Use of Large Scale Forest Maps for Teaching Forest Sampling Methodology

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Several problems frequently arise when teaching forest sampling methods in plant ecology classes. Suitable undisturbed stands are often not readily accessible; it is difficult for students to gain experience in sampling and studying contrasting forest types; and testing sampling adequacy is frequently impracticable in the field, because incomplete stand data and forest spatial relations are usually unknown or poorly known. Also, time and weather may prevent sufficiently detailed field study.

Large scale maps of representative undisturbed forest stands overcome most of the above objections. Furthermore, they help give students an overview of an entire stand and a better appreciation of forest spatial relations. Indoor study of such maps enables students to become familiar with several kinds of forest sampling methods during rather brief laboratory periods. Sampling adequacy and efficiency are easily attainable and sampling confidence limits may be set because exact stand data are available for comparison. Maps should not be used, however, to supplant field experience in sampling but as a laboratory supplement.

Detailed forest maps are also desirable to show successional and stabilization trends within a stand over relatively long periods of time. As shown by Lindsey and Schmelz (3), individual trees may be rechecked at decade or longer intervals to indicate mortality, growth rates, and species composition changes.

Location and Description of Areas

The first stand mapped is a representative beech-maple dominated hardwood forest. This virgin stand, known as Hoot Woods, is located approximately three miles northwest of Freedom, Owen County, Indiana. Of the 64 acres comprising the stand, a square segment of 10.9 acres was mapped. This section represents the least disturbed portion of the stand and it occupies a topographically similar unit, namely a gentle east-facing slope. The mapped portion is largely included within the 17 acres that were full-tallied by Petty and Lindsey (5).

The second stand is a virgin coastal redwood dominated coniferous forest in Jedediah Smith Redwoods State Park in Del Norte County, the northwesternmost county in California. The stand is located about 9 miles northeast of Crescent City at the confluence of the Smith River and Mill Creek. An 8.1-acre floodplain section of the 44-acre Frank D. Stout Memorial Grove was mapped in this study. Occasionally the Smith River overflows this stand (as in the December, 1964, flood) and spreads fertile alluvium over the floodplain. This regeneration of soil fertility no doubt accounts for the very large trees found there, the success of redwood seedlings on the mineral soil, and the preponderance of redwood in the stand.

Only the floodplain was mapped because of the uniform topography represented; moreover, the adjacent upland stand had been slightly disturbed during construction of a stagecoach road in the late 19th Century.

Methods

Field mapping of Hoot Woods was completed in the summer and fall of 1965. The Stout Grove was mapped in June, 1966. The locations of all trees over 4 inches dbh were determined to within one-half foot accuracy in the eastern stand and to within one foot accuracy in the western stand. Diameters were recorded to the nearest one-tenth inch in Hoot Woods; the larger western trees were measured to the nearest one-tenth foot circumference. Species nomenclature follows Little (4).

The Hoot Woods stand was divided into 64 equal plots, which in turn were divided into north and south halves. Allowing for a margin along the forest edges, each plot was 86 ft square. The plots were laid out and checked with a compass and a standard 200 ft steel tape. Each plot was marked with corner posts and outlined with string.

The Stout Grove was mapped similarly to Hoot Woods, but one-tenth acre plots (66 ft square) were used. Plot corners and half corners were marked with plastic tape. A 200 ft tape was placed along the plot center on a compass line; the accuracy of plot dimensions was checked at both ends of each plot. The distance from the plot edge to a point perpendicular to each tree was measured along the 200 ft center tape; the distance from the center tape to the tree in question was measured with a second 50 ft tape laid normal to the center tape.

Stand maps were constructed on a 33:1 scale on heavy chart paper by laying out sufficient paper on a large classroom floor and then delimiting plots on the paper in the same sequence as they were mapped in the field. Tree centers were located on the map by first measuring the distance along the plot center line from the plot edge to a point perpendicular to the tree center. Perpendicular distances from the center line to the tree centers were measured with a T-square graduated into the proper scale. Trees with map diameters of 1 inch (actually 33 inches dbh) or less were drawn to scale to within 0.5 inch dbh accuracy by using standard circle drafting templates. Larger trees were drawn to scale with drafting compasses to within 1.0 inch dbh accuracy. Species symbols (usually the first letters of the generic and specific names) and tree diameters were placed adjacent to each tree on the maps. The resultant maps were *ca.* 21 feet square and 10 feet x 36 feet for Hoot Woods and Stout Grove, respectively (Figures 1 and 2).

Coordinates placed along the map outlines permit random location of points when using plotless sampling or the determination of plot locations when sampling the maps by quadrat methods. Transects or line strips may also be run for any distance in any direction by using map coordinates for location and direction. Sampling templates of various sizes and shapes for student sampling of the maps were constructed of transparent plastic.

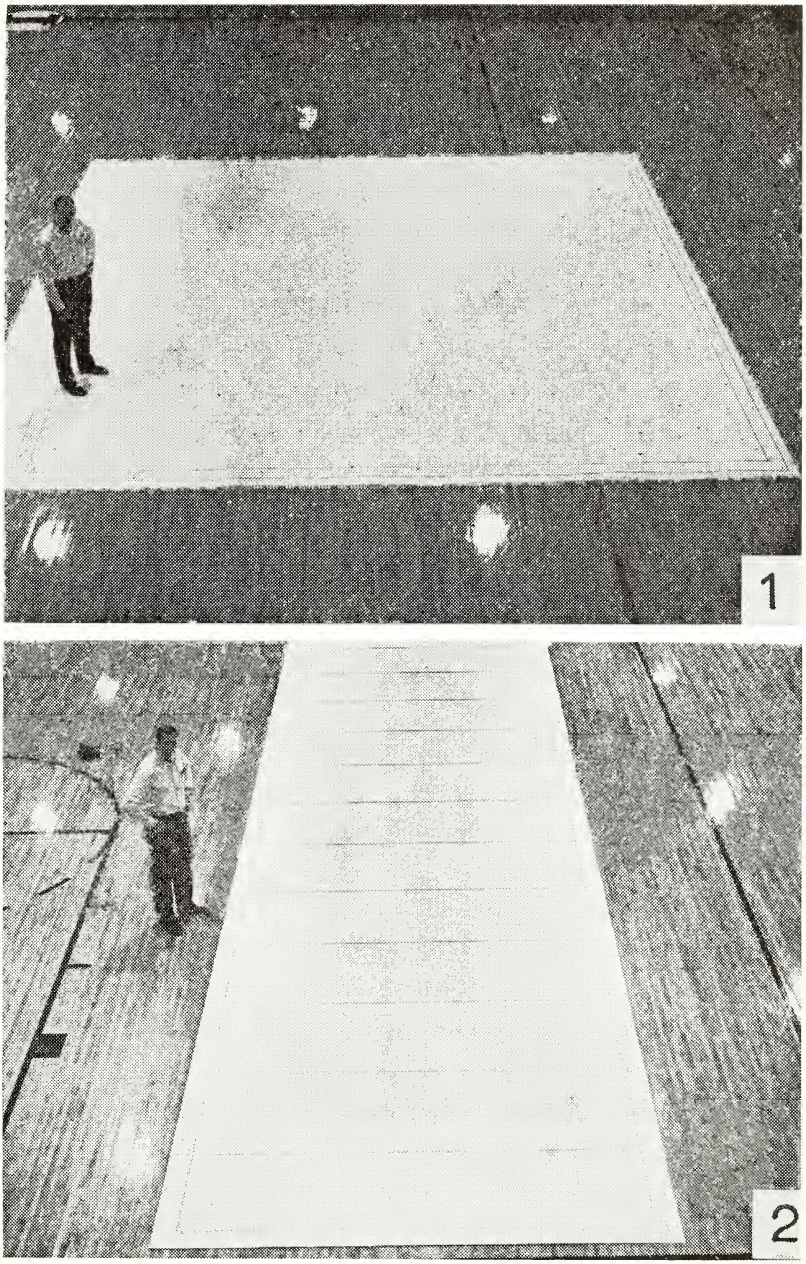
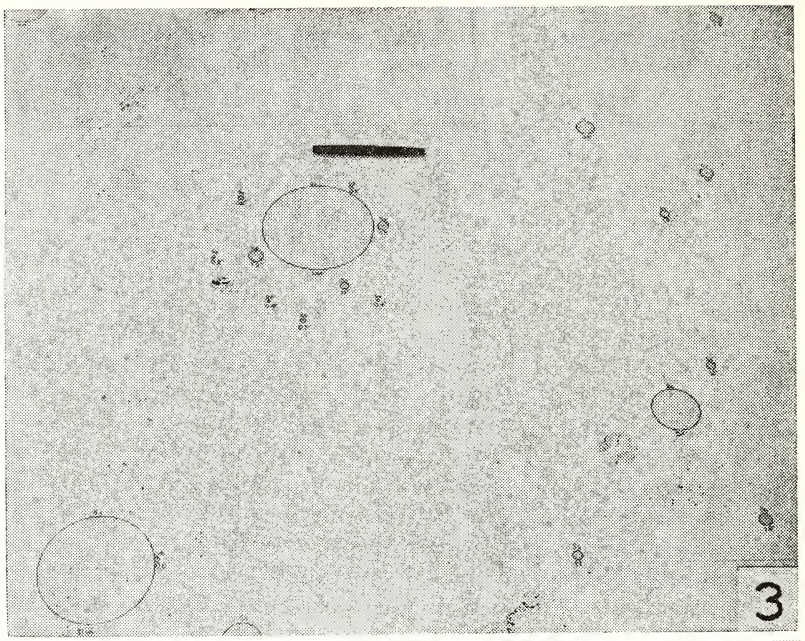
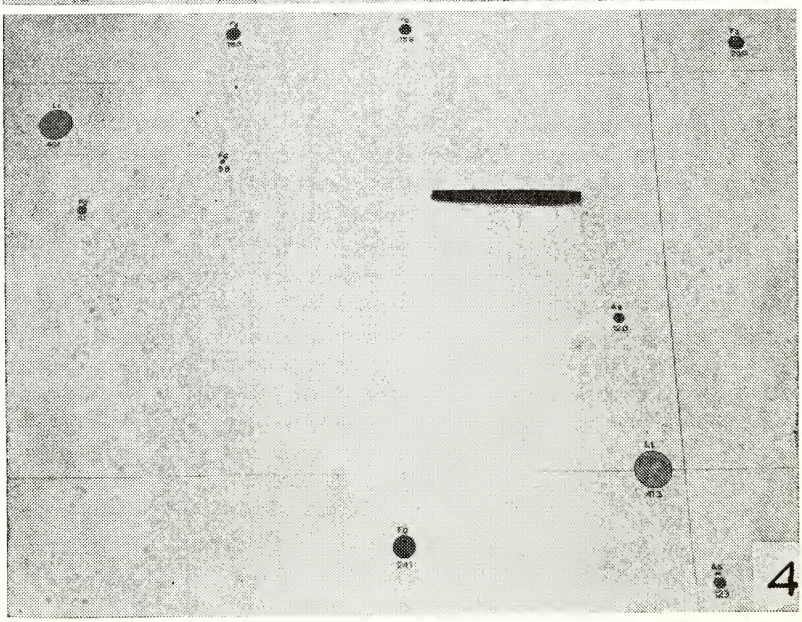


PLATE I

(1) Map of 10.9 acre section of Hoot Woods at 33:1 scale. Actual map is about 21 feet square.
(2) Map of an 8.1 acre section of Stout Grove at 33:1 scale. Actual map is 10 feet by 36 feet.





(3) Close view of map of coastal redwood forest showing the enormous size of mature trees and the extreme clumping of young redwoods around a "nurse" tree. Subordinate species are insignificant in impotance and generally occur in widely scattered clumps. Tree diameters are given in feet. Fountain pen gives scale.

(4) Close view of map of virgin hardwood forest showing the very large tulip poplar (Lt) and the predominance of beech (Fg) and sugar maple (As) in the stand. Tree diameters are given in inches. Fountain pen gives scale.

Results

Mapping Efficiencies. Field mapping required 10 and 9 man hours per acre in Hoot Woods and Stout Grove, respectively; whereas, laboratory construction of the maps required 6 and 5 man hours per acre, respectively. Field work was slowed in the redwood stand due to difficulty in getting over fallen logs and in circling huge trees to obtain diameters. Included is all time employed in setting up field plots, cutting and assembling map paper to scale and outlining plots on map paper. These rates make this technique a practicable method of analysis of virgin forest stands and for use in developing a forest sampling laboratory "tool".

Stand Attributes. Since a full tally of Hoot Woods was previously done by Petty and Lindsey (5), tabular results for attributes of that stand are not given. Twenty-one species were recorded with 899 individuals above 4 inches dbh. This gave a density per acre of 83 trees, as compared with 73 reported by Petty and Lindsey. Basal area figures were 119 and 136 square feet per acre, respectively. These differences are accounted for, in part, by greater forest edge effect in our sample, hence proportionally more and smaller stems.

The only significant variation in data between the two full tallies is our importance value for sugar maple of 24% as compared to 41% for Petty and Lindsey (5). Examination of size class data indicates that several of the largest maples previously tallied in their 17-acre plot fell outside the 11-acre section that we mapped.

Perhaps the most surprising finding was the high density of the redwood stand. The density was about as high as in the eastern stand, 74.4 to 82.8 stems per acre. Of course, the enormous size of the western conifers gave basal area figures ten times greater than in the eastern stand (1260 square feet per acre to 119 square feet per acre). Volume figures would make the contrast even more striking. Stand attributes shown in Table 1 indicate that of the 11 species found in the Stout Grove, all are very insignificant and widely scattered except redwood, which accounts for 90% of the importance value of the stand. Stand attributes as follows are those advanced by Lindsey (1): D_2, density per acre; D_3, relative density; B_2, basal area per acre; B_3, relative basal area; V_3, importance value found by averaging D_3 and B_3. All size classes of redwoods are well represented (Table 2) indicating that reproduction is succeeding adequately in the periodically deposited mineral alluvium. No major shifts in species composition of this stand are expected for many years. However, the marked increase in number of individuals in the 3.0 to 4.0 foot size class indicates that extensive natural disturbance undoubtedly occurred several decades ago. Fire or an abnormally high flood at that time could have created favorable conditions for extensive seedling establishment. No attempt was made to date the event since increment corings are impracticable for trees 4 feet in diameter.

Using the Maps. Eventually a library of several maps of contrasting successional or virgin forests can be assembled to provide more fruitful

student experience in forest analysis. Vegetation types other than forest could be mapped, but more labor would undoubtedly be required. Small artificial population boards for use in laboratory sampling exercises can also be assembled by computer analysis of a random selection of "individuals" of different species, sizes and locations (6). Maps of actual stands, however, have the advantage of teaching the student something about spatial relations, individual size and species composition rather than just teaching sampling methodology. They also provide a basis for further studies of forest phytosociology and forest sampling efficiencies (2). The major disadvantages are the relatively long time required for field and laboratory mapping of the stands, storage space for the rather bulky maps and finding a large enough area for laboratory use of the maps.

For student sampling, perhaps the maps are most easily used by being laid out flat on a gymnasium floor. Ample space is available and several maps may be sampled simultaneously. The clear plastic overlays used is sampling easily permit individual trees to be tallied while the quadrat is in place. Transects and plotless sample locations are as easily and efficiently located and sampled as are plot samples. Moreover, the 33:1 scale facilitates use of the variable-radius Bitterlich plotless sampling method. The analytic sampling attributes of density, frequency and basal area are easily determined by any of several sampling methods, but cover estimates are available only from basal area data. Future maps could include crown areas in addition to trunk cross sectional areas. This would, however, increase the field labor substantially. If enough stands of a given association were mapped, synthetic characteristics of presence, constance and fidelity could be determined as could continuum and ordination analyses.

The two stands reported here give students valuable experience in forest sampling because of the widely contrasting tree sizes and spatial relations of representative species in the two types. As shown in Figures 3 and 4, the clumping of small individuals of relatively rare species in the stand wholly dominated by large coastal redwoods, as compared with greater species diversity and more even distribution of similarly sized individuals in the hardwood forest co-dominated by beech and sugar maple does indeed present some interesting sampling problems for ecology students.

Acknowledgements

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TABLE 1. Stand Attributes Stout Grove, Del Notre County, California.

Species	D_2	D_3	B_2	B_3	V_3
Sequoia sempervirens	60.0	80.7	1249.1	99.1	89.9
Lithocarpus densiflorus	4.1	5.5	1.2	0.1	2.8
Umbellularia californica	2.5	3.3	1.2	0.1	1.7
Acer circinatum	2.1	2.8	0.3	<.1	1.4
Abies grandis	1.9	2.5	0.3	<.1	1.3
Chamaecyparis lawsoniana	1.5	2.0	4.9	0.4	1.2
Tsuga heterophylla	1.4	1.8	1.7	0.1	1.0
Alnus rubra	0.4	0.5	0.3	<.1	0.3
Acer macrophyllum	0.2	0.3	0.5	<.1	0.2
Corylus cornuta var. californica	0.2	0.3	<.1	<.1	0.2
Pseudotsuga menziesii	0.1	0.2	1.1	0.1	0.1
Totals	74.4		1260.6		

TABLE 2. Size Class Midpoints (in feet, dbh) Stout Grove, Del Norte County, California.

Species	0.5	0.75	1.25	1.75	2.25	2.75	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	Total
Sequoia sempervirens	55	69	54	38	22	23	45	27	28	27	27	19	20	15	7	3	3	2	1	1	486
Lithocarpus detnsiflorus	20	10	3																		33
Umbellularia californica	5	13	1	1																	20
Acer circinatum	14	3																			17
Abies grandis	12	3																			15
Chamaecyparis lawsoniana		1	2	4	2	2	1														12
Tsuga heterophylla	1	4	3	3																	11
Alnus rubra	2			1																	3
Acer macrophyllum			1	1																	2
Corylus cornuta	2																				2
Pseudotsuga menziesii							1														1
Totals	111	103	64	48	24	25	47	27	28	27	27	19	20	15	7	3	3	2	1	1	602