. General descriptors : elevation (ft.), aspect (deg), slope (%), location, brush cover (%) and average brush height (ft.). Record log length by species. A

Before Falling Any Tree

2. Starting from north and working clockwise on the 1/5<sup>th</sup> acre plot record on Plot Card 1 the distance and azimuth from the plot center to trees 5.6 inches and greater in DBH. C  
Record the position of stumps and dead trees and the stump diameter or the DBH of the dead tree when greater than 5.5 inches. A  
Paint the tree number at eye level toward the plot center. A  
Also record species, DBH, Dunning and Keene's crown classes. C  
Record damage and/or disease codes when appropriate. A  
If the tree falls within the 1/10<sup>th</sup> acre plot (radius 37'3"), circle the tree number.

3. Choosing Trees to be Felled

a. Site Trees to be Felled<sup>1/</sup>

Site trees are defined to be healthy dominants receiving full light from above and partly from the side with well-developed crowns, although they may be somewhat crowded on the sides (SAF definition of dominant). In an all-aged stand "site" trees need to extend above the general level of their group but not necessarily above the general level of the stand to be dominant. A  
Additionally "site" trees should have minimal past A

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<sup>1/</sup> The term "site tree" is used as an abbreviation for "site index tree".

damage to tops and minimal height-growth reduction due to extremes of density. Boring to inspect the pattern of diameter growth will give some indication of past stand density/suppression. This may help in judging whether or not there was significant height growth suppression.

A  
A  
A  
A  
A

Four to six dominants (two to three for each of the two most prevalent species in the overstory) should be chosen randomly when possible from among the trees on the 1/5<sup>th</sup> acre plot. That is, when there are more than three dominants of each of the two most prevalent species in the overstory, choose randomly between them. Random number tables are provided and should be used to select among "site" trees by picking a random number and seeing if any "site" tree has that same number. If not, choose a new random number. Repeat as necessary. When possible choose six dominants.

A  
A  
A  
A

If only one species is present, only measure three dominants in total. Where possible choose young growth trees. Go outside the plot boundaries if necessary to find suitable dominants adjacent to the plot. In rare cases when there are no dominants in the proximity of the plot, co-dominants can be used. Refer to these trees as DU and CU (Dominants Unsuppressed, and Co-dominants Unsuppressed).

A  
A

b. Problems with the use of traditional site tree definitions in all-aged stands

Frequently, there are cases where many (if not all) trees on a plot exhibit either abrupt and prolonged or gradual radial growth reduction. In this case no traditionally defined site trees exist. None the less, we would like to select the best available trees to indicate the potential growth performance on the site. Thus choose dominant trees (or codominant if dominants are not available) that have all the other attributes of site trees (full crowns, receiving light from above and partly from the side, with minimal damage to tops). Refer to these trees as DS and CS (Dominant Suppressed and Co-dominant Suppressed)

A--entire  
page

Because of the many potential choices in finding suitable trees, the selection priority is established as follows:

1. "Site" tree on the plot (DU--Dominant Unsuppressed)
2. "Site" trees adjacent to the plot (DU)
3. Codominants on the plot (CU -- Co-dominant Unsuppressed)
4. Radially suppressed "site" trees
  - i) Dominants (DS -- Dominants Suppressed)
  - ii) Codominants (CS -- Co-dominants Suppressed)

For all subsequent reference a "site" tree will be considered as any tree from the four classifications above

(DU, CU, DS, CS) chosen to indicate site potential.

Paint these trees with a single stripe around the bole at 1.5' and breast height (4.5'). Paint a couple of "S's" on the tree to indicate it is a "site" tree. Indicate on the plot form that a "site" tree will be felled by writing "site/DU", "site/CU", "site/DS", or "site/CS" next to the tree number. If the "site" tree is off the plot use the Off Plot Site Tree form". Fall the tree, and write "off" in the column "on/off plot" on the Stem Analysis Form. C

Paint a vertical arrow with the letter "N" at the breast height stripe and a vertical arrow with the letter "S" to indicate the two cardinal directions. After the tree is felled, these reference arrows will allow the location of the north arrow on each section disk. Use a template with a moderately sized north arrow (see Supplement II) to trace the north cardinal direction on each disk with an indelible pen (such as a Sharpie) that writes small enough that the arrow would not hinder or prevent measuring annual rings on another part of the disk. Trace the north arrow on the outermost part of the disk. C

The purpose of the north arrow is two-fold. First it allows realignment of the disk in relation to the original orientation and second it provides data to study stem cross-section eccentricity in relation to cardinal

directions, slope and aspect.

The stem analysis data from "site" trees will be used to obtain site index curves. This information, combined with data from the felled dominants and co-dominants, intermediates and suppressed trees (noted as others in part 3c below), will provide the data to estimate height and diameter increment for all portions of the stand.

- c. Other Trees to be Felled On the 1/5<sup>th</sup> acre plot count the number of trees in each class not chosen as "site" trees to be felled. Record the plot tree number by diameter classes on Stand Table Form 1. Diameter classes are:

Diameter Class	DBH-o.b.(in.)
1	5.6-10.9
2	11-12.9
3	13-14.9
4	15-16.9
5	17-18.9
6	19-20.9
7	21.0+

A maximum of seven other non-site trees (other than as in 3a,b) will be felled on the 1/5<sup>th</sup> acre plot.

When all classes (1-7) are represented, randomly choose one tree per class to fell. Otherwise take  $1/3^{\text{rd}}$  of the trees per diameter class randomly chosen from the healthy trees in the class. That is, whenever possible avoid choosing trees with broken tops or severe crook for example. If this requires that more than seven (7) trees are be felled, take  $1/4^{\text{th}}$  (or  $1/5^{\text{th}}$ ) of the trees per diameter class. However, whenever a diameter class is represented, no less than one tree should be taken. A maximum of four trees will be felled from any one diameter class (excluding "site" trees). This allows for proportional representation by diameter class similar to Dolf (1979) while still insuring that all classes with trees are represented.

For example take the following tally for trees greater than 6" DBH excluding site inex trees:

Diameter Class	Tally/fifth acre	1/3 rule	1/4 rule
1	5	1	1
2	6	2	1
3	4	1	1
4	4	1	1
5	-	-	-
6	2	1	1
7	6	2	1
Total	25	8	6

Diameter Class	Tally/fifth acre	1/3rule	1/4rule	1/5rule
1	20	6	5	4
2	6	2	1	1
3	1	1	1	1
4	-	-	-	-
5	-	-	-	-
6	-	-	-	-
7	3	1	1	1
Total	30	10	8	7

Diameter Class	Tally/fifth acre	1/3rule
1	6	2
2	2	1
3	-	-
4	-	-
5	1	1
6	-	-
7	-	-
Total	9	4

After determining the number of trees to be selected in each diameter class, the trees should be chosen randomly without regard to species and avoiding trees with obvious defects unless there are no other trees that can be taken in that class. A table of random numbers is included. Randomly choose a starting point from the table from which to begin selecting numbers. Numbers can be sequenced vertically, horizontally, or diagonally. Select a tree in a diameter class in accordance with the random number. This can be done easily by associating the random number reference on the Stand Table Form 1 with the plot tree number on the same form. If there is no tree in the diameter class to match the random number simply reselect the random number until a match occurs. Repeat the procedure for each diameter class choosing as many trees as indicated in Stand Table Form 2.

Mark the selected trees with a single paint stripe around the bole at stump height (1.5') and breast height (4.5'). Indicate on the plot card next to the tree number that the tree will be felled.

#### Measuring Growth and Ingrowth

4. One crew member will measure height and crown height for all trees greater than 5.5" DBH. Additionally, 5, 10, and 15 year height growth is to be measured for all dominant trees to be felled, with the exception of Incense Cedar. This includes all types of "site" trees and off-plot "site" trees (3a,b) and other dominants on the 1/5<sup>th</sup> acre plot that are

to be felled. These measurements are to be recorded on Plot Card 2. To facilitate measuring the correct trees, species, tree number, DBH and total height are copied from Plot Card 1 prior to measuring dominant tree height growth.

A pair of field binoculars should be used to locate 5, 10, and 15 year whorls. Use a clinometer to measure the height at those points. The binoculars are also effective in identifying trees with broken tops and other abnormalities.

5. While a crew member is doing "4", another can measure 5, 10 and 15 year radial increment on trees that will not be felled and are over 5.5" in DBH in the 1/10<sup>th</sup> acre plot. Record the information on Plot Card 3. These trees are numbered and have a circle around the tree number. Also they do not have any paint at stump height or at breast height. In addition, all "site" trees will be bored to ensure that growth is reasonably regular with no abrupt periods of growth reduction (see part 3(b) for exceptions). Prior to measuring radial increment the tree number, species and DBH of all non-fell trees greater than 5.5" DBH within 37.2 feet of the plot center should be copied onto Plot Card 3 to facilitate location of those trees and to ensure that the proper trees are measured.

6. On a 1/20<sup>th</sup> acre subplot count the number of trees by

species in 1-inch diameter classes from 2" to 5". Use Plot Card 4. A

Felling Trees (Stem Analysis Form)

1. Fell the tree so that the entire cross section, i.e. a level cut, can be obtained at 1.5 feet (called cut #1). Measure the true stump height from the ground on the uphill side of the tree. Measure diameter inside bark along the major axis and minor axis referred to as stump diameter 1 and stump diameter 2, respectively. Record the average bark thickness for the stump.

2. Using a staff marked at 5, 10, and 15 feet place it along the side of the tree bole and mark with paint points 5, 10, and 15 feet from the top leader or the tip of the tree. If this proves inconvenient, use a loggers tape to locate these points. These will be convenient points from which to reference rounds to be taken in the upper crown. In some cases it will be necessary to reconstruct the top if broken during falling.

3. Measuring back from the butt of the 1<sup>st</sup> log cut a thin disk (1-1.5" wide) at 1.5' (already marked on the tree). This is cut #1. Mark the north cardinal direction on the disk and leave it at the base of the tree. Do the same for the breast-height round (cut #2). Since the portion below the breast height is no longer usable, start from the breast

height cut (now zero feet) and measure out and mark a log length (market requirements may necessitate various log lengths between species i.e. 16.5 feet for conifers and cedar and 20.5 feet for firs). Cut the disk from the base of the next log before measuring out another log. Repeat the procedure until reaching the live crown. The person recording the data tallies the number of disks cut excluding T5, T10 and T15 as disks are being cut. Record the tally on the stem analysis form.

After the buckeer makes his first buck in the live crown, he must stop to let a crew member measure the crown radius just above the buck on the left and right sides of the bole (measured from the center of the bole). At the same time one person records the data and measures from the base of the bole (breast height cut) to the first buck in the live crown. This will be done for all felled trees regardless of crown class.

The buckeer then proceeds to limb up the bole to the next cut point and measurements outlined above are recorded. The buckeer should continue limbing and cutting sections even if a merchantable log cannot be obtained. However, he should stop before T15 is reached. This will allow good crown profile information to be obtained.

Go to the tip and count 5 whorls down the stem from the tip and take a section immediately above the node. Determine the age of the section by starting at the section pith and counting spring wood as you move outward toward the circumference.

C

In some cases a hand lens must be used to count the rings where the rings are very close together or are apparently indistinguishable.

In some cases false rings may be present usually due to abnormal weather conditions which temporarily halt the normal growth process. Often these false rings do not encircle the tree. False rings show no abrupt borders between early and late wood as true rings do, but rather a light-dark-light gradient.

A

A

If the ring count is not a full five rings, make another cut down the stem at about a 12-inch interval (or simply move down and cut above the next whorl) until the ring count shows a full five rings (Dolf,1979). Measure from the closest paint mark reference (5 or 10 feet) to this point. Determine and record the distance from the tip. Call this point T5 for five years from the tip (T). Repeat the same procedure for 10 and 15 year whorls down the stem from the tip. Call these locations T10 and T15. Make sure there are

the correct number of rings per section. Be sure to get these cuts for all felled trees regardless of crown class. Measure and record distance from the last cut in the crown to T15.

Because of the difficulty in counting rings on incense cedar, simply make cuts at 5,10, and 15 feet from the tip for this species. Refer to Supplement I.

4. Store T5, T10 and T15 in a small plastic bag such as a baggie in order not to loose them in the field. Write cluster, plot, tree number and species on the bag.

In cases where the stem is quite small near the tip, a key hole saw (small hand saw) may be more appropriate to use than a chain saw in obtaining T5, T10 and T15.

5. Lop and scatter branches.

6. Measure with a loggers tape the distance from the breast height cut to the tip. Add 4.5' to get total height (tip to ground) and record it on the stem analysis form.

7. Collect the rounds starting at the tip and working to the base of the tree. Make sure that a paint mark is put on the bark indicating one of the cardinal directions before the disk is taken from the tree. Use a template to trace the N cardinal direction onto the disk. Draw a pair of cross-lines (see drawing at the end of supplement II) on the disk. However, do not extend the cross-lines all the way to pith - as this would obscure the measurements at the center of the round.

A

A

A

C

C

A

A

A

A

Staple a card to the bottom of each section. It should contain:

- a. Cluster Number
- b. Plot Number
- c. Tree Number (Same as on the 1/5<sup>th</sup> acre plot card)
- d. Cut Number (1,2,3...,T15,T10,T5)
- e. Species
- f. Total number of disks cut excluding T5, T10, and T15.

C

Also write this information in indelible ink on the other side of the round in case the card is lost.

Disk Diameter is measured and recorded on the Stem Analysis Form as is the average thickness of the disk. This is a check to make sure all sections are with the correct tree after shipping, or that photographs match the measurements. The diameter is needed in properly reconstructing the tree height.

C

The identification card should appear as follows:

1/1/8/3/wf/6

for Cluster 1, Plot 1, Tree number 8, Cut number 3, species white fir, and a total of 6 disks were cut other than T5, T10 and T15.

It is suggested to print headings on cards to facilitate completing them in the field.

8. Photograph the section rounds.

Every section, except the 3 tip cuts (T5, T10, and T15) must be photographed. See supplement II for details.

9. Retain the breast height cut as well as tip cuts for shipment to Berkeley. The breast height cut will be used as a check on our photographic measurements.

10. Keep all disks from one tree together in a heavy gauge plastic bag. Mark the bag with tape indentifying plot, cluster and tree number. Place  $1/8^{\text{th}}$  of a cup of naphthelene flakes in the bag to prevent mold and splitting. Alternatively, spray or wipe the disks with a 4 or 5 X solution of water soluble sodium pentachlorophenate to prevent molding. Also treat the breast height section that will be sent to Berkeley.

11. Folliage Collection Instructions

- a. Collect folliage from a felled dominant tree of each species. If a dominant tree of the species has not been felled, collect the folliage from the most vigorous felled tree of the species. Combine the plot samples for each species into a cluster sample. C
- b. Take separate samples of current year folliage and last years folliage. List 1 or 2 on the bag for current or last years growth (see instruction 11d for labeling). C
- c. Sample ponderosa pine by taking folliage bearing twigs from the center of the lower third southside of the crown. Strip a small handful of current year growth needles from 1 twig and place in the bag. Then strip a C

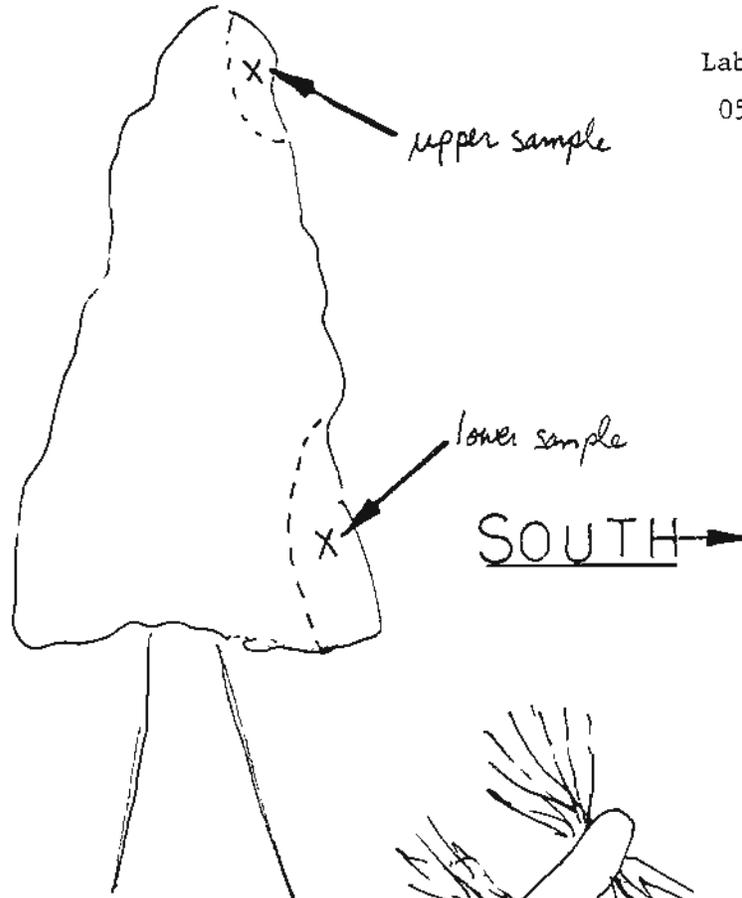
handful of needles from last years' growth from the twig. Keep needle bundles intact.

- d. Take a duplicate set from the upper third southside of the crown. Label the bags as follows: (see next page)

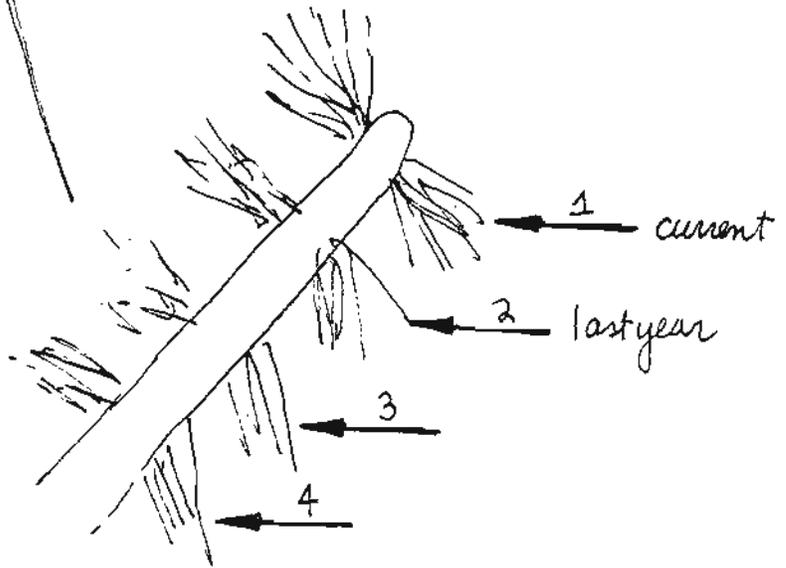
Cluster number/species/1 or 2/upper or lower

- e. Use the same procedure for other species of pines.
  - f. For Douglas fir and other firs clip twigs just below the node and needles representing current and 2nd years' growth.
12. Sometimes visibility of rings in a section that is roughly cut or has very close rings can be improved by using a sharp knife to cut a small clean swath. This may enhance photographic interpretation. A

Example	
Cluster	05
Species	pp
Foliage	1 - current year
Position	upper

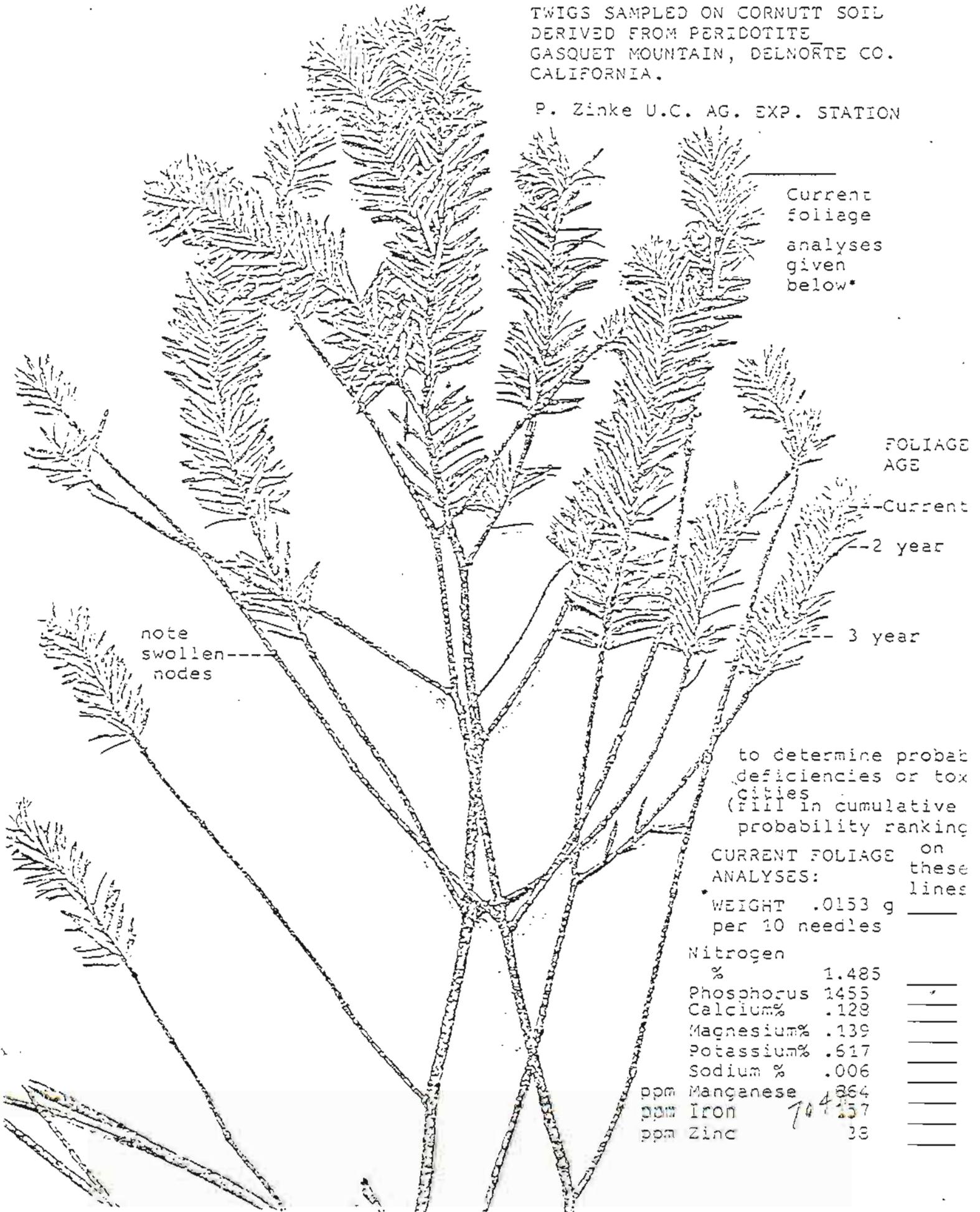


Label:  
05/pp/1/upper



DEFICIENT DOUGLAS FIR FOLIAGE & TWIGGS SAMPLED ON CORNUTT SOIL DERIVED FROM PERIDOTITE GASQUET MOUNTAIN, DELNORTE CO. CALIFORNIA.

P. Zinke U.C. AG. EXP. STATION



Current foliage analyses given below\*

FOLIAGE AGE

--- Current

--- 2 year

--- 3 year

note swollen nodes

to determine probable deficiencies or toxicities (fill in cumulative probability ranking

CURRENT FOLIAGE ANALYSES: on these lines

WEIGHT .0153 g per 10 needles

Nitrogen	%	1.485	_____
Phosphorus		1455	_____
Calcium	%	.128	_____
Magnesium	%	.139	_____
Potassium	%	.617	_____
Sodium	%	.006	_____
ppm Manganese		864	_____
ppm Iron		704.157	_____
ppm Zinc		38	_____

Supplement I

A Guide to Recognizing the Position of Annual Nodes for  
the Estimation of Tree Height Growth  
and the Location of 5,10, and 15 Year Cuts

June 11, 1980

This guide is the result of analysis of the tips of 30 trees felled during the course of stem analysis by Champion International Timber Company in the fall of 1979. Only those species felled in the stem analysis were available for study. They include ponderosa pine, douglas-fir, white fir, and incense cedar. Since the analysis is based on trees from only two clusters, deviations from these findings in different locations and sites can be expected. Any corroborative or contradictory experiences reported will be appreciated and passed on to the other cooperators.

1. Ponderosa pine: In the samples brought from the McCloud area every location in the tip where branching occurred indicated the start of annual height growth. While this may not be the case for every location, when this is not true it would be expected that branch sizes may be a helpful indicator. Branches much smaller than those above or below would be expected to be internodal branches. Since there were no apparent bud scars, branch locations should be counted to find 5, 10, and 15 year height growth on felled trees.
2. White fir: Nodal branching in white fir is indicated by a whorl of 4 or 5 branches. Internodal branching is common in this species, but generally in clusters of 3 or less. Bud scars are easily distinguished on felled trees as a line or crease encircling the stem at a whorl.
3. Douglas-fir: The start of annual height growth in douglas-fir was indicated by a whorl of 3 or more branches. Internodal branching is common in this species also, but not usually in whorls. Branch size was also a good indicator in distinguishing internodal branching.
4. Incense cedar: It was impossible to determine the location of annual nodes on incense cedar. While an estimation of height growth on incense cedar has never been requested, finding the 5, 10, and 15 year cuts on incense cedars felled in stem analysis is very time consuming. We would like to change the procedure for incense cedar to, 'Remove sections at 5, 10, and 15 feet from the tip of the tree'.

Supplement II

Guidelines for Photographing Section Rounds for NCFYC Stem Analysis

June 3, 1980

Intent

Much of the time, and therefore cost, in stem analysis is spent in recording ring measurements in the field. In trying to avoid these costs some experimentors have measured 5 or 10 year groups of rings. Others have attempted to make a transparency of the section using clear or frosted acetate. Carefully done, photographing the sections provides the fastest and most accurate record of the rounds, but enlarging costs and problems with distinguishing the rings have outweighed these benefits.

However, indications from an experimental plot on Blodgett Forest and from stem analysis by Champion Timber Co. are that photo slides can be used in conjunction with a "ball and point spectral densitometer" at the Remote Sensing Research Center (UCB) to efficiently measure and record individual section ring widths on magnetic tape.

Equipment

- 1) 35mm Camera
- 2) 50-55 mm lense (a macro lense is best, but not necessary)
- 3) Kodak ASA 64 Ektachrome Slide film and Kodak mailer
- 4) Avery labels and pen
- 5) A thin, white 6" scale that will lie flat on the section
- 6) Lightweight tripod and shutter release cable (Optional)
- 7) Dark, thin marking pen (such as a Sharpie)

### Guidelines

The photographs should be taken in an area receiving direct sunlight. A shutter speed not slower than  $1/250^{\text{th}}$  of a second should be used. If a tripod and shutter release cable are available speeds down to  $1/60^{\text{th}}$  of a second may be used.

Generally, it is advisable to use an f-stop of not less than 5.6 to allow a great enough depth of field to provide some margin of error in the focus. If light conditions do not allow the use of both an f-stop of at least 5.6 and a shutter speed not slower than  $1/250^{\text{th}}$  of a second, reduce the f-stop as low as 2.8, taking special care to get the best focus possible. If it is too dark to photograph the sections at these specifications, leave the rounds and come back when there is more light.

The photos should be taken with the camera held as close to the section as possible while including the entire section in the photo. However there is a threshold of resolution, depending on the ring widths, beyond which some of the rings will not be clearly distinguishable.

The following is a rule of thumb for finding the maximum distance from a section given a minimum ring width.

Measure the smallest 5 year radial increment in the section. The maximum distance from the section is given by:

distance (feet) = 10 x 5yr radial growth (inches)

For example, if the smallest 5 year radial increment is .15 inches, the maximum distance from the camera to the section should be 1.5 feet.

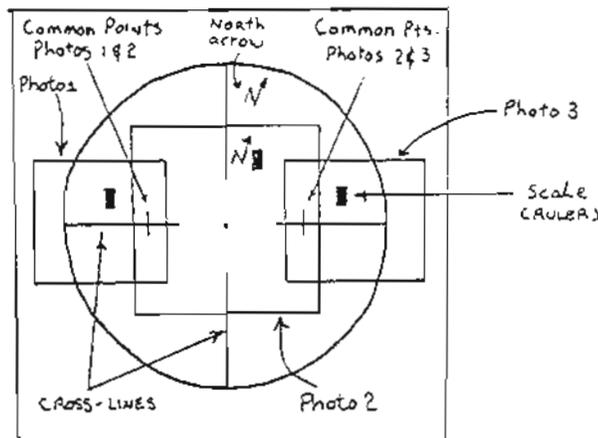
For many sections there will be no problem photographing the sections at these specifications. Some of the problems which may occur are:

- 1) There may be trees for which the smallest 5 year radial increment is less than .14 inch. Since most camera lenses do not focus closer than 1.4 feet, it would be impossible to follow the rule.
  - a. If the section is small, it should be sent in with the 5, 10, and 15 year cuts (any section can be sent to us, but sending many large sections involves more work for you).
  - b. If the section is large, divide the section into 2 photos. Be sure to photograph the section in direct sunlight (direct sunlight increases the contrast between the spring and summer woods, allowing a slightly greater distance between the section and the camera).
- 2) The rule for determining maximum distance between the camera and the section may require the camera to be so close to the section that the entire section is no longer contained in the photo.  
The section should be divided into two or more

photos. Each photo must be identified and contain a scale, and each pair of photos must contain a well-marked common point (such as the pith, or a pen mark).

T5, T10, and T15 cuts need not be photographed. Test photos show that these sections do not photograph well. They should be taken from the field and will be measured in the lab at Berkeley. However, all other sections should be photographed whether taken from the field or not.

Example: Dividing a section into 3 photos.



NORTHERN CALIFORNIA FOREST YIELD COOPERATIVE

FIELD PROCEDURES FOR STEM ANALYSIS

June, 1980

Choice of Clusters and Plots

See the expanded stem analysis procedures for choice of clusters and plots.

Plot Measurements

1. Record elevation, aspect, slope, location, brush cover and average brush height on the cluster card. Record log lengths by species.
2. For the 1/5<sup>th</sup> acre plot record on Plot Card 1 distance and azimuth from the plot center to trees greater than 5.5" in DBH. Also record the position and diameter of stumps and dead trees greater than 5.5", write "dead" or "stump" in the comments column of Plot Card 1 (no other measurements need to be taken on these trees). Paint the tree number at eye level toward the plot center. If the tree falls within the 1/10<sup>th</sup> acre plot paint a circle around the number.
3. On a 1/20<sup>th</sup> acre subplot count the number of trees by species in 1 inch diameter classes from 2" to 5" DBH. Use Plot Card 4.

Before Felling any Tree

1. Site Index Trees

Choose 6 dominants 3 each of the two most prevalent species in the overstory. Where possible choose young growth trees. Take only trees with healthy tops. When possible choose unsuppressed dominants (DU) on the plot or less preferably adjacent to the plot. When this is not possible choose unsuppressed codominants (CU) on the plot. Take an increment boring to check for past suppression. When no traditional site trees (DU) exist on or near the plot and when no unsuppressed codominants are on the plot (CU) choose trees that otherwise have all the other attributes of site trees (full crowns, receiving full light from above, etc.). That is, in this case select dominants that display significant radial suppression (DS) or less preferably codominants that are suppressed (CS). Refer to any tree chosen to represent site potential (whether DU, CU, DS or CS) as "Site" trees.

Paint a stripe at 1.5 and 4.5 feet above the ground as well as an "S" on the trees. Paint the north and south cardinal directions on the bole. Write Site/DJ, Site/CU, Site/DS or Site/CS next to the tree number on Plot Card 1.

2. Make a stand table for trees greater than 5.5" DBH excluding "Site" trees (of any kind). Record the plot tree number on Stand Table Form 1.
3. Measure total height, crown height, Dunning and Keene's Crown Class for all trees greater than 5.5" in DBH. Record damage and disease code where appropriate.
4. Determine the number of non-"site" trees to be felled from Stand Table Form 2. Take a maximum of 7 of these non-"site" trees, they too should have full healthy tops.
5. Randomly choose the trees to be felled from each diameter class. Paint a stripe at 1.5 and 4.5 feet above ground as well as a north and south arrow on the bole. Record on Plot Card 1 that the tree is to be felled by writing "felled" next to the tree number. Even though at most 7 trees are taken, 7 is a target number. Only in rare cases are 2-3 non-"site" trees an acceptable number.
6. Additional Measurements (Plot Cards 2 and 3)
  - A. "Site" Trees & Dominants. For Dominants (SAF definition) and "Site" trees (whether Site/DJ, CU, DS, or CS) record 5, 10, and 15 year height growth on Plot Card 2. This applies to the entire 1/5<sup>th</sup> acre. If a "site" tree is off the plot use the off plot site tree form. Write "off" in the column "on/off plot" on the Stem Analysis Form.
  - B. Non-fell Trees over 5.5". For all non-fell trees greater than 5.5" in DBH on the 1/10<sup>th</sup> acre subplot (Plot Card 3) measure 5, 10 and 15 year radial growth. These trees have a circle around the tree number, but do not have any paint at stump or breast height.

#### Felling Trees (Stem Analysis Form)

1. Fell the tree with a level stump. Record true stump height and diameter inside bark along the major and minor axis inside bark of the stump as well as average bark thickness.
2. Paint a mark on the bole 5, 10 and 15 feet from the tip of the tree.
3. Make 1-1.5" section cuts at 1.5 and 4.5 feet (already marked on the tree). Before cutting any section mark a cardinal direction on the bark (North only on sections

T5, T10, and T15).

4. Starting from the 4.5' mark make a section cut at log lengths until reaching the first buck in the live crown. As you progress, tally the number of disks cut excluding the tip cuts (T5, T10, and T15).
5. At the first buck in the live crown record the radius of the crown on both sides of the bole in the column marked 1<sup>st</sup> buck in the live crown (measure from the center of the bole). Measure the distance from the breast height cut to the first buck in the live crown.
6. Continue cutting log lengths in the live crown even if they are non-merchantable. Record the radius of the crown at each buck point. Do not buck past the paint mark 15 feet from the tip (approx. at T15).
7. Count 5 whorls down the stem from the tip and make a section cut above the whorl. Resection if necessary until the ring count shows a full five rings. Record distance from the tip. Call this section T5. This is done for all felled tree regardless of crown class. For incense cedar simply cut sections at 5, 10, and 15 feet from the tip.
8. Repeat as in 7 for locating sections at 10 and 15 year ring counts (T10 and T15). This is done for all felled trees. (Cedar is cut at 10 and 15' from the tip).
9. Measure and record the distance from the last cut to T15.
10. Store the sections cuts from the tip (T5, T10, T15). Write Cluster, Plot, Tree number and species on the bag to identify the tip cuts.
11. Foliage Analysis Instructions
  - a. Collect foliage from a felled dominant tree of each species. If a dominant tree of the species has not been felled, collect the foliage from the most vigorous felled tree of the species. Combine the plot samples for each species into a cluster sample.
  - b. Take separate samples of current year foliage and last years foliage. List 1 or 2 on the bag for current or last years growth (see instruction 11d for labeling).
  - c. Sample ponderosa pine by taking foliage bearing twigs from the center of the lower third southside of the crown. Strip a small handful of current year growth needles from 1 twig and place in the bag. Then strip a handful of needles from last years' growth from the twig. Keep needle bundles intact.
  - d. Take a duplicate set from the upper third southside of the crown. Label the bags as follows:

Cluster number/species/1 or 2/upper or lower
  - e. Use the same procedure for other species of pines.
  - f. For Douglas fir and other firs clip twigs just below the node and needles

representing current and 2nd years growth.

12. Lop and scatter branches.
13. Using a tape, measure and record distance from breast height cut to tip and total height (Breast height cut to tip + 4.5').
14. Begin collection of section rounds. Remove the disk from the bole and mark the north cardinal direction on the disk (excluding sections T5, T10, and T15). Draw a pair of cross-lines on the disk (see example in Photographic Procedures). Measure disk diameter and average disk thickness and record them on the Stem Analysis Form. See the Stem Analysis Form for preparing identification cards. Also write the identification in indelible ink on the opposite side of the round.
15. Photograph each section (excluding T5, T10, and T15). Make sure a scale is included in the picture. See attached photographic instructions for details. Be sure that the photo contains a north arrow.
16. Bring tip sections T5, T10, and T15 as well as the breast height section out of the woods for all felled trees.
17. Store the other rounds in an untied heavy duty plastic bag after being sprayed with a 4 or 5x solution of water soluble sodium pentachlorophenate. Also spray the breast height section.

Photographic Procedures

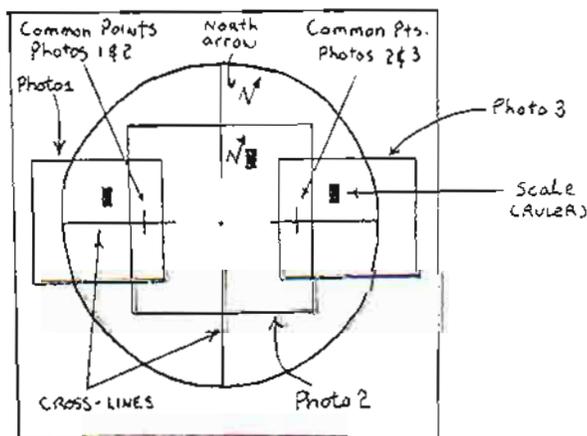
1. Label the tree sections and draw a north arrow and cross-lines as in the Stem Analysis Procedures.
2. Move the rounds to an area receiving direct sunlight.
3. Calculate the maximum distance between the section and the camera. Determine the number of photos needed to cover the section. Mark points common to each pair of photos and check to be certain there is a scale in the picture. Make sure that **at least one photo contains a north arrow.**
4. Set the shutter speed and f-stop.
5. Take the picture while holding the camera directly above the section. To avoid distortion it is important to keep the focal plane parallel to the plane of the section when taking the photograph.
6. Spray the sections with a 4 or 5x solution of water soluble sodium pentachlorophenate and store in labeled plastic bags, so that if some of the pictures do not turn out you can easily find and rephotograph the sections.
7. Send completed rolls of film to the Kodak processing center in San Jose by means of a Kodak mailer (available at most photo centers).

For a return address use:

Robin L. Filion  
145 Mulford Hall  
University of California  
Berkeley, Ca. 94720

8. Send a letter to Robin indicating the number of rolls of film to expect. Make arrangements to deliver the dbh cuts, foliage samples, and tip cuts to Berkeley. Please give us notice as to when you will be sending these down.

Example: Dividing a section into 3 photos.



NORTHERN CALIFORNIA FORESTRY YIELD COOPERATIVE

FIELD PROCEDURES FOR STEM ANALYSIS

June, 1980

Choice of Clusters and Plots

See the expanded stem analysis procedurea for choice of clusters and plots.

Plot Measurements

1. Record elevation, aspect, slope, location, brush cover and average brush height on the cluster card. Record log lengths by species.
2. For the 1/5<sup>th</sup> acre plot record on Plot Card 1 distance and azimuth from the plot center to trees greater than 5.5" in DBH. Also record the position and diameter of stumps and dead trees greater than 5.5", write "dead" or "stump" in the comments column of Plot Card 1 (no other measurements need to be taken on these trees). Paint the tree number at eye level toward the plot center. If the tree falls within the 1/10<sup>th</sup> acre plot paint a circle around the number.
3. On a 1/20<sup>th</sup> acre subplot count the number of trees by species in 1 inch diameter classes from 2" to 5" DBH. Use Plot Card 4.

Before Felling any Tree

1. Site Index Trees

Choose 6 dominants, 3 each of the two most prevalent species in the overstory. Where possible choose young growth trees. Take only trees with healthy tops. When possible choose unsuppressed dominants (DU) on the plot or less preferably adjacent to the plot. When this is not possible choose unsuppressed codominants (CU) on the plot. Take an increment boring to check for past suppression. When no traditional site trees (DU) exist on or near the plot and when no unsuppressed codominants are on the plot (CU) choose trees that otherwise have all the other attributes of site trees (full crowns, receiving full light from above, etc.). That is, in this case select dominants that display significant radial suppression (DS) or less preferably codominants that are suppressed (CS). Refer to any tree chosen to represent site potential (whether DU, CU, DS or CS) as "Site" trees.

Paint a stripe at 1.5 and 4.5 feet above the ground as well as an "S" on the trees. Paint the north and south cardinal directions on the bole. Write Site/DU, Site/CU, Site/DS or Site/CS next to the tree number on Plot Card 1.

2. Make a stand table for trees greater than 5.5" DBH excluding "Site" trees (of any kind). Record the plot tree number on Stand Table Form 1.
3. Measure total height, crown height, Dunning and Koene's Crown Class for all trees greater than 5.5" in DBH. Record damage and disease code where appropriate.
4. Determine the number of non-"site" trees to be felled from Stand Table Form 2. Take a maximum of 7 of these non-"site" trees, they too should have full healthy tops.
5. Randomly choose the trees to be felled from each diameter class. Paint a stripe at 1.5 and 4.5 feet above ground as well as a north and south arrow on the bole. Record on Plot Card 1 that the tree is to be felled by writing "felled" next to the tree number. Even though at most 7 trees are taken, 7 is a target number. Only in rare cases are 2-3 non-"site" trees an acceptable number.
6. Additional Measurements (Plot Cards 2 and 3)
  - A. "Site" Trees & Dominants. For Dominants (SAF definition) and "Site" trees (whether Site/DU, CU, DS, or CS) record 5, 10, and 15 year height growth on Plot Card 2. This applies to the entire 1/5<sup>th</sup> acre. If a "site" tree is off the plot use the off plot site tree form. Write "off" in the column "on/off plot" on the Stem Analysis Form.
  - B. Non-fell Trees over 5.5". For all non-fell trees greater than 5.5" in DBH on the 1/10<sup>th</sup> acre subplot (Plot Card 3) measure 5, 10 and 15 year radial growth. These trees have a circle around the tree number, but do not have any paint at stump or breast height.

Felling Trees (Stem Analysis Form)

1. Fell the tree with a level stump. Record true stump height and diameter inside bark along the major and minor axis inside bark of the stump as well as average bark thickness.
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3. Make 1-1.5" section cuts at 1.5 and 4.5 feet (already marked on the tree). Before cutting any section mark a cardinal direction on the bark (North only on sections

T5, T10, and T15).

4. Starting from the 4.5' mark make a section cut at log lengths until reaching the first buck in the live crown. As you progress, tally the number of disks cut excluding the tip cuts (T5, T10, and T15).
5. At the first buck in the live crown record the radius of the crown on both sides of the hole in the column marked 1<sup>st</sup> buck in the live crown (measure from the center of the hole). Measure the distance from the breast height cut to the first buck in the live crown.
6. Continue cutting log lengths in the live crown even if they are non-merchantable. Record the radius of the crown at each buck point. Do not buck past the point mark 15 feet from the tip (approx. at T15).
7. Count 5 whorls down the stem from the tip and make a section cut above the whorl. Retract if necessary until the ring count shows a full five rings. Record distance from the tip. Call this section T5. This is done for all felled trees regardless of crown class. For incense cedar simply cut sections at 5, 10, and 15 feet from the tip.
8. Repeat as in 7 for locating sections at 10 and 15 year ring counts (T10 and T15). This is done for all felled trees. (Cedar is cut at 10 and 15' from the tip).
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  - d. Take a duplicate set from the upper third southside of the crown. Label the bags as follows:  
Cluster number/species/1 or 2/upper or lower
  - e. Use the same procedure for other species of pines.
  - f. For Douglas fir and other firs clip twigs just below the node and needles

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representing current and 2nd years growth.

12. Top and scatter branches.
13. Using a tape, measure and record distance from breast height cut to tip and total height (Breast height cut to tip + 4.5').
14. Begin collection of section rounds. Remove the disk from the bole and mark the north cardinal direction on the disk (excluding sections T5, T10, and T15). Draw a pair of cross-lines on the disk (see example in Photographic Procedure). Measure disk diameter and average disk thickness and record them on the Stem Analysis Form. See the Stem Analysis Form for preparing identification cards. Also write the identification in indelible ink on the opposite side of the round.
15. Photograph each section (excluding T5, T10, and T15). Make sure a scale is included in the picture. See attached photographic instructions for details. Be sure that the photo contains a north arrow.
16. Bring tip sections T5, T10, and T15 as well as the breast height section out of the woods for all felled trees.
17. Store the other rounds in an untied heavy duty plastic bag after being sprayed with a 4 or 5x solution of water soluble sodium pentachlorophenate. Also spray the breast height section.

Photographic Procedures.

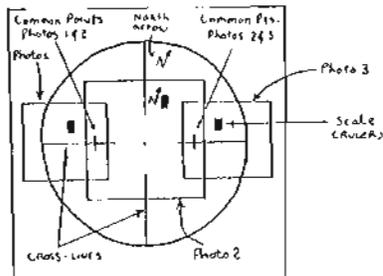
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3. Calculate the maximum distance between the section and the camera. Determine the number of photos needed to cover the section. Mark points common to each pair of photos and check to be certain there is a scale in the picture. Make sure that at least one photo contains a north arrow.
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8. Send a letter to Robin indicating the number of rolls of film to expect. Make arrangements to deliver the dbh cuts, foliage samples, and tip cuts to Berkeley. Please give us notice as to when you will be sending these down.

Example: Dividing a section into 3 photos.



- 35 -  
CLUSTER CARD

Crew Members

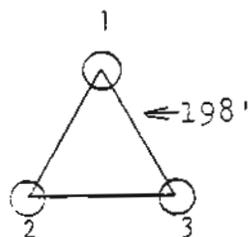
- 1.
- 2.
- 3.
- 4.

Legal Description T \_\_\_\_\_ R \_\_\_\_\_ S \_\_\_\_\_ 40 \_\_\_\_\_

Date \_\_\_\_\_ Cluster no. \_\_\_\_\_

Company \_\_\_\_\_

	Plot 1	Plot 2	Plot 3
Slope (%)			
Aspect (degrees)			
Elevation (ft)			
Brush Cover (%)			
Brush Height (ft)			



Forms Needed include:

- |                        |  |
|------------------------|--|
| Plot Card 1            | - Height, diam., azimuth, etc. for trees on 1/5 <sup>th</sup> acre |
| Plot Card 2            | - Height growth for Dominant trees on 1/5 acre                     |
| Plot Card 3            | - Radial growth for non-felled trees on 1/10 acre                  |
| Plot Card 4            | - Stem count by species on 1/20 acre plot                          |
| Off Plot Site Trees    | - Off plot "site" trees to be felled                               |
| Stand Table Form 1     | - Stand table excluding "site" trees on 1/5 acre                   |
| Stand Table Form 2     | - Number of trees to be felled by diameter class                   |
| Stem Analysis Forms    | - Data taken on felled trees                                       |
| Tables of Random no's. | - Table A-E, random no's. used to select felled trees              |

Log Length	Species
	Douglas fir
	White fir
	Sugar pine
	Ponderosa pine
	Incense cedar

1/5 acre	1/10 ac	1/20 ac
52.7'	37.2'	26.33'
52'8"	37'3"	26'4"

Plot Card 1 (1/5<sup>th</sup> acre plot)

Cluster no. \_\_\_\_\_ Plot no. \_\_\_\_\_  
 Card \_\_\_\_\_ of \_\_\_\_\_

Tree No.	Felled-Site/DW, CU,DS,CS	Sp.	DBH (.1")	Dist. (Feet)	Azim. (Deg.)	Total Height (Feet)	Crown Height (Feet)	Crown Class		Comments and Damage Notes
								D	K	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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39										
40										

Damage/Disease Codes:

- |                    |               |                               |
|--------------------|---------------|-------------------------------|
| 1 - Insect (crown) | 4 - Mistletoe | 7 - Broken or dying top       |
| 2 - Insect (bole)  | 5 - Fire      | 8 - Other crown damage (note) |
| 3 - Conks          | 6 - Bole Scar | 9 - Other bole damage (note)  |
|                    |               | 10 - Forked top               |







Stand Table Form 1 (1/5<sup>th</sup> acre excluding "site" trees to be felled)  
Record Plot Tree Number.

Diameter Class		1	2	3	4	5	6	7
DBH		6.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	>20.9
Random No. Reference	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
Total No. trees/Diam. class								

Stand Table Form 2 (A maximum of 7 trees are selected, no more than 4 per class) From above table				
Diameter Class	Number of Trees	1/3 Rule	1/4 Rule	Other Rules
1				
2				
3				
4				
5				
6				
7				

## STEM ANALYSIS FORM

Cluster no. \_\_\_\_\_ Plot no. \_\_\_\_\_ Card \_\_\_\_\_ of \_\_\_\_\_

/ 1 / 2 / 8 / 3 / np / 6 /  
Clust. Plot Tree Sect. sp. no. disks

Plot tree number														
On/off plot														
Species Code														
DBH (.1")														
True stump height (.1')														
Stump diam.1 (.1" i.b.)														
Stump diam.2 (.1" i.b.)														
Av. bark thick. (.1")														
Tally of no. of section cuts excluding T5, T10 and T15														
Crown Profile Notes														
Dist. from b.h. cut to 1st cut in live crown (.1')														
Radius (.5') of crown at:	Left	Right												
1st buck in live crown														
2nd buck in live crown														
3rd buck in live crown														
4th buck in live crown														
5th buck in live crown														
Dist. from tip to T5 (.1')														
Dist. from tip to T10 (.1')														
Dist. from tip to T15 (.1')														
Dist. last cut to T15 (.1')														
Av. disk diam. (.1" o.b.) / Av. disk thick. (.1")	↓ Av. Diam. / Av. Thick.													
Cut #1 1.5'														
Cut #2 Breast height														
Cut #3														
Cut #4														
Cut #5														
Cut #6														
Cut #7														
Cut #8														
Cut #9														
Cut #10														
Taped dist. DBH to tip (1')														
DBH to tip +4.5' (1')														
Climometer total height (1')														

Tables of Random Numbers from 1 to 25

Table A

6	16	10	21	6	20	10	17	22	12	9	3	5	20	12	25	14	18	23	14
5	2	9	3	9	3	22	13	19	22	15	24	4	14	1	5	14	3	15	5
21	11	14	13	3	5	21	11	24	1	17	22	14	22	13	9	23	14	17	17
16	11	20	3	11	7	12	21	1	10	3	12	19	25	25	10	7	16	3	3
5	18	19	11	15	20	9	2	12	10	3	9	1	3	14	7	13	5	16	2
5	1	7	18	12	13	4	3	25	5	4	13	14	17	10	14	10	3	4	21
25	17	19	15	12	2	6	24	3	2	21	6	11	25	13	5	23	9	23	13
4	3	5	20	10	8	24	2	16	13	17	19	19	10	10	7	1	20	21	19
24	4	12	22	3	4	19	24	21	2	5	21	3	15	13	7	13	2	5	19
14	17	20	20	12	7	23	7	18	22	1	14	22	4	24	18	5	24	25	3
17	23	21	18	7	20	14	25	13	3	6	22	19	4	16	10	11	7	19	17
21	3	6	1	1	6	1	5	2	14	4	14	25	15	23	15	14	13	21	17
21	20	12	24	6	3	7	16	5	14	12	4	3	7	16	20	4	5	25	5
13	3	5	11	4	10	3	19	5	23	1	10	7	16	18	2	25	25	2	3
10	3	17	25	17	9	21	15	1	8	23	14	8	16	4	10	21	19	4	10
21	8	22	23	20	13	6	22	15	19	2	7	8	12	2	2	13	10	6	10
25	2	6	17	24	22	22	16	21	3	25	9	4	14	17	22	24	19	7	18
19	19	10	23	15	19	20	9	21	12	2	5	12	8	24	18	17	6	3	3
10	9	21	15	24	24	25	15	12	21	6	16	2	7	18	3	24	18	17	5
6	21	13	14	3	16	12	22	7	17	23	2	10	10	24	20	5	7	7	19
18	16	13	16	24	17	18	17	23	21	2	6	25	23	12	19	7	15	4	2
9	20	10	2	20	19	23	19	22	6	4	5	5	12	14	10	20	22	24	22
5	21	8	13	14	19	22	25	5	18	11	7	13	8	7	17	20	3	14	5
	16	5	18	1	3	16	5	20	1	22	13	11	12	11	4	15	10	17	18
11	5	22	10	3	9	10	25	14	2	11	13	15	4	15	4	25	22	15	5
5	16	23	8	15	14	15	25	19	24	18	18	25	10	1	13	7	4	8	10
6	5	6	5	5	9	23	1	9	21	7	24	6	17	20	13	9	10	3	4
9	6	1	16	5	3	2	8	6	20	11	3	1	24	23	11	18	14	15	12
12	21	5	3	13	6	21	4	7	8	11	13	2	21	18	3	16	23	13	11
6	3	10	20	6	9	23	18	9	7	23	1	3	21	21	14	14	16	19	20
11	18	19	2	13	21	8	11	21	4	11	25	2	14	7	3	5	9	7	1
12	4	17	23	8	10	11	20	13	22	4	1	23	13	2	21	12	25	8	17
5	11	3	21	9	5	4	3	22	21	16	20	12	12	17	13	6	2	16	13
11	4	21	2	14	15	15	10	18	19	23	9	2	9	11	23	2	15	11	2
17	12	4	9	12	8	20	11	5	12	13	24	15	5	12	18	1	12	11	25
19	10	19	20	23	6	9	13	6	2	22	10	1	13	5	1	11	24	8	10
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Tables of Random Numbers from 1 to 25

Table D

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Tables of Random Numbers from 1 to 25

Table E

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13	11	25	16	9	13	8	12	20	17	7	25	4	14	14	23	17	21	17	25
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3	11	23	15	2	21	13	13	2	1	17	13	2	5	10	19	14	20	13	22
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7	14	9	7	1	1	7	1	21	23	19	3	14	6	4	10	24	3	17	11
8	13	14	20	1	13	20	19	3	15	15	23	22	18	20	3	4	5	10	18
6	17	3	5	11	18	20	6	14	1	3	24	2	22	5	19	22	17	1	2
22	11	14	5	18	15	5	22	2	12	6	25	8	10	23	1	13	11	7	11
7	25	3	11	1	2	10	21	1	11	6	3	5	7	11	4	3	4	20	4
20	18	22	21	23	13	24	6	25	16	14	14	19	2	11	23	5	22	5	14
24	3	5	19	22	2	18	21	22	16	2	13	5	21	23	7	8	23	7	5
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19	1	13	7	21	17	4	15	25	21	2	4	16	14	24	7	2	9	25	17
20	23	18	22	20	23	3	23	2	16	22	10	12	22	18	16	19	2	14	25
15	16	15	10	19	23	24	1	13	21	2	9	9	5	5	8	9	11	19	22
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21	22	2	13	14	3	10	11	6	6	5	12	12	1	8	3	24	16	19	4
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25	19	15	13	5	3	7	7	25	14	6	1	9	4	13	20	19	17	4	13
	18	17	14	24	1	13	5	15	1	10	13	21	4	19	13	8	21	9	17
43	2	16	16	24	8	24	20	13	20	8	17	17	14	9	7	5	5	9	2