Instructions

▲ Keep this sheet for your records.

Forestry Suppliers, Inc.
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Using Forest Densiometers

No. 43887
Spherical Convex Densiometer

No. 43888
Spherical Concave Densiometer

Originally developed and published by Dr. Paul E. Lemmon, the Spherical Densiometer is designed for rugged field use while remaining compact and lightweight for ease of transport. This instrument has been extensively tested by numerous foresters and forestry technicians on stands of ponderosa pine, lodgepole pine and Douglas fir.

History

The pioneering work was done mainly in the Pacific Northwest; however, subsequently the instrument has been used for measuring overstory density throughout the U.S. and internationally. The original methodology was developed to characterize and quantify canopy density for representative forest sites where numerous parameters such as tree size (height, girth, age and growth rates), tree spacing, soil type, slope and slope orientation, elevation and others were determined.

Reading Canopy Areas

The spherical densiometer consists of either a concave or a convex mirror with twenty-four ¼″ squares engraved on the surface. The design is such that the operator views the same degree of arc overhead regardless if the user is in a low lying canopy area or a mature stand of high canopy timber.

Each square of the grid is then equally sub-divided mentally into 4 smaller squares (⅛″ x ⅛″) and represented by an imaginary dot in the center of each of the smaller squares. Thus a total of 96 dots representing smaller square areas can then be counted within the grid. Once the representative forest site has been selected for measurement, the user holds the instrument level and far enough away from his/her body such that the operator's head is just outside the grid. The operator can then count the number of dots, representing the smaller (⅛″ x ⅛″) square areas of canopy openings, up to a total of 96. The number determined is then multiplied by 1.04 to obtain the percent of overhead area *not* occupied by canopy. The difference between this percentage and 100% is the estimated overstory density in percent.

Four readings are taken about a reference tree in each site area and averaged. The operator should be positioned with his/her back toward the reference tree, and moving about the reference tree facing North, East, South and West.

"The reference tree in each site represents a typical dominant or co-dominant species in the stand. The points selected around each reference tree should be far enough away (from the reference tree) so that the crown of the reference tree is just outside the overstory area being estimated" (Lemmon, 1956).

The statistical accuracy and repeatability of the instrument is based on taking four readings, using up to 96 dots representing the smaller (⅛″ x ⅛″) squares for up to a total of 384 smaller squares per site (96 x 4), and then averaging all four readings at the different orientations about the reference tree. Obviously, in a forest environment, you will be counting considerably less than 9 dots representing the smaller squares, so the exercise is a lot less laborious than it might first appear. The denser the overstory canopy, the fewer dots you will have to count since you are counting the ⅛″ x ⅛″ areas in which you can see sky in the major portion of each of the smaller squares. With a little practice, you will find that the data can be gathered quickly and with repeatability using the same or different operators.

In open forest where more than half of the canopy area is open to the sky, you can reverse the process and count just the smaller square areas (⅛″ x ⅛″) that are covered by the canopy and multiply by 1.04 to obtain the estimated overstory density percentage.

Reference: Lemmon, Paul E., 1956, A Spherical Densiometer for Estimating Forest Overstory Density; Forest Science 2(4)314-320.
Lemmon, Paul E., 1957, A New Instrument for Measuring Forest Overstory Density; Journal of Forestry 55(9)667-668. 236501.LET

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A New Instrument for Measuring Forest Overstory Density[1]

A new instrument called a "spherical densiometer" has been described for estimating forest overstory density.[2] This pocket-type instrument employs a mirror with spherical curvature which makes possible the reflection of a large overhead area. A grid is used to estimate percentage of this overhead area covered with forest canopy. Estimation is usually from a point near the forest floor. Adequate sampling gives the average canopy of a forest area.

Two models, A and B (Figures 1 and 2), have been adopted as standard. Each employs a highly polished chrome mirror 2½ inches in diameter and having the curvature of a 6 inch sphere. The convex side of the mirror is used in MODEL A and the concave side in MODEL B. Each has some advantages over the other.

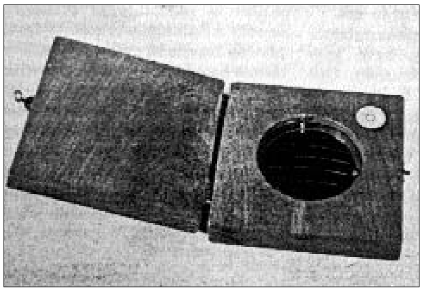


Figure 1
Spherical densiometer, Model A, with estimating grid scratched on the surface of the convex mirror

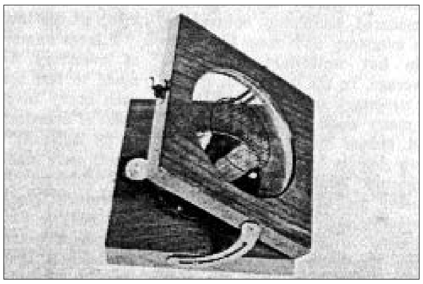


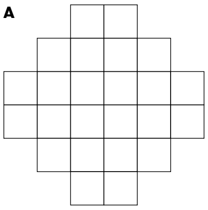
Figure 2
Spherical densiometer, Model B, with estimating grid superimposed between the eye and surface of the concave mirror.

The mirrors are mounted in small wooden recessed boxes with hinged lids similar to compass boxes. The overall dimensions are about 3½ x 3½ x 1⅛ inches. A circular spirit level is mounted (recessed) beside the mirrors. Positive slide fasteners are provided in MODEL B which allow the lid to open to an angle of about 45 degrees.

Cross-shaped and circular grids with squares and dots are used to estimate overstory coverage by tree crowns. Grids are of two kinds: (1) those scratched upon the surface of the mirror (MODEL A), and (2) those superimposed between the mirror and the eye (MODEL B).

The cross-shaped grid scratched upon the convex surface of the mirror in MODEL A has 24 quarter-inch squares (Figure 3A). Instructions for using the densiometer and cumulative values for the squares on the grid are shown on a chart that is attached to the inside of the box lid (Figure 3B). It is easier and faster to estimate the relative amount of overstory coverage with this instrument by assuming the presence of four equi-spaced dots in each square and by counting dots representing openings in the canopy. The percentage of overstory density is then assumed to be the complement of this number. Each assumed dot is assigned a value of one percent in this case. A slight discrepancy exists between estimations using the squares and estimations by counting assumed dots, because there are only 96 dots in the entire grid area. Cumulative values of the squares shown in the chart add up to 100 percent for the entire area within the grid. If desired, one may calculate the exact percentage values for each assumed dot and thereby make the two methods of use exactly comparable.

A



B

SPHERICAL DENSIOMETER
FOR ESTIMATING
FOREST OVERSTORY DENSITY
INSTRUCTIONS
Hold instrument level and so that operator's head is just outside of grid. Estimate totol number of squares that are not occupied by overstory conopy. The complement of this represents overstory density. Make four readings per location facing North, East, South and West. Record and average. Cumulative values for the squares on grid are

NO. OF SQUARES	AREA IN PERCENT NOT OCC.	OCC.	NO. OF SQUARES	AREA IN PERCENT NOT OCC.	OCC.
1	4	96	13	54	46
2	8	92	14	58	42
3	13	87	15	63	37
4	17	83	16	67	33
5	21	79	17	71	29
6	25	75	18	72	25
7	29	71	19	79	21
8	33	67	20	83	17
9	38	62	21	86	12
10	42	58	22	92	8
11	46	54	23	96	4
12	50	50	24	100	0

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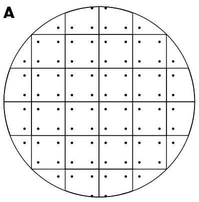
Figure 3
(A) Cross-shaped grid scratched on the convex surface of the mirror in Model A. Each square is 1/4 inch on a side. (B) Instructions for using Model A. This is fastened to the inside of the lid of the mounting box.

A



B

SPHERICAL DENSIOMETER
FOR ESTIMATING
FOREST OVERSTORY DENSITY
INSTRUCTIONS

Hold instrument with both hands, about 12" in front of body, and at elbow height. Press elbows against sides of body for more rigid support. Have lid open as far as it will go facing away from operator. Center grid (with instrument level) on the mirror by looking through plastic window with one eye closed. Estimate overstory canopy by counting dots repreenting non-occupied areas. Each dot represents approximately one percent of the grid area. Make four readings per location facing North, Wast, South and West. Record and average.

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Figure 4
(A) Circular grid superimposed between the eye and the concave mirror in Model B. Each square is 1/4 inch on a side. (B) Instructions for using Model B. This is fastened to the bottom of the mounting box.

MODEL B has a circular grid. The circle is 1½ inches in diameter superimposed over quarter-inch squares. Each square has four equispaced dots (Figure 4A). This grid is made from a positive print of a photographic film mounted between thin sheets of plexiglass and fitted into the window of the box lid. Instructions for operating MODEL B are given on a chart mounted on the bottom of the instrument box (Figure 4B). The operator estimates overstory density by counting the dots representing overstory openings and assuming this to represent the percentage of non covered overstory area. Here again a slight discrepancy exists because there are only 96 dots included within the area of the circular grid. Exact percentage values for each dot may be calculated to estimate the entire circular area as 100 percent. This refinement is not considered necessary for ordinary use of the instrument.

Instruments can be developed with different kinds, sizes, and shapes of grids and with mirrors of different curvatures. However, standardization of these properties is necessary to provide comparable information that can be duplicated. The instruments described have been thoroughly tested and have given satisfactory results with most western conifers. We believe the spherical densiometer described (either MODEL A or B) will serve the needs of practicing forester, range conservationist, and plant ecologist or those of most scientists doing highly technical work.

Operators need a little training to become consistent in the use of the instrument. Judgment and experience is needed to differentiate between overstory areas that are considered completely covered by the overstory and those that have thin but uniformly distributed coverage. In the latter case it may be necessary to estimate the area of many small irregular openings and reduce the percentage overstory density by the sum of these. Training and experience are needed for each different forest species or type because of the differences in overstory characteristics. The season of the year is important when making measurements in forests containing deciduous species.

Experience has shown that sufficient accuracy can be attained with the spherical densiometer by holding it as nearly level as possible in the hand. This is made possible by installing a circular spirit level in the mounting box. No mechanical support, such as a tripod, is needed. This adds to the practicability of the instrument in use.

A large number of measurements of overstory density have been made to test the instrument. One such study involved the measurement of overstory density at points in 28 different forests. Measurements were made at each point by four different operators each using instrument MODEL A and MODEL B. The results were subjected to an analysis of variance to determine consistency of measurements. There were no significant differences among measurements made by different operators or with different instruments and none of the interactions were significant. The differences due to forests, however, were highly significant-above the 99 percent level of probability. Under similar conditions one can expect variations in overstory density measurements to be within ±1.3 percent, ±2.4 percent, and ±3.1 percent at probability levels of 70, 95, and 99 percent respectively. These variations amount to about 2, 3, and 4 percent when the standard deviation is expressed in terms of the overstory at the point of measurement (coefficient of variation).

Another study involved placement of 416 different forest overstory measurements into 5 percent overstory density classes. Variation around the mean within each class was calculated and the standard deviations and coefficients of variation plotted against the overstory density classes. It was found that variation among measurements increased as the overstory being measured decreased only slightly when overstory density decreased from 100 down to about 60 percent but rapidly thereafter. When placing overstory density into 5 percent classes with the spherical densiometer, reliability in the order of about 5 percent can be expected so long as one is measuring forests that have more than about 50 percent overhead canopy. Since one naturally estimates percentage of overstory area not covered in dense forests and overstory area covered in open forests, estimations of overstory density when placed in classes will seldom vary more than ±5 percent.

Loss in reliability of overstory density measurements results from placing forests in overstory density classes based on measurements with the spherical densiometer as contrasted with using the actual measurements. For instance, reliability of about ±1.3 percent can be attained when actual measurements are used whereas the reliability is reduced to about 5 percent when classes are used.

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[1] Editor's note: At the request of the author the reader's attention is called to the commercial availability of this instrument.

[2] Lemon, Paul E. 1956. A Spherical Densiometer For Estimating Forest Overstory Density. Forest Sci. 2:314-320.