

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
DISTRICT 5

RS
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April 15, 1926

INSTRUCTIONS FOR THE
ESTABLISHMENT AND MEASUREMENT OF
METHODS OF CUTTING SAMPLE PLOTS

District 5

By

Duncan Dunning
Associate Silviculturist

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INSTRUCTIONS FOR THE
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METHODS OF CUTTING SAMPLE PLOTS

District 5

General

The purpose of this paper is to describe the technique of sample plot work which experience has shown to give most efficiently the data desired in D-5. It will serve as a check list of equipment needed and things to be done. Even the experienced man will find it advantageous to check over these lists to see if he has the necessary equipment or has done the necessary things. There is no question but that careful attention to the many apparently trivial details will greatly increase the amount of work done in a day and produce better data, thereby simplifying office work.

Purpose

To provide reliable data as a basis for management as to the effects of different cutting methods in various timber types on various sites on,

1. Growth of the remaining stand.
2. Securing of reproduction and recovery and survival of advance growth.

These plots will also furnish related data upon the following subjects:

Windfall losses as related to distribution, species, etc.

Effects of injurious agencies on rate of growth and reduction of net growth by loss due to death. Relative resistance of various species to fire and other agencies.

Relation of crown class or crown size and form to rate of growth.

Relative growth of different species as related to site.

Growth as related to age.

Response to cutting of different degrees with relation to age, species and character of individual trees. Duration and effect of accelerated growth on yield.

Relative damage by different methods of logging to stand and advance growth.

Seed bearing with relation to species, age, distribution, degree of cutting, form of crown, etc., periodicity of seed crops.

Invasion of brush and ground cover.

Damage by slash disposal; per cent of area covered by slash and slash burning.

Succession of types.

Existing Plots

The following table shows the status of the plots already established. (For details, see summaries for each plot in files).

Existing Plots

Forest	Location	Plot No.	Acres	Site	Type	Trees:					Exam. Due	Length Periods-Years		
						Last Exam.	1st Exam.	2nd Exam.	3rd Exam.	4th Exam.		1st	2nd	3rd
Lassen	Facht	1	10.0	III	YP	115	5/17/22				5/1/27			
"	"	2	10.0	III	YP	104	5/17/22				"			
Flumas	Portola	1	24.0	III	YP	*1495	5/18/11	5/15/17	9/25/20	10/15/25	9/1/30	6	3-7/8	5
"	Massack	1	6.4	II	Mix.	495	8/11/14	6/15/19	9/4/23		9/1/28	4 1/2	4-5/8	
"	"	2	6.4	II	"	492	8/14/14	6/10/19	9/3/23		"	4 1/2	4-5/8	
"	"	3	6.4	II	"	533	7/15/13	5/15/19	8/29/23		"	5 1/2	4-7/8	
"	"	4	6.4	II	"	552	7/20/13	5/22/19	8/30/23		"	5 1/2	4-7/8	
"	"	5	6.4	II	"	438	7/30/14	6/18/19	9/5/23		"	4-5/8	4-5/8	
"	"	6	6.4	II	"	416	8/7/14	6/24/19	9/7/23		"	4-3/4	4-1/2	
"	"	7	6.4	II	"	507	7/30/13	6/4/19	9/2/23		"	5 1/2	4-3/4	
"	"	8	6.4	II	"	534	7/25/13	5/28/19	8/31/23		"	5 1/2	4-3/4	
"	Meadow Valley	1	10+	II	Mix.	500+	July 1921				9/1/26			
Sequoia	Likely Mill	1	10.0	I	SP-WF	*1169	10/21/11	6/15/17	5/1/21	8/19/25	9/1/30	5-3/8	3-7/8	4-3/4
"	Buckman's Mill	3	10.0	II	YP	*913	Oct. 1911	6/1/21	9/1/25		"	-	9-1/4	4-3/4
"	"	4	10.0	I	YP-WF-IG	*1625	"	"	"		"	-	9-1/4	4-3/4
"	"	5	10.0	I	YP-SP-IG	*303	"	"	"		"	-	9-1/4	4-3/4
"	"	6	10.0	I	YP	*721	"	"	"		"	-	9-1/4	4-3/4
Shasta	Parks Creek	6	25.0	III	YP	1570	5/1/11	5/1/16	9/1/20	5/1/26	5/1/31	5	5	5
"	"	11	10.9	III	YP	965	"	"	"	"	"	5	5	5
Sierra	Hogan Ranch	1	6.0	I	YP-SP	585	7/15/11	7/1/17	10/1/20	11/1/25	9/1/30	5-7/8	3 1/2	5
Stanislaus	Cold Springs	1	20.0	I	SP-WF	*1616	8/18/10	6/1/16	10/5/20	9/8/25	"	5-3/8	4-3/4	5
"	"	2	20.0	I	SP-YP	*903	"	"	"	"	"	5-3/8	4-3/4	5
"	"	3	20.0	I	SP-YP	*913	"	"	"	"	"	5-3/8	4-3/4	5
"	"	4	20.0	I	SP-YP-WF	*1128	"	"	"	"	"	5-3/8	4-3/4	5
"	Cow Creek	5	10.0	I	SP-YP-WF	472	6/1/23				5/1/28			
Tahoe	Sage Hen Creek	3	20.0	III	JP-WF	626	Fall 1911	6/1/17	9/25/20	10/20/25	9/1/30	5 1/2	3-3/4	5
Total		26	307.1				19690							

*No. in 1920

* Incl. number of dead in 1925

Policy as to Maintenance of Old Plots

From time to time it has been urged that some of the older plots be abandoned because lack of coordination at the time of establishment resulted in a series which did not represent to the best advantage the range of variations in sites, types, and cutting methods, and it is argued that marking methods have since undergone considerable changes. It should be remembered that the lapse of time adds greatly to the value of these old plots and that the final advantages and disadvantages can not be thoroughly realized until they are cut over a second time. Besides the value of long time records of stand growth, losses and restocking, information is furnished as to the behavior of various individual tree types, or tree classes, which is exceedingly important as a guide in marking. None of these plots should be completely abandoned. In some cases intensity of study may be decreased, but sufficient maintenance should be done to furnish a reasonably complete history at the time of the second cutting. Improvements in field and office methods has greatly reduced the time and expense of maintenance.

On Stanislaus Plots 2 and 4, and Sequoia Plot 5, diameters only should be taken at the next few examinations. Tags should be reset and new trees over 3.6 inches tallied but not tagged.

There is a possibility that the Massack plots could be cut over again soon. If this is possible some of the plots should be cut, the rest retained as check plots.

Policy as to Establishment of New Plots

New plots should be established from time to time, as funds permit, to round out a series representing the important sites and types and recent improvements in marking and logging.

Selection of Plots. With the small force available for research work it is important that permanent sample plots be so distributed in time and place in relation to other existing or projected work as to permit systematic examination with the least amount of travel and avoid periodic overloading with work. The District Research map showing the location of permanent plots should be consulted. The permanent plot program should eventually provide an approximately equal amount of re-measurement work each year.

Plots should not be chosen where road construction, claims, uses or other operations may result in damage. Formal withdrawal should be made, if necessary. Plots should be marked with enameled signs stating their purpose and warning against damage. The local forest officer should be shown the plots to avoid granting of uses, etc.

Present and future accessibility by road and ease of working are important considerations in determining the location of sample plots.

Too much care can not be exercised in the selection of the immediate location of plots. Final selection of permanent plots should only be made after approval by the District Officer in charge of Research. It is necessary to have clearly in mind the objects to be attained. Experience in judging the conditions of stands is essential. Too frequently abandonment of plots has been necessary after a few examinations have proved them to be badly selected. When a series of plots under similar conditions are to be studied for differences in treatment a careful preliminary tally should be made and boundaries shifted to obtain as nearly similar stands as possible on all the plots.

New plots should only be established on timber sale areas before cutting. It is very important that conditions existing prior to cutting be thoroughly understood. Each tree cut should be measured and described. Permanent reproduction sub-plots or strips of quadrats should be laid out and examined prior to cutting, after logging, and after slash disposal to determine the effects on advance growth present in the virgin stand.

A plot should represent only one type, one site, and one method of cutting.

Determination of Type. In the absence of a generally applicable type classification, for convenience in filing in this study, the type should be designated by the species which enter into the original composition to the extent of 20 per cent of the volume in board feet, trees 12 inches in diameter and over.

Determination of Site. The site quality should be determined from the average maximum height growth of mature dominant trees in the original stand. Yellow pine, sugar pine, Douglas fir and white fir may be considered, but incense cedar should be ignored. The 10 per cent tallest trees shown in the preliminary measurements should be averaged and reference made to the following schedule:

Site	Total Height - Feet
I	175 +
II	150-175
III	125-150
IV	100-125
V	- 100

Commercial cuttings on Sites IV and V are limited and new plots should preferably be confined to the three more important classes.

Plots should not include contrasting exposures. On a given slope the range in elevation should not be sufficient to involve important changes in soil depth and soil moisture relations.

The species and condition of shrubby and herbaceous plants often give valuable confirmatory evidence of site quality. The size attained by California black oak is frequently significant.

Note should be taken of soil depth, the physical character of the soil and the rocks from which the soil is derived. Intensive soil examinations are not feasible at present.

Any local weather records should be studied.

Uniformity of Cutting. The actual volume, number of trees per acre, and distribution of the stand left are more important than the percentage of the original stand cut and left. The plot should be surrounded by timber treated similarly to that on the plot. The borders of sale areas are usually undesirable because of excessive exposure to wind, fire damage, influence of virgin timber on restocking, etc.

Area. Plots should be from 6 to 10 acres in area, preferably square or rectangular, but establishment of irregular plots including uniform factors is better than strict adherence to regularity at the expense of including heterogeneous factors. Long narrow plots or plots with acute angles should be avoided.

Time of establishment and reexaminations should be arranged so that measurements will be completed before growth starts in the spring or after growth ceases in the fall. Generally what growth occurs prior to May 1 or after September 1 may be disregarded. If it is necessary to take measurements during the growing season an estimate should be made in the field of what portion of the season's growth has probably elapsed, using an increment borer for diameter growth and ocular estimates for height growth. In spring when elongation of the leaders has commenced, height measurements may be taken to the base of the new growth for pines and firs, but this is not possible for cedar. For purposes of computation, until more is known about the distribution of growth throughout the year, the growing season should be considered May 1 to August 31, 4 months, subdividing to nearest 2 weeks, or 1/8 of a season. Measurements should ordinarily be repeated every five years.

Crew

The field work is best done by a crew of three men. Two men can do the work, however, in which case the height man must keep notes. By careful study of equipment and details of the work, two men can remeasure 250 to 500 trees per day, depending on character of topography and underbrush. If diameters only are taken 1000 or more trees can be examined under favorable conditions in a day.

Only one of the men need be experienced. He should be responsible for the conduct of the work, should take the heights and keep the notes.

The diameter man should be preferably of the student forester type and not afraid of hard work.

Equipment

Check List

- 1 F. S. Abney
- 1 F. S. compass and staff socket
- 1 Pocket box compass
- 1 Klausner hypsometer and staff socket
- 1 F. S. hypsometer
- 1 Jacob staff
- 1 Increment borer, 11-3/4" And. Mattson, Mora, Sweden
- 1 Aneroid barometer
- 1 Camera, 3-1/4" X 5-1/2", roll films and case
- 1 Camera tripod, telescopic, with combination for traverse board
- 1 Hand lens
- 1 Traverse board
- 1 100-ft. steel tape
- 3 20-ft. diameter tapes, Lufkin, "Forest Service"
- 1 Tape repair outfit, with tape scraps and rivets
- 1 Tree scribe
- 1 6-inch alidade and scale
- 1 6-inch scale
- 1 12-inch boxwood engineer's scale
- 1 Claw hammer
- 1 pr. 8-inch pliers
- 100 ft. twisted cotton cord
- Grazing prohibition signs
- Enameled sign giving purpose of plot
- 1 Set numbering dies, 1 to 9 and 0
- Blank tags, punched
- 8d wire nails (106 nails per pound)
- Wire pins for reproduction plots.
- 1 Tatum holder, letter size, cloth bound, punched for tree sheets
- 6 Atlas binder screws, 1 1/4"
- Individual tree tally sheets
- Map sheets
- F. S. notebooks, F-289
- Photo record sheets, F-166
- Films
- 1 Doz. 3H pencils with erasers
- 1 Doz. 4H pencils, drafting
- 6 Indelible pencils
- 6 Ruby erasers
- 1 Art gum
- 6 Wood marking crayons - large - red and blue

Check List, Cont'd.

- 1 4-oz. bottle fountain pen ink
- Stationery, Forms 5-A, etc.
- 1 Instrument and record trunk
- 1 Numbering machine
- Ball twine
- Thumb tacks
- Rubber bands
- Tube for increment cores
- Field notes, plot summary, maps, previous photographs

Camp Equipment

- 1 7' X 9' Burch tent
- 1 7' X 7' heavy tarpaulin
- 1 Pole axe with sheath
- 1 Hand axe with sheath
- 1 Shovel, No. 2 cut down
- 2 Canteens
- 1 Canvas water bucket
- 1 Lantern and tight sealing kerosene can
- Candles
- 3 F. S. canvas carrying cases
- 1 F. S. knapsack
- 1 U. S. flag
- First aid packets, bandages, adhesive tape, iodine, alcohol, potassium permanganate crystals.
- Cooking utensils and provisions as needed
- 30 feet 3/8" rope
- 1 piece 20 guage sheet iron 18" X 24" for stove

The Hypsometer. The Klaussner hypsometer is the best of a bad lot. It can be used at any distance from the tree and does not require determination of horizontal distance. It can be operated more rapidly than the others and gives a degree of accuracy consistent with the amount that can be spent on height measurements. For trees of the type left on sale areas the source of considerable error lies in the indefinite tops and bases of the trees, and in determining the distance from instrument to tree, so that the use of a transit or other more accurate instrument can result in no improvement sufficient to justify the added expense. The Forest Service hypsometer should never be used where growth is to be determined by comparing periodic measurements.

The hypsometer should be checked and adjusted, if necessary, before work starts, by sighting on marks set at 10 ft. intervals in a perpendicular tree not less than 50 feet high.

The best Jacob staff is made from an extra long hoe handle. It should be 5½ feet long including the spike. A notch should be cut around near the top to permit tying the hypsometer on with a string. The spike should be slender, as long as obtain-

able, and continuous, or one piece with the thimble. By properly fitting the thimble or by using a screw instead of a nail to hold it on, the spike can be removed for convenience in packing. Such a Jacob staff when thrust into the ground brings the hypsometer sight opposite the eye of the average man, reducing eye-strain and stooping.

The Diameter Tape. Lufkin Rule Co. "Forest Service" 20-ft. tape is the best. It is graduated in inches and tenths, the zero mark being placed a short distance above the hook. The press button for pushing out the handle helps considerably.

The claw hammer should have nearly straight claws, ground sharp with an emery-wheel to assist in digging out grown over tags.

Nails. Copper nails 6d may be used but 8d wire nails are more easily handled as copper nails are difficult to reset at future examinations. Copper nails may be purchased at Weeks, Howe, Emerson Co., 51 Market Street, San Francisco. There are about 100 nails per pound. Of 8d wire nails there are about 106 per pound, of 6d, 181 per pound.

Tags should be galvanized iron, round, 1-3/4 inches in diameter, 1/30 inch thick, punched 1/4 inch from the edge with a hole 1/8 inch in diameter. Numbers should be 1/2 inch high. Numbered tags may be purchased from John Blakeway, 105-117 Beale St., San Francisco, strung on wire in bunches of 100 for \$30 per 1000. Unnumbered tags cost \$17 per 1000 in 1921. With a set of dies small lots of tags can be stamped by hand at a considerable saving. Weeks, Howe, Emerson Company, 51 Market Street, and Justinian Caire Company, 573 Market Street, San Francisco, also furnish these tags. When possible, tags should be purchased in quantity on contract from Washington, where the Forest Service has a numbering machine. Series should run from 1 to 500 and from 1 to 1000 in general.

Field Procedure

Survey. For methods of cutting plots a light transit and 100 ft. tape should be used for the survey. Compass surveys are invariably inaccurate and efforts to obtain a reasonable closure frequently require more time than a single transit survey. Extreme accuracy is unnecessary. Plots should be carefully referenced to a public land survey corner or to some easily recognized permanent land mark.

Marking Boundaries. Corners should be marked with 4" x 4" x 36" posts of heart cedar or pitchy pine (if obtainable) set firmly in the ground and mounded up with rocks. The corner posts should be clearly scribed with the plot designation and the number of the post as designated in the field notes. Painting the posts white aids in relocation. On large plots boundary stakes should be set at 2 to 5 chain intervals depending on density of the stand and visibility. These stakes need not be as large as the corner posts. The lines should be marked by blazing

trees outside the plot so far as possible. Oaks or other trees of little value should be blazed preferably.

Careful witnessing of corners by bearings and distances to two or more trees should always be done. The witness trees should be marked by chopping X's into the wood below stump height facing the stake. If the X's can be so located that a tape stretched between their intersections passes over the center of the stake, it is only necessary to record the distance from each X to the stake, no bearings being required. When the plot is established before logging and there is likelihood of disturbance, temporary 2" x 2" hubs should be driven in flush with the surface.

Permanent corners replace the hubs after the danger of disturbance is past.

Marking. If the plot is to be typical of current marking practice, the assistance of local timber sale administrative officers should be obtained in marking. If some special system of marking is to be reproduced the area should be marked by the Chief of Research.

Preliminary Measurements. The trees to be reserved should be given temporary numbers. A smooth place may be made on the bark with an axe and the number written on with red or blue lumber crayon. The diameters of all trees 3.6 inches and over in d.b.h. should be measured. Heights of the trees to be cut should be taken with a Forest Service hypsometer. The heights of reserved trees need not be measured prior to cutting. A complete description of each reserved tree should be made showing its original condition and relation to associates. Photographs should be taken showing the original condition of stand and undergrowth, marking the points for later repetition. The reproduction inventory strips should be established prior to cutting.

Complete Examination

Tagging.

After cutting is completed and before the area is mapped all trees should be tagged, replacing temporary numbers set before logging. Tagging should proceed by strips not over 2 chains wide, all tags facing in the direction of procedure. A 4½-foot stick is used to place the tags at breast height. On slopes the distance is measured at one side. Allowance should be made for growth by leaving ½ to 1 inch of the nail protruding.

Malformed Trees. Prostrate or malformed trees which will never become merchantable and have no appreciable effect on the growth of other trees should not be tagged.

New Trees. In remeasurements, if there are many new trees, these should be left until the last. The diameter man then carries a graduated 12-foot pole with d.b.h. marked on it. Trees up to 25 feet in height can be measured in this way within

a degree of accuracy of one foot, thus eliminating the long tape and hypsometer. The diameter man can reach 19 feet with this pole while the note keeper with a little practice can safely estimate the additional distance up to 6 feet. New trees should be referenced by two measurements and general bearings from original trees for future location.

Tags should be removed from dead trees.

Missing tags should be duplicated and reset.

Diameters should be taken to 0.1 inch, placing the tape beneath the tag just above the nail. The tape may be swung around small trees but care must always be taken to keep it horizontal, away from knots or swellings, and free from twists. Where knots or projections of bark would make future comparable measurements difficult they should be removed. Loose bark that will later fall off or strips that will be raised by callousing around scars should be pulled off. If it is impossible to take the diameter at breast height, the tag should be set where it can be taken. Where a fork occurs below breast height both forks should be tagged. The tape should be frequently cleaned with kerosene or gasoline.

Caliper measurements can not be repeated consistently.

The diameter man should be equipped with a F.S. canvas carrying case with shoulder strap, hung on his right side, held in a convenient position by a strap around the waist which is passed once around one of the belt straps on his trousers. This prevents the case slipping around in the way when stooping, etc. The flap of the case should be cut off. When tagging new trees, tags should be strung consecutively on a wire and stood up in one corner of the case. The tape should be carried in the pocket of the carrying case. Colored lumber crayon for marking tags should be carried in the hand. The diameter man holds the zero end of the hypsometer tape. The diameter man stretches the distance tape, calls the number of the tree to the height man, sets the tag, or resets the old tag with the hammer, and takes the diameter. The tag is marked with the crayon to avoid later confusion. The diameter is called to the height man at the instant he is seen to open the notebook. It will frequently be necessary for the diameter man to shake small trees to make the tops visible. By keeping instruments always in the same place and proceeding in the same order a good diameter man can go faster than an ordinary height man. By a little headwork the diameter man can divide thickets into "runs" which will minimize tape changes and moving by the hypsometer man. Where there is a choice he should select trees progressing in size. Jumping from a 20-foot tree to a 150-foot tree means a time consuming change of the elevating thumb screw of the hypsometer and usually a change of position by the height man. Where trees are grouped it is preferable to work out natural groups rather than to adhere strictly to definite strips.

Heights. To secure consistently accurate height measurements is the most expensive and time consuming part of the field operations. Attention to details is essential to get reasonably satisfactory results. Distances from hypsometer to tree are measured with a 100-foot steel tape, which should be wide and strong enough to withstand kinking and other rough usage. Care should be taken to measure the distance from the rear sight of the hypsometer to the middle of the base of the tree. For leaning trees the end of the tape should be held in the vertical projection of the tip. More consistent results will be obtained, especially on steep slopes and for large trees if the distance is taken to the center of the tree at tag height and 4½ feet added uniformly to the instrumental reading. In some cases the diameter man must indicate tag height. The distance from the tree should be at least equal to its height.

For large trees with round or flat tops without a definite leader, it is impossible to get consistent consecutive height measurements. Such trees are usually mature, suppressed or injured. There is no appreciable increase in the length of the main axis and consequently no effective change in the height factor as used in determining volume. After one careful measurement has been made on such trees, the subsequent height should be indicated by a check mark as remaining the same as before.

For badly leaning trees where the axis is growing appreciably in length, increases should be estimated from the internodes after the first measurement.

Where the tip is broken out of thrifty trees, measurements should be taken on the limb which is to function as the leader.

Base of crown measurements should be taken to the first live limb which constitutes a considerable part of the crown area, isolated limbs being ignored. On young trees this measurement should be taken every 10 years, but on large old trees a measurement at the beginning and end of the experiment is enough.

Merchantable heights should not be taken and clear length measurements are of little comparative value.

The height man carries a canvas case as above. He holds the long end of the 100-foot tape. Pencil should be carried in a slot in the left breast pocket so arranged that it will stay open but will not permit the pencil to fall out when the note keeper stoops to pick up the tape. The tatum holder is carried under the left arm or dropped into the carrying case. The height man first plants the hypsometer, then tightens up the 100-foot tape, reads the distance to the tree, sets this distance on the horizontal bar of the hypsometer, sets the lower sight on the base of the tree, raises the upper sight, takes the reading, and records the notes, checking measurements with previous data. By choosing his settings to see as many

trees as possible, and far enough away to get the largest, the height man can avoid many moves. Frequently there will be time for him to size up the next tree and raise or lower the upper hypsometer sight to approximately the right angle.

Notes

Emphasis should be laid on complete clear field notes. In the large amount of computation involved much time is lost in trying to decipher slovenly notes. Comparable data can not be secured at subsequent examinations by different men unless original methods are made clear. When compilation begins there ought to be no difficulty in understanding just what was done in the field. Especial care should be taken to give dates of beginning and completion, and the status of growth for the season.

Elimination of Discrepancies. During reexaminations every effort should be made to eliminate obvious errors and omissions from previous records. Form 561 makes it possible for the note keeper to have before him complete records for each tree. At the second measurement a systematic check should be made of the species designation of each tree. Erroneous or omitted height measurements can often be corrected by counting back and estimating the length of the proper number of growth periods. Obviously wrong diameter measurements should be revised by making as close an estimate as possible of the correct diameter, or the correct diameter should be determined with an increment borer. Considerable effort is justified in locating every tree previously numbered. Trees improperly classified as to original diameter or species, or missing trees which later reappear, cause endless corrections and rearrangement of data. It is extremely difficult to carry such corrections through all the items and totals affected.

Standard individual tree sheets, Form 561, will be used (copy attached). 400 of these may be carried serially arranged in two bunches in a cloth bound tatum holder supplied with 4 Atlas binder screws properly spaced to hold the sheets. A piece of wood the thickness of 200 sheets should be slipped into the top of the tatum holder to hold the covers apart. Sheets for trees tagged subsequent to the original establishment of the plot should always be carried in the field, as such trees may be encountered at any time.

The sheets should be numbered with a numbering machine before going into the field, and stamped with the plot designation with a rubber stamp. A set of rubber type is kept in RS.

The blanks at the bottom "Elevation," etc., need not be filled in since these factors should be uniform for a given plot.

The item "Vigor" was erroneously placed at the beginning of the crown description. This should not be filled in until the last, since its appraisal depends on a mental summary after detailed analysis of other indicator factors.

Dates need be entered only for the first and last tree.

FORM 661

S-7058

U. S. DEPT. OF AGRICULTURE—FOREST SERVICE

TREE DESCRIPTION

Tree No. _____

Project *M* _____ N. F. Plot _____ Species _____

DATE	D. B. H.	HEIGHT			BOLE CONDITION	VIGOR	CROWN					AGE CLASS	SEED CROP	REMARKS
		BASE OF CROWN	CLEAR	TOTAL			WIDTH	L'NGTH	D'NS'Y	TOP	CLASS			
<i>Notes:</i>														
<i>Notes:</i>														
<i>Notes:</i>														
<i>Notes:</i>														

Elevation { Absolute _____ Slope _____ Site _____
 Relative _____ Exposure _____ Type _____

The following abbreviations should be used:

- | | |
|---------------------------|---------------------|
| J P - Jeffrey pine | D F - Douglas fir |
| Y P - western yellow pine | W F - white fir |
| S P - sugar pine | I C - incense cedar |
| L P - lodgepole pine | R F - red fir |

Length of crown,

- L, long, forming 70% or more of the total height
 M, medium " 50-70% " " " "
 S, short, " 50% or less " " " "

Width of crown,

W, wide; M, medium; N, narrow.

Vigor,

V, vigorous; M, moderate; P, poor.

Crown class,

X, isolated; D, dominant; C, codominant; I, intermediate;
 S, suppressed.

Age class,

Y, young; TM, thrifty mature; M, mature;
 OM, overmature or decadent.

- Number 1. Refers to form. 1, crooked; 1f-20', forked at 20 ft; 1 l leaning; 1p, prostrate.
2. Refers to health. 2i, insects; 2f, fungi; 2 fw, fungus witch's broom; 2m, mistletoe; 2mw, mistletoe witch's broom; 2sp, suppression.
3. Logging damage. 3b, butt scar; 3bw, bole wound, 3c, portion of crown raked off.
4. Top injury. 4d, recently dead, cause unknown; 4st, spiked top; 4bt, bayonet top; 4b, top broken off cause unknown; 4bl, by logging and 4bs, by snow. (Or omit the 4 and place letters in proper space on note form).
5. Fire damage. 5b, butt scar; 5c, crown injured by slash burning. (Give position and extent of injury by diagram, e.g. .
6. Miscellaneous injuries. 6ax, axe scar; 6pore, porcupine damage; 6sap, sapsucker injury; 6l, lightning scar; 6fr, frost crack; 6w, wound, cause unknown.
- ^lC, crown one-sided; ^tC, foliage thin; ^dC, foliage dense; ^pC, foliage pale green.

In the case of wounds, give dimensions of two longest axes.

S, added to above symbols indicates a serious condition.

Form of top is best described by the following diagrams placed in the proper space on the tree sheet:

 top pointed;  , top round;  top flat.

Seed crop data should be recorded in the proper space on the tree sheet as X, scanty; XX, moderate amount; XXX, abundant. Cone counts should be made on a certain number of trees whose position will permit segregation of the cones.

Vigor is determined from the size of the crown, density and color of foliage, form of top, length of internodes, color of bark, thickness of bark, thickness of annual layers in the bark, width and depth of bark fissures, size as related to age class, degree of dominance, freedom from injury and disease. No single item taken alone can be taken as an infallible indicator of vigor. Trees with pointed tops are usually vigorous, though slender crowned weak trees sometimes have pointed tops due to failure to develop normal side branches. Similarly flat or round topped trees are usually lacking in vigor, though open grown vigorous trees may have round or

flat tops resulting from excessive growth of side branches.

Under "Crown Class" the ordinary conception is assumed.

From time to time the note keeper should run through the series of numbers being worked and call the diameter man's attention to any trees missed. Rubber bands help as markers and save thumbing over completed series of sheets. At the end of each day the notes for all trees measured should be checked over so that missed trees can be located.

A special effort should be made to determine and record the cause in cases of death of trees.

General Plot Notes. At the time of establishment complete notes should be taken in the field describing existing conditions and what is done. For field and office use in future examinations a compact summary should be made including maps and photographs. The summary should show,

1. Forest, plot number, date established, and reexamination.
2. Location, how reached, where to stay while working, where supplies can be secured. Location of water.
3. Area, form, field notes, boundary marks, magnetic variation, elevation, aspect, slopes, situation.
4. Methods of securing data.
5. Date of cutting.
6. Method of cutting in detail, showing original stand by d.b.h. classes and stand cut and left. Distribution before and after cutting.
7. Type, percentage of species by volume board feet, original stand.
8. Treatment, method of logging, time and method of slash disposal, fire history, grazing history, origin of stand.
9. Site quality (based on 10% of highest trees in original stand), soil, rock, litter, humus.
10. Precipitation, mean annual. (Other climatic data if obtainable.)
11. Brush, percentage of area covered, species present; ground cover, give species if indicative of site quality, or if affecting growth or reproduction.
12. Reproduction, general summary of condition, distribution and degree of stocking. Notes on plots - original tally.

13. Last tag set; number of trees tagged, location of extra tags.
14. Time required for completion; crew; costs.
15. Photographs. Location. Purpose.
16. Maps.

Photographs. A few photographs should be taken from well considered points to illustrate conditions immediately before and after cutting and subsequent changes. To get satisfactory repeats the places must be marked on the ground and previous prints must be carried in the field. Photographs furnish valuable evidence of changes in reproduction, ground cover, etc.

The 3-1/4 X 5¹/₂ size camera is the most convenient and should be used in this study.

It is often necessary to take such pictures under adverse light conditions. An exposure meter lessens the number of failures. The ICA shaded disc type is better than most other meters.

Maps

Sketch Map. A generalized sketch map should be prepared showing the location of the plot with relation to the public land survey and roads by which it is reached. This large scale map may be placed in the margin or corner of the detailed map.

Detailed Map. The detailed map should be prepared after the trees have been tagged and the measurements completed. A scale of 1" to 30' is convenient for plots up to 10 acres in area. This map should show:

Bearings and length of boundaries; boundary stakes and witness trees with bearings and distances from stakes.

Reproduction or other sub-plots.

Tagged trees with species symbol and number. For D-5 species symbols are: WYP, • : JP, ◦ : SP, ▲ : DF, ◊ : WF, × : IC, ■ .

Stumps with species and diameters in inches.

Clumps of brush and reproduction.

Streams, roads, chutes and main skidding trails.

Slash piles; areas burned in slash disposal.

Large logs, or rock outcrops which exclude reproduction.

Location of photographs.

Direction and average slope in per cent.

Contour maps are usually not of sufficient value to justify the expense of taking elevations.

The detailed map can best be made as follows:

After the boundaries have been surveyed and staked, the plot is divided into squares by setting temporary lathe stakes at two chain intervals in two directions at right angles with a transit and tape. With a mapping radius of about a chain the minimum number of set-ups will be necessary if the first interior temporary stake is set one chain in each direction from one of the plot corners. The boundaries and temporary stakes are plotted on a sheet of mapping paper and this base is mounted on a planetable or traverse board. The plane table is set up over the first temporary interior stake in one corner of the plot and oriented by sighting along the rows of stakes. Two slender pins with large round glass heads make a good alidade. One pin is set at the point corresponding to the station occupied, the other being used to line in objects to be mapped. Distances are measured on the ground with a 100-foot tape and on the map with an engineer's scale, 1" to 30'.

If contours are desired vertical angles should be taken with the transit for the boundary and interior stakes.

Two men can map ten acres in this way in about five days, unless the plot has dense cover or is very rough.

It would hardly seem necessary to enumerate the items that should appear in the title of every map, yet there is scarcely a map made of this character which has a complete title. The title should show:

1. The project designation and title, plot number, name by which the plot is generally known, public land subdivision and the national forest.
2. The scale, contour interval (if any), north point, magnetic variation, area, instruments used, date of survey, name of surveyor, and legend.

Reproduction Sub-plots. The purpose of such plots is to furnish a periodic inventory of reproduction as an indication of progress in restocking. Such strips should not be expected to yield information as to the reasons for success or failure. They should be established before any cutting is done. A reexamination should be made following logging and again following slash disposal to get the percentage of the advance growth destroyed by these activities. Annual reexaminations should subsequently be made to follow the progress of restocking. Special note should be made if seedlings of the current year's germination are included in the tally.

Cutting analyses of enough seedlings to give average ages of the above size classes should be made on similar adjoining areas.

Extensive plots should be in the form of mechanically located strips 6.6 feet wide, the center line marked at the ends and at one chain intervals by good stakes. The center line of strips should be located with a transit; slope distances should be taken on steep ground. Errors should be thrown into the last chain length. It is essential that the end stakes be referenced in such a way that they can be accurately relocated if disturbed by logging. Intermediate stakes are referenced at intervals depending on the length of possible unobstructed sights. Referencing should be done by transit shots and accurate measurements from the stakes to small crosses chopped near the ground on two stumps or trees which will not be moved by yarding. If two stumps or trees can be found on opposite sides of the stake in such a position that a line between the crosses passes through the stake, then tape measurements only are necessary for relocation.

The tally is kept separate by chain lengths on special forms designed for this purpose. Each chain length should be described separately, giving the percentage of the area occupied by ground cover, rock, skidding trails, roads, slash piles, slash fires, logs, or other features affecting reproduction. The following symbols should be used:

Exposure, N, S, E, W.

Slope, Express in per cent.

Seed trees, Species, distance, direction: e.g., Y P - 100'S.

Light, XXX, open; XX, half shade; X, full shade.

Litter, O, none; X, scanty, less than $\frac{1}{2}$ inch deep;
XX, moderate, $\frac{1}{2}$ to 1 inch deep; XXX, deep, over
1 inch in depth.

Rock, Ground cover, and Brush as O, absent; X, scanty;
XX, moderate; XXX, abundant. In the case of brush
and ground cover give technical name and relative
abundance by species.

The strips are not mapped nor the seedlings tagged. The tally should be made by species and height classes, as follows:

0'- $\frac{1}{2}$ ', $\frac{1}{2}$ '-1', 1'-2', 2'-3', 3'-4', 4' in height to 3.5" in d.b.h.

Seedlings in squaw carpet or bear clover and in the open may be kept separate by using different tally marks. A stout cord to stretch between stakes along the center line, and a stick 6.6 feet long notched at 3.3 feet, are useful in examining these strips.

More intensive reproduction sub-plots should be established on Mc plots when the work of studying natural reproduction and methods of cutting can profitably be combined. The technique for intensive field study of natural reproduction has not been worked out in D-5 and can not be until a field station is available.

Cost of Field Work

Cost depends to a large extent on the amount of detailed mapping, the area and detail of reproduction sub-plots, the number of trees per acre, the character of the crew, amount of brush, and character of topography.

The Shasta plots, comprising 36 acres with about 3 acres of reproduction sub-plots, without detailed mapping, cost in 1911 about \$7.30 per acre for field work.

Remeasurement work is usually more cheaply done. In 1916, 116 acres were reexamined at a cost of \$9.15 per acre. In 1917, 60 acres were examined at a cost of \$7.07 per acre. In 1923 the Feather River plots, 51.2 acres with 6 reproduction plots, were reexamined at a cost of about \$5.40 per acre.

Compilation of Data for Mc Plots

In order to make reliable periodic comparisons it is essential that each set of field measurements be worked up in the same way. Four special Atlas size permanent record forms are provided for this purpose. A 4H pencil and plain engineering style of lettering should be used throughout. The data are entered and computed on the forms as follows:

1. Sort the individual tree sheets (Form 561) by species and one inch diameter classes. Sort each diameter class into crown classes. The diameters at the time of the first measurement serve as the basis for grouping and no subsequent rearrangements are made. Trees 3.6" to 4.5" are placed in the 4-inch class, those 4.6" to 5.5" in the 5-inch class, etc. Arrange numbers serially within the crown classes.

2. List the trees on Forms 562-A, using a separate series of sheets for each species. Record the species in one of the blanks in the upper left corner, not in Col. 2. Write the inch classes in large figures in the left margin at the beginning of each diameter class. Tree numbers only should appear in Column 1. List the X trees first, then the dominants, codominants, intermediates and suppressed. Leave two lines blank for totals and averages at the end of each crown class. Leave at least two additional lines after the last tree in the diameter class for diameter class totals and averages. Place the initials of the crown classes in the left hand margin of the sheet and the beginnings of the respective crown classes. Begin each diameter class at one of the heavy lines. Use separate sheets for the 4, 5, and 6-inch classes in order to provide room for new trees, which enter at subsequent examinations. If new trees appear at reexaminations which are more than 6 inches in d.b.h., it may be assumed that they were overlooked at a previous examination (if only 5 years have elapsed) and such trees should be grouped with the original trees or with the new trees of some previous examination, depending on which groups they most nearly correspond to in size.

Record notes and tree descriptions by symbols in Col. 6. (Basal areas are not entered for each tree.) For trees which die, write "Dead" in the proper date columns.

The blanks in the upper right corner of F-562-A, "Area" and "Location", and those at the middle of the bottom for volume tables need not be filled in.

3. Total the number, diameters, heights, and heights to base of crown for each inch class. Compute the average diameters, heights, and heights to base of crown. Obviously erroneous measurements, abnormal heights, broken or leaning trees, etc., are omitted in obtaining the averages. Enclose figures not used in circles. (For the present the averages of the crown classes will not be calculated for Mc plots, but the spaces are left for possible future use.)

4. Enter average board foot volumes for each inch class 12 inches and over to the nearest board foot in Col. 5. Interpolate tables to the nearest 0.1 inch in d.b.h. and 1 foot in height. Special volume tables are provided for Mc studies and these only should be used. (Copies attached).

5. Transfer to Form 562-B (one sheet for each species) by inch classes, the average diameters in Col. 1, average heights in Col. 2, total number of live trees in Col. 3, and number of dead trees in Col. 6. Enter new trees separately in the spaces provided near the bottom of the sheet. The few odd inch classes usually represented above 36 inches may be written in consecutively without spacing for the intervening diameters.

6. Calculate the total basal area in each inch class in Col. 4 to the nearest 0.1 sq. ft., using a basal area slide rule.

7. Calculate the total cubic foot volume for each inch class in Col. 5 to the nearest cubic foot. Special tables are provided for this purpose interpolated to 0.1 inch in diameter and one foot in height.

8. Total Columns 3, 4, 5 and 6 at the bottom of Form 562-B. In the line marked "Total" enter the total for the original trees only. In the next line total the new trees. In the third line total all trees.

9. On a separate work sheet calculate by diameter classes, the basal area, cubic feet, and board feet, for trees which died during the period. Use average dimensions of the trees in the inch classes to which the dead trees belong, at the beginning of the period in which the tree died. Place the totals in the proper spaces in the lower right corner. Express as per cent of total alive at the beginning of the period.

10. Board foot volumes are not entered by diameter classes on Form 562-B. The total board foot volume for each species should be obtained from the Form 562-A and entered to the nearest 10 board feet at the bottom of the Form 562-B. When the first measurements are worked up, the ratio of board feet per cubic foot is calculated for each species by dividing the total volume in board feet by the total volume in cubic feet of all trees 11.6 inches and over. Record this ratio at the bottom of Form 562-B. At subsequent examinations it is unnecessary to compute the board foot volumes by diameter classes. To obtain the total board foot volume, add to the total cubic foot volume of trees 12 inches and over the volume of those trees which have attained 11.6" in diameter since the last measurement, as shown by examination of the averages in the first 8 diameter classes. Multiply this sum by the board foot - cubic foot ratio entered at the bottom of Form 562-B.

11. Transfer the totals for all species from Form 562-B to the lower half of Form 563. Record species and plot totals in basal area to the nearest square foot, cubic feet to the nearest unit, board feet to the nearest ten. The headings on Form 563 are largely self-explanatory. In the upper right corner should be recorded the area of the plot in acres and the length of each period in years and fractions.

On Form 563 the number of trees per acre and basal area per acre should be expressed to one decimal, cubic feet per acre to the nearest foot, and board feet per acre to the nearest ten feet.

Under "Total increment" express basal area to the nearest sq. ft., cubic feet to the nearest foot, and board feet to the nearest ten feet.

Under "Annual increment per acre", express basal area to the nearest 0.01 sq. ft., cubic feet to the nearest 0.1 cu. ft., and board feet to the nearest foot.

Express all percentage values to one decimal except annual percentages at the right where two places should be used.

Compute the "Total increment" in basal area, cubic feet, and board feet, according to the following examples:

$$(B.A. 1915) - (B.A. 1910) = \text{Net increment basal area (B.A. I)}$$

Compute the "Annual increment per cent" as follows:

$$\frac{BA I}{BA 1910} \div 5 \text{ equals net periodic annual increment per cent.}$$

Each step in compilation work must be carefully checked.

Form 562-D is intended to indicate the condition of the stand. The principal causes of injury and death are written in the "Agent" column. In the six spaces under the date headings the following generalized diameter classes are written: 4-11, 12-17, 18-23, 24-29, 30-35 and 36+.

The data on injuries is obtained directly from the Forms 561. The cases of injury are first tallied in the proper spaces by the dot system and the figures representing the totals entered later. These figures should represent the number of cases, not the number of injured trees. Thus a tree with both a fire scar and a logging scar is tallied twice.

Much special information not provided by these forms must be computed on work sheets.

It is very instructive to summarize the gross or potential rate of growth for trees of various species, size classes and thrift classes. For this purpose the generalized diameter classes listed above are usually sufficient. The effect of entering new trees and death must be eliminated by including in the averages only those trees which were present at the beginning of a given period and survived throughout. Where a tree dies in a diameter class the average must be recomputed for those that survived.

Reproduction Data. In general data from strips or plots on Mc areas are intended to serve as inventories to check the progress of restocking or determine the extent of damage due to exploitation. For these purposes summaries on a unit acre basis in the classes provided for in the tally sheets will be sufficient.

Punched Card System. Unless a large mass of data are to be worked up and close supervision can be given the work by an experienced person, the punched card system will be found unsatisfactory. The only saving this system accomplishes is in the sorting and additions, a relatively minor part of the compilation if Forms 561 are used. The necessity of coding, card punching, verifying, and the difficulty of checking, more than offset these advantages. Furthermore, this system provides no complete copy of field records for future use, there is danger of loss of original field records in shipment, and additional time is lost in transportation and correspondence.

AREAS OF CIRCLES

Diameter Inches	Tenths of Inches									
	0	1	2	3	4	5	6	7	8	9
Area - Square Feet										
1	.006	.007	.008	.009	.011	.012	.014	.016	.018	.020
2	.022	.024	.026	.029	.031	.034	.037	.040	.043	.046
3	.049	.052	.056	.059	.063	.067	.071	.075	.079	.083
4	.087	.092	.096	.101	.106	.110	.115	.120	.126	.131
5	.136	.142	.147	.153	.159	.165	.171	.177	.183	.190
6	.196	.203	.210	.216	.223	.230	.238	.245	.252	.260
7	.267	.275	.283	.291	.299	.307	.315	.323	.332	.340
8	.349	.358	.367	.376	.385	.394	.403	.413	.422	.432
9	.442	.452	.462	.472	.482	.492	.503	.513	.524	.535
10	.545	.556	.567	.579	.590	.601	.613	.624	.636	.648
11	.660	.672	.684	.696	.709	.721	.734	.747	.759	.772
12	.785	.799	.812	.825	.839	.852	.866	.880	.894	.908
13	.922	.936	.950	.965	.979	.994	1.009	1.024	1.039	1.054
14	1.069	1.084	1.100	1.115	1.131	1.147	1.163	1.179	1.195	1.211
15	1.227	1.244	1.260	1.277	1.294	1.310	1.327	1.344	1.362	1.379
16	1.396	1.414	1.431	1.449	1.467	1.485	1.503	1.521	1.539	1.558
17	1.576	1.595	1.614	1.632	1.651	1.670	1.689	1.709	1.728	1.748
18	1.767	1.787	1.807	1.827	1.847	1.867	1.887	1.907	1.928	1.948
19	1.969	1.990	2.011	2.032	2.053	2.074	2.095	2.117	2.138	2.160
20	2.182	2.204	2.226	2.248	2.270	2.292	2.315	2.337	2.360	2.382
21	2.405	2.428	2.451	2.474	2.498	2.521	2.545	2.568	2.592	2.616
22	2.640	2.664	2.688	2.712	2.737	2.761	2.786	2.810	2.835	2.860
23	2.885	2.910	2.936	2.961	2.986	3.012	3.038	3.064	3.089	3.115
24	3.142	3.168	3.194	3.221	3.247	3.275	3.301	3.328	3.355	3.382
25	3.409	3.436	3.464	3.491	3.519	3.547	3.574	3.602	3.631	3.659
26	3.687	3.715	3.744	3.773	3.801	3.830	3.859	3.888	3.917	3.947
27	3.976	4.006	4.035	4.065	4.095	4.125	4.155	4.185	4.215	4.246
28	4.276	4.307	4.337	4.368	4.399	4.430	4.461	4.493	4.524	4.555
29	4.587	4.619	4.650	4.682	4.714	4.746	4.779	4.811	4.844	4.876
30	4.909	4.942	4.975	5.008	5.041	5.074	5.107	5.140	5.173	5.207
31	5.241	5.275	5.309	5.343	5.377	5.411	5.445	5.480	5.515	5.550
32	5.585	5.620	5.655	5.690	5.725	5.760	5.796	5.832	5.868	5.904
33	5.940	5.976	6.012	6.048	6.084	6.120	6.157	6.194	6.231	6.268
34	6.305	6.342	6.379	6.416	6.453	6.491	6.529	6.567	6.605	6.643
35	6.681	6.719	6.757	6.796	6.835	6.874	6.913	6.952	6.991	7.030
36	7.069	7.108	7.147	7.187	7.227	7.267	7.307	7.347	7.387	7.427
37	7.467	7.507	7.548	7.589	7.630	7.671	7.712	7.753	7.794	7.835
38	7.876	7.918	7.960	8.002	8.044	8.086	8.128	8.170	8.212	8.254
39	8.296	8.339	8.382	8.425	8.468	8.511	8.554	8.597	8.640	8.683
40	8.727	8.771	8.815	8.859	8.903	8.947	8.991	9.035	9.079	9.123
41	9.168	9.213	9.258	9.303	9.348	9.393	9.438	9.483	9.529	9.575
42	9.621	9.667	9.713	9.759	9.805	9.851	9.897	9.944	9.991	10.038
43	10.085	10.132	10.179	10.226	10.273	10.320	10.367	10.415	10.463	10.511
44	10.559	10.607	10.655	10.703	10.751	10.800	10.849	10.898	10.947	10.996
45	11.045	11.094	11.143	11.192	11.241	11.291	11.341	11.391	11.441	11.491
46	11.541	11.591	11.641	11.691	11.742	11.793	11.844	11.895	11.946	11.997
47	12.048	12.099	12.150	12.202	12.254	12.306	12.358	12.410	12.462	12.514
48	12.566	12.618	12.671	12.724	12.777	12.830	12.883	12.936	12.989	13.042
49	13.095	13.149	13.203	13.257	13.311	13.365	13.419	13.473	13.527	13.581
50	13.635	13.690	13.745	13.800	13.855	13.910	13.965	14.020	14.075	14.130
51	14.186	14.242	14.298	14.354	14.410	14.466	14.522	14.578	14.634	14.691
52	14.748	14.805	14.862	14.919	14.976	15.033	15.090	15.147	15.205	15.263
53	15.321	15.379	15.437	15.495	15.553	15.611	15.669	15.727	15.786	15.845
54	15.904	15.963	16.022	16.081	16.140	16.199	16.259	16.319	16.379	16.439
55	16.499	16.559	16.619	16.679	16.739	16.799	16.860	16.921	16.982	17.043
56	17.104	17.165	17.226	17.287	17.349	17.411	17.473	17.535	17.597	17.659
57	17.721	17.783	17.845	17.907	17.970	18.033	18.096	18.159	18.222	18.285
58	18.348	18.411	18.474	18.538	18.602	18.666	18.730	18.794	18.859	18.922
59	18.986	19.050	19.115	19.180	19.245	19.310	19.375	19.440	19.505	19.570
60	19.635									

Area of a circle in sq. ft. = D^2 in inches \times 0.00545424
 " " " " " " " " " " " " " " \times 0.021817-