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USE OF THE DENSIOMETER TO ESTIMATE DENSITY OF FOREST CANOPY ON PERMANENT SAMPLE PLOTS

by

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An instrument known as the spherical densiometer[1/] has been found adaptable to permanent-plot estimates of relative canopy closure or density in forest and range ecological studies. The device is more compact and simpler to use than previous ocular-type instruments. Because the instrument has a curved reflecting surface which results in observations from lateral as well as overhead positions, a problem of overlap in readings occurs when adaptation of the densiometer to permanent-plot work is attempted. Some modifications were developed to eliminate this difficulty.

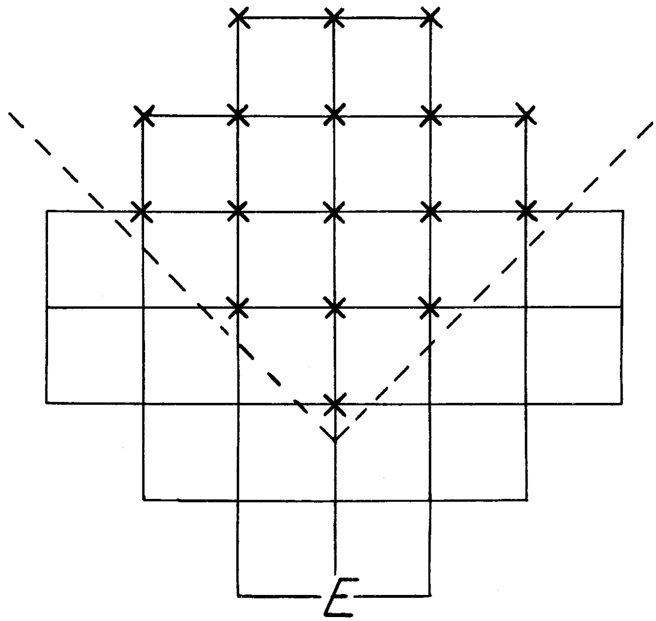
As ordinarily used, the densiometer is held in the hand and canopy density is estimated by counting how many of 96 dots on a mirrored grid are covered by the image of the canopy. The observer makes one reading in each of the four cardinal directions, with each reading made at a point 15 to 20 feet from the plot center to prevent duplication of the canopy area being observed. Exact distance from the center depends on height of the stand. The four readings are then totaled and averaged for the sample density. During each observation, the observer tries to (1) hold the instrument level, (2) keep it oriented in the desired direction, and (3) hold a certain viewing angle so as to prevent parallax of the reflection angle between the eye and the mirror.

1/ Lemmon, Paul E. A spherical densiometer for estimating forest overstory density. Forest Sci. 2: 314-320, illus. 1956.

In permanent-plot work, four observations are made over a staked location, and accurate duplication of the observer's procedure must be assured. This presents some mechanical problems and introduces a new problem in technique--overlap of canopy area read. When the customary 96 dots (4 simulated dots equally spaced within each of 24 grid squares) are used for each directional observation, the curved surface of the mirror reflects some canopy image from back and to the side of the observer--an amount of image that is outside the 90 degrees arc-area necessary when observing from a permanent point. Tests showed that approximately 42, 4, and 20 of 96 dots observed in any one direction would be observed twice, three times, and five times respectively in the other three directional observations. Thus, point or plot averages in many instances would tend to be higher than the true relative value.

This problem can be overcome by estimating from 17 points in a wedge-shaped area of the densiometer grid for each directional measurement (fig. 1). The technique is to record the number of points in this area that are covered by the mirrored image of the canopy. Each point has a value of 6 percent in calculating directional densities, and 1.5 percent when calculating average plot density. A slight error exists, since complete coverage would result in 102 percent density. However, this discrepancy is not considered important for comparison of relative values. For those interested in percentiles, 1 percent can be removed from totals between 30 and 60 percent, and 2 percent removed for those over 66 percent. For plot averages, the total of points from the four readings are multiplied by 1.5 and the correction percentage removed, i.e., (7+8+10+7)(1.5) = 48, subtract 1 percent = 47 percent density.

Use of the wedge-shaped area permits calculation of an average density value that is not biased by point duplication, and results in an eye position that is easier to maintain and standardize. In addition, a replacement is not required for the standard reflecting mirror. Estimating from the 17 points, distinctly formed within the wedge-shaped area by the intersecting grid lines, requires less effort, time, and confusion than when estimating from simulated dots.



X Observation point

E Standard position of eye reflection

Limit of wedge-shaped area

Figure 1.--Grid of Model A spherical densiometer, showing the 17 points of observation and the position of eye reflection when a directional reading is made. Canopy reflected in the wedge area within the dotted lines is not duplicated in subsequent directional readings.

An important mechanical modification involves use of a light tripod and panhead to provide a steady, level support for the densiometer (fig. 2). Because of natural body movement, it is difficult to keep a hand-held instrument level and oriented and prevent parallax while counting points on the mirror. This difficulty, combined with the need for keeping the instrument centered and steady over a staked location, makes use of the tripod necessary.

The box (tripod adapter) in which the densiometer rests is attached to the tripod with the tightening bolt in the panhead. With the tripod centered over the plot, the densiometer can be raised to the desired height, oriented, and leveled in a very short time.

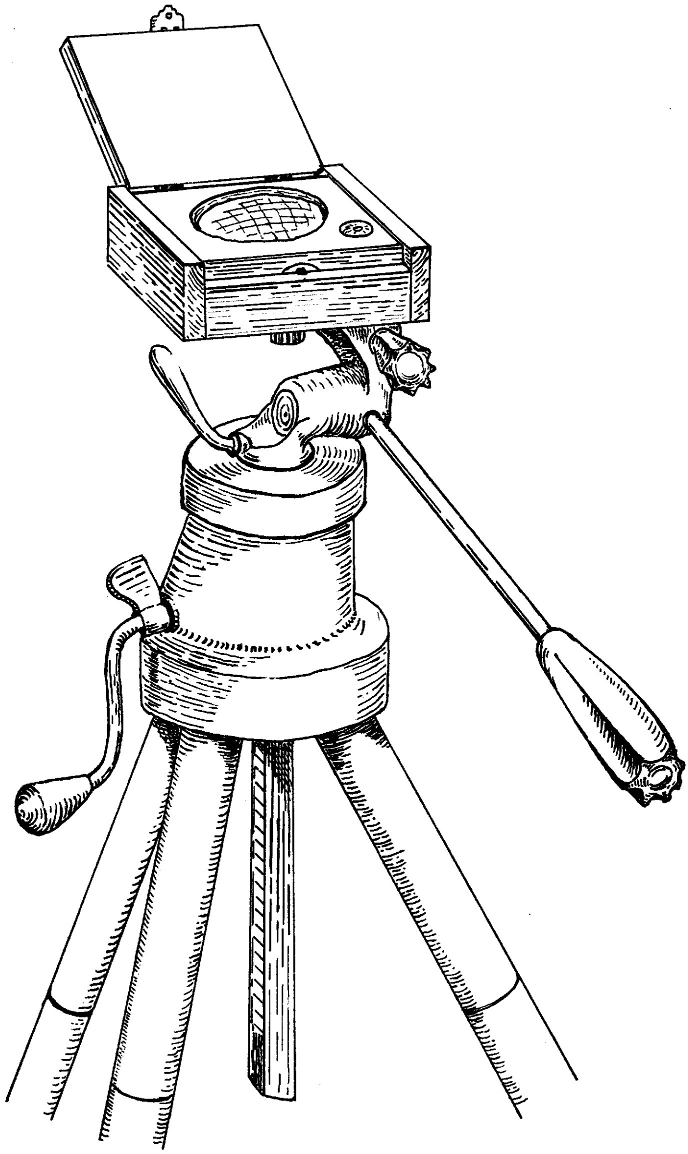


Figure 2.--Type of tripod used to provide support for the densiometer. A threaded nut, embedded in the bottom of the adapter box, secures the box to the tripod.

Accuracy in cardinal directions is easily obtained by aligning a pocket-type compass on the face of the densiometer and rotating the panhead to the desired direction. Once the instrument is set, the observer stands in the four positions around the densiometer and counts the points covered.

These modifications were tested by two men on seven clusters of four plots each in ponderosa pine–Douglas-fir stands. Average canopy densities of plots ranged from 23 to 87 percent. One man, new to both densiometer and method, received 15 minutes of instruction. Each man set up the tripod on each plot and kept his own records. An analysis of variance of plot means showed a significant difference between relative canopy densities for both plots and clusters. Differences greater than 11 percent density between plots and 15 percent between clusters were significant at the 95-percent level. Differences between men were not significant, with a standard deviation between man means of 4.2 percent.

Observation time by an experienced observer averaged 7 minutes per cluster (16 directional estimates) using the new method. This included the time required to set up the tripod for each plot. Using the tripod, but estimating from 96 dots, required a little over 14 minutes per cluster.

With the mechanical and technique changes described here, the spherical densiometer was found to be a sufficiently accurate and useful instrument for permanent-plot work. Further investigation by forest and range ecologists to determine the value of lateral coverage as a parameter of forest stands would be desirable. Yet workers interested in canopy densities should find the instrument a welcome addition to range and forest inventory tools.