PERMANENT SAMPLE PLOTS.

By Theodore S. Woolsey, Jr.

As early as 1906 the need for a systematic study of cut-over areas on the National Forests was keenly felt. It was impossible to predict to any degree of accuracy the net increment of the trees left after cutting, the height and diameter growth of individual trees, the death rate of some of the older trees nor was it possible to foretell the actual effect on reproduction and on the remaining stand of the different methods of marking, brush disposal, or grazing. Preliminary instructions were drawn up by the writer in co-operation with Mr. G. A. Pearson in 1909. These early instructions have since been amplified and amended chiefly through the efforts of Mr. Pearson and Mr. H. D. Burrall. While the exact methods cannot perhaps be applied directly to other parts of the United States, chiefly on account of the larger number of trees per acre, yet the instructions undoubtedly contain many points that will be of interest professionally. As issued on December 1, 1911 they are as follows:

The general object of these "intensive" reproduction plots is to secure accurate data along the following lines as a foundation for a system of management:

1. Actual increment in feet board measure or cubic feet.
2. Height and diameter growth of individual trees.
3. Death rate in different age classes.
4. Effect of the different degrees of cutting, methods of brush disposal, ground cover, soil, exposure, grazing, fires, insects, etc., upon seeding reproduction or the growth of individual trees.
5. Accurate photographic record to supplement paragraph 4.

LOCATION AND AREA.

Areas should be selected on which a timber sale has occurred not more than five years before the establishment of the plots. Where a sale area exhibits only slighly varying degrees of forest density, type, exposure and slope, reproduction plots covering five per cent. of the total area will usually suffice. In broken country or where the stand or types are irregular ten per cent. is often necessary. It is desirable that large plots of from 10 to 15 acres be established where one general density, exposure, type or slope would be included, otherwise areas of from 5 to 10 acres should be selected which embody a single feature. No plot of over 15 acres or under 5 acres should be established; the major dimension should not be more than 13 chains and the minor not less than 5.

Plots should be established and designated so that major plots can

include them, if necessary, in the future. Plots on the same section or those within one-half mile of each other, when not separated by private land, should be designated by the same major plot arabic numeral.

ESTABLISHMENT.

Withdrawal.—Formal withdrawal is usually not necessary* but the following form should be used in writing to the Ranger on whose district the plots are located.

Corners and Boundaries.—All corners** should be either of very durable wood or of some semi-durable species which has been seasoned for some time or creosoted. Forest Order No. 23, Part 4, should be followed with following changes:

In marking corners the letter "S" should be used instead of the letter "R", so as to indicate a silvicultural area. Each plot should be designated by a serial letter in addition to the arabic number of the major plot, i. e., the marking S-2-B-4 indicates corner number 4 of reproduction plot number B of major sample plot number 2.

All plot corners should be set 2 feet in the ground where possible; the smaller stakes should be driven in until firm.

MEASUREMENTS.

Diameter.—All merchantable species having an average diameter at breast height, outside the bark, of an even 4.0 inches or over should be measured and numbered. All stumps should be measured outside the bark and their diameters and location placed upon the map of the plot.

All trees whose crowns extend for at least half of their width into the plot should be measured and mapped.

All diameter measurements should be recorded to the nearest tenth of an inch, the first measurement being taken 4.5 feet from the ground or six inches above the copper nail with which the number tag is fastened, and the second taken at right angles to it; both figures should be recorded separately. Where a measurement can not be taken at breast height it should be taken at the nearest practical point above and below and an average obtained; where a fork occurs below breast height each fork should be numbered and recorded separately; where the fork is too high for this the main stem of the tree should be measured below and where the swelling (from the fork) is not appreciable. Care must be taken that swellings or small limbs are not measured on the opposite side of the tree from which the caliper man is standing. Notes should be made of any irregularities in the form of the tree which visibly affects the figures obtained such as large burns, deep scars, swellings, etc. In using the calipers they should be always held at right angles to the bole of the tree for both of the readings. The first diameter reading should be taken directly over the copper nail so that the trees diameter (at that point) divided by two will appear directly above the nail i. e., for a reading of 20 inches the 10 inch mark on the calipers should appear directly above the nail. The points 4′ and 4′ 6″ above the ground at which the number is placed and the diameted measurements are taken should always be measured, preferably with the 51 inch calipers.

Height.—All trees having a diameter breast high of 4 inches or over outside the bark should have their heights recorded with the Klaussner hypsometer; the distance from the tree to the instrument should in all

*Any conflicts with mineral locations, special or other uses, Forest Homestead applications, etc., should be avoided.

**Where the danger from fire is great the plot corners should be surrounded by large mounds of earth or rocks or both.

cases be measured with a steel tape.* In measuring leaning trees the hypsometer should be set for a horizontal distance measured from a point directly under the top of the tree and a note should be made in the individual tree records to that effect.

NUMBERING.

Nails.—Number 12, 6 d, copper nails should be used. They can be purchased upon application to the District Forester.**

The numbered metal tags are attached to the trees at four feet from the ground, or 6 inches below the diameter measurement, with the copper nail. On mature trees or those having a thick bark the nail should be driven in its entire length but on small growth or where the bark is thin they should be driven in to only about one-half inch from the head to allow for the growth of the next five years.

Tags.—The tags should always be placed on the same side of the trees for a single plot.

Both the common tin and zinc numbered tags have been tried in the field and found unsatisfactory, the former rusting badly and the latter turning white upon exposure to the air so that the numbers could hardly be read. The galvanized iron tags are the most satisfactory. These can be obtained upon application to the District Forester in accordance with the following specifications:

"Of first class galvanized iron, at least 16 gauge, rolled flat into discs of one and three-quarters inches in diameter, consecutive numbers one-half inch in height, from 1 to 5,000* to be deeply stamped on each tag one-half inch from the base, a hole one-eighth inch in diameter to be punched at the top of the tag at one-eighth inch from the outside edge; all tags to be wired with strong wire in bunches of one hnudred each, the bunches to be placed in consecutive order in a strong box and to be securely packed with excelsior or some other good packing material."

INDIVIDUAL TREE RECORDS.

Form 333, Valuation Survey Book should be used in keeping the records of the measurements of the trees on the plots. Each sheet should be marked with the reproduction plot number, the Forest, the date, and the serial page number. The following data are to be recorded:

1. Consecutive tree number.
2. Species.
3. D. B. H. two measurements.
4. Height in feet to base of crown.
5. Height of tree in feet.
6*. Volume in feet board measure or cubic feet.
7. Health of tree.
8. Description of the length, width, vigor and top of crown.
9. Damage to the tree or crown by insects, fires, etc.
10. Seeding of tree at time of measurement.

1. Use consecutive numbers on those Forests which are measured in one season. No numbers over 5,000 should be used because of the large space taken up by them in mapping and the making of tree records.

2. The distinction between "yellow pine" with its light colored bark and high form factor and "black jack" with its dark bark and lower form factor should be used in these records. Where a tree has begun to form

*By fastening a wooden handle on the 100 foot steel band tape it has proved to be the best for this work.

**Cost about 25 cents per pound.

*Cost $2.90 per M. in lots of 50 M.

*Computed in the office.

light colored flakes on at least one side, the tree should be classed as a yellow pine.

3. The diameter taken first, whether on the south, north, east or west side of the tree, should be just over the numbered tag; the second measurement taken at right angles to this should be entered above it in the records. An explanation of this fact should appear on the first page of the typewritten sheets of each plot. The numbers on all plots, up to the present time, have been placed on the south side of all trees; they should always be placed on one side of the trees for a single plot.

4. In many instances the first live limb on a tree is not indicative of the height of the base of the crown from the ground; in such instances the base of the crown should be taken and not the limb. This measurement should be taken with the hypsometer, except where the limb is very close to the ground, and the reduction from the instrument reading in meters be made later on in the office rather than in the field at the time the measurement is taken.

5. This should be reduced from the field reading in meters to feet in the office, like the clear length reading. In the Klaussner hypsometer the screws controlling the horizontal movement of the sliding weighted upright should be kept tight since in using a 100 foot tape the horizontal distance has to be changed only at long intervals for trees over 100 feet or under 50 feet high. The measured horizontal distance should always be as much as the height of the tree.

6. In ascertaining the volume of the trees by volume tables interpolations must often be made to include the smaller or larger growth; a record should be made of these in the typewritten copies of the reports. Wherever possible tables should be used in which the volume is based on both D. B. H. and total height of tree. Where cubic feet tables for different heights and diameters are available for all of the species on a plot the contents should be ascertained by this method also.

8. The following classification has been used under this heading:

A. Length—long, medium or short.
B. Breadth—broad, medium or narrow.
C. Vigor—full, medium, narrow or one-sided.
D. Top—pointed, medium or flat.

MAPPING.

Reproduction Plots.—Stakes 2" x 2" x 18"* should be set a distance of one chain (66 feet) apart when the outside lines of the plot are run out and also in the division of the plot into squares measuring one chain each way. After the outside lines have been run a start is made at one of the small stakes and a line of stakes set across the small dimension of the plot at intervals of one chain. The stakes can be lined in with a Forest Service compass where the distance does not exceed 5 or 6 chains; for longer distances a telescope sight should be used on the compass. In western yellow pine ordinarily a scale of one inch to the chain should be used in mapping in the field; where the growth is dense a scale of 4 inches to the chain can be used.

A traverse board 16" square should be set up over a stake one chain in each direction from a corner of the reproduction plot, on this board a sheet of mapping paper ruled four squares to the inch should be fastened with thumb tacks.* The map should be orientated by sighting with a Forest Service compass on one of the nearby stakes (it is preferable that a stake be used for this purpose which was set in line from two stakes on opposite sides of the plot and not one which was set by measuring along).

*Stakes should be 24" long where the ground is soft.

*It is advisable to place heavy paper beneath sheet to avoid pricking through with the hard pencil.

When the board has been orientated all the features to be mapped can be located from this set up for the four surrounding squares. The pacing should be carefully done and figured to the nearest link. When a tree or other feature is near the set up it should be paced to from that point otherwise the stakes bounding the surrounding squares can be used and the number of links, north, south, east, or west to the object can be given. If a scale of one inch to the chain is used the entire plot can be mapped on one sheet, if a larger scale is used the map will have to be divided into two or more parts; a 6 or 7 H pencil should be used. After all of the four squares have been mapped from a single set-up the traverse board is moved two chains in any direction within the plot; the board orientated and that set-up mapped. Where a plot is an odd number of chains in width a strip 3 chains in width will, of course, have to be mapped from one of the lines of set-ups.

The following features should appear on the map:

1. Corners and winesses.
2. All trees (of commercial species) over 4 inches in diameter breast high outside bark with appropriate symbols (where the tree species are not too numerous) and their corresponding numbers.
3. Seedlings over one foot in height and over 15 feet apart as individuals and with appropriate symbol.
4. Seedlings over one foot in height, between 8 and 15 feet apart as groups of fair reproduction indicated by a symbol.
5. Seedlings over one foot in height, less than 8 feet apart, as groups of good reproduction, indicated by a symbol.
6. Brush piles, burned or unburned, burned or scattered brush, all indicated by separate symbols. Down trees, similarly.
7. Seedling count strips or plots.
8. Contours, roads, fire lines, drainage, etc.
9. Prevailing wind direction.
10. Area of plot.
11. Local compass variation.
12. Stumps with corresponding diameters, outside bark. Each species should be mapped separately.
13. Legend.
14. Areas covered with brush or non-commercial species. In some instances where tree growth is dense this has to be made on a separate map.
15. Location and direction of photographs taken.

Seedling Count Strips.—Strips five feet (or 8 links) in width should be laid out across the major dimension of each reproduction plot and all of the growth located and measured; such a strip includes about 8% of the total plot area. By making the length of these strips 33 feet only 3 additional stakes are needed to mark their boundaries on each one-chain square and a 50 foot tape can be used for the locations; if the seedlings are not dense a strip 66 feet long can be measured with a 100 foot tape. It is preferable to make notes of the size, species and location of each seedling, including those one year old. All growth, including one year seedlings, should be mapped to the nearest tenth of a foot two ways from a stake and their height taken to the nearest inch.

Injuries to seedling from browsing of stock should be noted in every case.

Where seedlings were fairly common a scale of 4/10 inch to 1 foot has been used but in most instances a scale of 8/10 inch to 1 foot will be found satisfactory. In making the map in the office from the field notes, a piece of co-ordinate paper (ruled 10 squares to the inch) will aid materially in plotting positions of objects on the tracing line.

PERSONNEL.

The crew should consist of three men preferably all with technical training. The work on the plots should be divided and done in the following order.

1. Surveying. Placing the large corner posts and the stakes along the outside lines. Any small error in closure on the last line should be proportioned between all of the stakes on that line; where the error of closure is over 1 in 100 the lines should be re-run. After the outside lines have been adjusted the stakes across the narrow side of the plot should be set sub-dividing the area into one chain squares.
2. Measurements of individual trees. One man should place the numbers on the trees and do the calipering, the second man taking the heights and the man in charge writing the data as they are given to him and writing the trees description and health.
3. Mapping. The man in charge of the party should do the mapping with the traverse board while the two assistants locate the various features by pacing.
4. Contours. These should be mapped last since the position of the trees, brush piles, etc., greatly assists in their location on the map. Unless the topography is unusually steep, a 5-foot contour interval should be used.
5. Seedling counts. These can be made after the one chain squares have been established.
6. Reports. The reports should be made after all of the other work on the plots (including the photographing) has been done, usually in the field.

PHOTOGRAPHS.

In making a photographic study of the plots at the time of measurement it must be understood that these photographs show the condition of the plot only during its dormant period and another series should be made during the growing period.

OUTLINE FOR REPRODUCTION PLOT REPORT.

1. *Date Established.*
   Sale Area. Name and date in designation; when closed.
2. *Location.*
   Section, township, range, meridian. Field notes of boundaries. Field notes of tie into nearest land corner. Discrepancy in local variation. Order of setting one chain stakes. Stakes out of line.
3. *Withdrawal.*
   Copy of Supervisor's letter to District Ranger.
4. *Fire Protection.*
   Copy of suggestions to Supervisor embodying (a) size of burned strip. (b) inform District Forester of any accidental fires that occur with their location on blue print map of plot, with date and intensity.
5. *Area.*
   Acres. Dimensions.
6. *Elevation.*
   Relative and above sea level.
7. *Topography.*
8. *Soil.*
9. *Exposure.*
   Protection from winds, character of surrounding lands, private, Government, cut-over or virgin.
10. *The Forest.*
    a. *Original stand,* composition, relative importance of species.
    b. *Cutting,* date and character, brush disposal, etc.
    c. *Remaining stand,* composition, density, occurrence.

Reproduction, density, occurrence, size, age, rate of growth, health.
d. *Seed crop* (periodicity of seed years). An accurate record of the seed crop of each tree on each plot should be kept by the local Forest Assistant.
Underbrush.
Ground cover.

11. *Damage.*
    a. Fire, date, intensity, character, amount of damage.
    b. Grazing, period, kind, effect on ground cover and reproduction.
    c. Disease, fungus, mistletoe.
    d. Insects, lightning, etc.
12. *Method of Work.*
    a. Date of instructions, followed with modifications.
    b. Personnel of party with names, salaries and dates worked.
    c. Instruments used.
13. *List of Photographs.*
14. *Cost.*
    Include salaries, subsistence for days actually worked on plot. Include stakes and other material.
15. *Record of trees.*
    a. Total number with inclusive numbers.
    b. Lists of trees and shrubs
16. *Seedling or tree growth tables* or curves made on the same forest.

OUTLINE FOR SEEDLING COUNT STRIP REPORT.

1. Consecutive strip number.
2. Slope and exposure.
3. Shading on east, southeast, south, and southwest, overhead shading.
4. Nearby seed trees.
5. Litter, rock, soil, brush.

OFFICE WORK.

Six typewritten copies (on thin white paper) should be made.
1. Original and one carbon to Supervisor of Forest.
2. Two carbons to District Forester.
3. Two extra carbons.

The following copies of maps should be made:
1. Original (on tracing linen) and two blue prints to District Forester.
2. Two blue prints to Forester Supervisor.

MISCELLANEOUS.

Thin white paper 8 x 9½ inches should be used; the last dimension should be parallel with the platen of the typewriter.

All original notes, maps, and records should be placed in the files of the Supervisor on which the plots are established.

All records should be twice checked for errors.