Screenometer: a device for sampling vegetative screening in forested areas

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A device for estimating the degree to which vegetation and other obstructions screen forested areas has been adapted to an extensive sampling design for forest surveys. Procedures are recommended to assure that uniform measurements can be made. Examination of sources of sampling variation (observers, points within sampled locations, series of observations within points, and sectors within series) and sampling intensity suggests a sample design which involves a combination of points and sectors.

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Un appareil fait pour estimer le degré de couverture de la végétation forestière a été adapté à des fins de sondage extensif lors des inventaires forestiers. On recommande des façons d'opérer pour assurer une procédure uniforme. L'examen des sources possibles de variation au cours du sondage (observateurs, points de sondage, séries de mesures à chaque point et secteurs correspondant aux séries), de même que l'intensité du sondage suggèrent d'employer une procédure simple impliquant un mélange de points et de secteurs.

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Introduction

Periodic surveys are conducted by public forestry agencies and private industries to assess the current and prospective status of timber on forest land. Since the 1930's, field information on timber resources has been gathered by the United States Forest Service's Forest Inventory and Analysis (FIA) Units (formerly Forest Survey) largely from extensive sample measurements made at forested locations. With the passage of the Forest and Rangeland Renewable Resources Planning Act (RPA) in 1974, the scope of the survey has been broadened to include assessments of dispersed recreation resources along with wildlife, range, and timber resources.

Techniques to measure nontimber resource characteristics that are compatible with ongoing field surveys of timber resources are needed. To be effective in field surveys, procedures need to be easily conducted by a technician with a minimum of training and supervision. An estimate should be accurate, capable of verification, cost effective, and yet sensitive to important resource variation. Optimum sample size relative to a given level of precision and cost is an important consideration.

A technique to estimate vegetative screening is the focus of this paper. Screening is defined as the percentage of surrounding terrain that is obscured, or nearly so, when viewed parallel to the prevailing ground surface. Screening is an important forest characteristic used to quantify visual depth, aesthetics, and recreation user preferences (Hancock 1973) and to compute vegetation profiles and hiding cover for wildlife habitat assessments (Hays et al. 1981). When assessing burning, grazing, or other man-induced disturbances in surveys of timberland, screening estimates provide quantitative measures of understory vegetation not removed by these activities.

Density boards and photographs have been suggested as devices to quantify vegetative screening (Hays et al. 1981, p. 316). However, neither are appropriate for an extensive sampling design. The measurement of vegetative screening with density boards requires numerous measurements and movement of bulky field equipment. Photographs are costly to obtain.

Nord and Magill (1963) describe a simple hand-held device and procedures for estimating vegetative screening and other obstructions to vision in forest campgrounds. Though no statistical information was presented, Nord and Magill (1963) stated that the difference in screening estimates between observers was rarely more than 5%. The device and procedures have been used to make assessments regarding temporal and physical changes in screening at campgrounds (Hancock 1973; Magill 1970).

The device, a screenometer, is a Plexiglas viewpiece 19 × 5 cm (7.5 × 2 in.) in size that is etched so that each segment represents 10% of the viewing area. The device is used as a scale to assess the degree of screening that obscures visibility at eye level (approximately 1.7 m (5.5 ft)) outward to a distance of 15.2 m (50 ft). When placed 35.5 cm (14 in.) from the observer, the screenometer defines the viewing area which represents a 30° sector of a circle (Fig. 1).

Modifications are presented here to reduce differences in interpretation, increase the potential for verification, and limit field time. Sampling intensity and a sample design are discussed for use in extensive surveys of timberland.

Methods

The screenometer used in this study was reproduced from specifications described by Nord and Magill (1963). The device was constructed of materials readily available in a hardware store, i.e., a Plexiglas viewpiece attached to a dowel rod with a screw and wing nut.[2]

Six forest stand locations (plots) were selected in June 1980 from contiguous forest stands in Fountainbleau State Park, Louisiana, and along Interstate No. 10 in Hancock County, Mississippi. The locations were chosen to represent the range of screening conditions likely to occur on timberland and were assessed ocularly as follows:

Location No.	Description
1	Very dense screening, seedling–sapling stand
2	Dense screening, pole-timber–saw-timber stand
3	Moderate screening, pole-timber–saw-timber stand
4	Moderate screening, saw-timber stand
5	Limited screening, sapling–pole-timber stand
6	Very limited screening, saw-timber stand

Locations 1 and 2 are in a relatively unmanaged and infrequently burned area along Interstate No. 10. Location 5 is in a managed area adjacent to picnic facilities (Mississippi Welcome Station). Locations 3, 4, and 6 are in Fontainbleau State Park. Stand size was defined by the diameter at breast height of the majority of trees on the plot: seedlings, <2.5 cm (<1 in.); saplings, 2.5–12.5 cm (1–5 in.); pole timber, 13.0–25.0 cm (5–10 in.); sawtimber, >25.0 cm (>10 in.). A second stand size was indicated where no clear majority was observed.

Three observers made sightings. The observers were chosen to represent a common range of eye-level heights. Observer 1 (eye-level height, 1.6 m) was at locations 3, 4, and 6. Observer 3 (eye-level height, 1.8 m) was at locations 1, 2, and 5. The author, observer 2 (eye-level height, 1.7 m), was at all six locations.

Estimates of screening were made at each of five points at each location (Fig. 2). The arrangement of points was the same as that used for basal area estimation of timber by U.S. Forest Service FIA field crews in the midsouth States (Alabama, Arkansas, Louisiana, Mississippi, east Oklahoma, Tennessee, and east Texas).

At each point, two series of 12-sector observations were made (Fig. 1). The first series began at azimuth 0° and the second at azimuth 15°. In all, observations were made of 1440 sectors (6 locations ×

[2]The device has since been modified to limit the loss of equipment in the field. The dowel rod, screw, and wing nut were replaced with a stretch-resistant nylon twine marked at 35.5 cm (14 in.) and attached permanently to a Plexiglas viewpiece. When not in use, the twine is wrapped around the viewpiece and stored in a vest pocket.

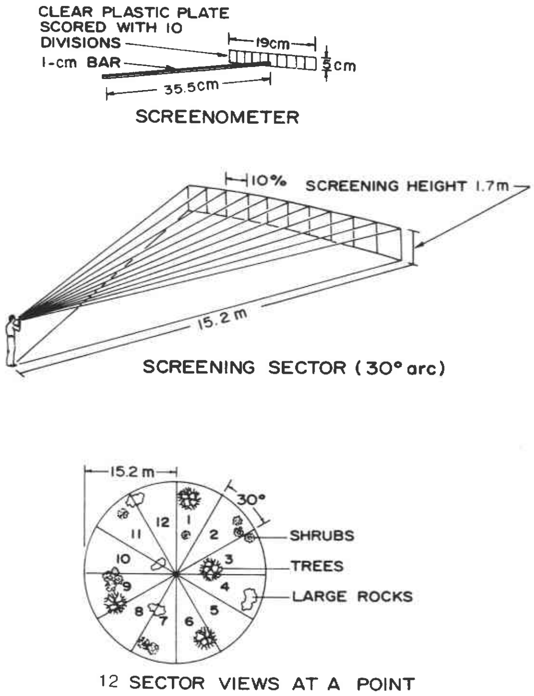

FIG. 1. Schematic drawing of screenometer, screening sector, and sector views at a point (after Nord and Magill 1963).

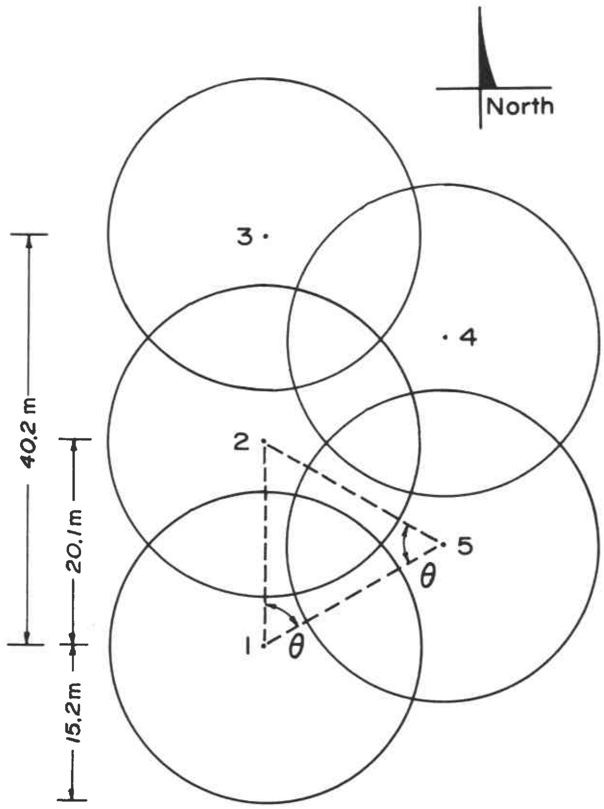

FIG. 2. Arrangement of views around points at a forest survey location (θ = 60°).

2 observers × 5 points × 2 series × 12 sectors). Measurement procedures were simplified as follows. (*i*) Each of the 10 segments viewed through the screenometer was classified into one of four categories constituting the plurality of that segment: 1, no screening; 2, tree boles ≥12.7 cm (≥5 in.) diameter at 1.37 m (4.5 ft) height (dbh); 3, other vegetation (including tree boles <12.7 cm dbh); 4, other nonvegetative screening (e.g., buildings, fences, etc.). (*ii*) The number of segments classified into a particular category were totaled for each sector. (*iii*) To ensure that observations could be reconstructed for verification, totals were recorded for each category and sector.

The response variable was defined as the proportion of segments for a given category and sector. Averages and analyses of variance were performed using an arc sine square root transformation. For the purposes of analysis, transformed data were assumed to approximate the normal distribution.

TABLE 1. Screening means by category, location, and observer

Location	Observer	Screening category: Tree boles (%)	Other vegetation (%)	No screening (%)
1	2	0.4	99.6	0.0
	3	0.3	99.6	0.0
	Mean	0.3	99.6	0.0
2	2	3.1	95.1	0.7
	3	2.5	95.3	0.7
	Mean	2.8	95.2	0.7
3	1	5.3	91.4	1.1
	2	10.3	85.5	1.5
	Mean	7.6	88.1	1.3
4	1	7.9	86.7	1.5
	2	10.2	83.9	2.0
	Mean	9.0	85.3	1.7
5	2	0.0	11.6	87.7
	3	0.1	14.5	84.6
	Mean	0.1	13.0	86.2
6	1	10.6	0.0	89.1
	2	9.5	0.0	90.4
	Mean	10.0	0.0	89.8

TABLE 2. Analysis of variance in screenometer estimates

Source	df	Mean square variance by screening category: Tree boles	Other vegetation	No screening
Observer 1				
Locations	2	970	198 739**	164 874**
Points	12	376*	655**	562**
Series	15	58	18	29
Sectors	330	217	249	88
Observer 2				
Locations	5	7671**	143 514**	139 499**
Points	24	612**	970**	669**
Series	30	16	25	30
Sectors	660	146	207	139
Observer 3				
Locations	2	1788*	144 744**	165 728**
Points	12	329**	1 241**	859**
Series	15	13	26	35
Sectors	330	73	180	139

NOTE: *F*-test, significant difference: *, $p < 0.05$; **, $p < 0.01$.

Results and discussion

Screening estimates at locations ranged from 0 to 90% for "no screening," 0 to 11% for "tree boles," and 0 to 100% for "other vegetation." Mean values are presented in Table 1.

TABLE 3. Optimum combinations of points and sectors between 5 and 6 min

Cost (min)	No. of points	No. of sectors per point	Variance
5.1	3	4	14.6
5.2	2	7	14.6
5.5	5	2	15.5
5.6	4	3	13.8
5.8	2	8	18.3
6.0	3	5	12.3

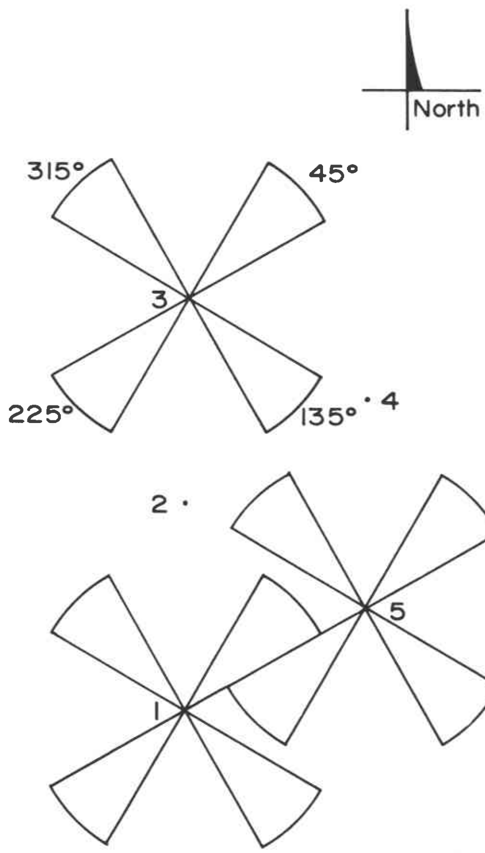

FIG. 3. Suggested field design of views with three points and four sectors per point.

Nonvegetative screening was not present at any of these locations. Differences in means between observers at a given location averaged less than 2%, with a maximum difference of 5.9% for "other vegetation" at location 3. No association between differences in eye-level height of observers and mean screening estimates was detected. Of the three screening categories for which estimates were made, mean values for "other vegetation" were most closely correlated with ocular estimates of screening.

Analysis of variance for each of the three categories and observers indicates that differences in the variance between series and sectors is negligible. A significant ($p < 0.05$) source of variation exists among points within locations, regardless of observer or screening category (Table 2). Differences in the variance among observers, series, and sectors were assumed to be negligible.

To get an idea of the sample size needed to adequately estimate screening at a location, sector observations were assumed to be normally distributed. Given that significant differences exist between point and sector variances, the sample size determination involved estimating the best combination of sectors and points that minimized the variance of the screening mean at a location for some reasonable cost.

From Cochran (1977, p. 281), one can estimate the optimum number of sectors, m, and the number of points, n, from

$$V = \left(S_1^2 - \frac{S_2^2}{M}\right) \Big/ n + S_2^2/nm$$

and

$$C = c_1 n + c_2 nm$$

where V is the variance of the estimated screening mean at a location, S_1^2 is the variance among point means, S_2^2 is the variance among sectors within a point, M equals 12 (total number of sectors per point), C is the total cost per location (minutes), c_1 equals 0.5 min (cost of defining a viewing area at a point), and c_2 equals 0.3 min (cost of observing and recording one sector observation). For the "no screening" category, S_1^2 is 21 and S_2^2 is 136. Relative to selecting one point and one sector per location ($V = 145.7$), the variance of the screening mean is reduced by 90% with a cost of 5 min/location. Optimum combinations of points and sectors between 5 and 6 min are given in Table 3. With "tree boles" and "other vegetation" screening, the same combinations of sectors and points yield comparable variances.

As an example, consider three points and four sectors per point. A suggested field design is where viewing areas are aligned at azimuths 45°, 135°, 225°, and 315° at points 1, 3, and 5 (Fig. 3). Overlap of viewing areas is slight. The systematic design assures consistency, ease of measurement, and representation of the total viewing area of the location. Accuracy of measurement can readily be verified by others.

Because some forest surveys are conducted year round, one must assume that a proportion of vegetative screening exists on branches and twigs when estimating screening during the dormant season. Further research will be needed to examine the effect of this seasonal judgment on screening differences among locations.

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