A Comparison of Four Distance Sampling Techniques in South Texas Live Oak Mottes

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Highlight: *Four distance sampling techniques; point-center-quarter (PCQ), random pairs (RP), nearest neighbor (NN), and closest individual (CI) were compared to total counts to determine accuracy of density and relative frequency approximations in a live oak (*Quercus virginiana*) motte vegetative type in South Texas. The PCQ method was the most accurate for estimating density, followed in decreasing order by RP, CI, and NN. Only the NN approximation was significantly different from the actual density. The PCQ method also provided the most accurate relative frequency approximations, followed in decreasing order by RP, NN, and CI.*

Rarely in nature does a population of organisms exist that is appropriate for a total count without an impractical expenditure of energy and resources. Such an opportunity is presented by the growth habit of live oak (*Quercus virginiana*) trees in portions of South Texas. These trees occur in mottes ranging in size from approximately 0.1 to over 200 acres. As few as two to several thousand trees occur in each motte, depending on tree density and motte size. Mottes up to approximately 30 acres in size can be totally counted in a feasible length of time and provide excellent units to compare phytosociological sampling techniques.

Distance sampling techniques, such as point-center-quarter (PCQ), nearest neighbor (NN), random pairs (RP), and closest individual (CI), provide an accurate and rapid estimation of tree densities (Cottam and Curtis, 1956). Lindsey et al. (1958) rate the PCQ method as generally less efficient than the Bitterlich plotless method (Grosenbaugh, 1952; Shanks, 1954) and some of the small-quadrat methods. Utilization of the four distance methods (PCQ, NN, RP, and CI), however, provides for calculation of four different density estimates from one sampling point. The purpose of this study was to compare these four distance techniques on accuracy of estimates of density and relative frequency approximations.

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Research was supported by the Caesar Kleberg Research Program in Wildlife Ecology through the Texas Agricultural Experiment Station. Appreciation is extended to Mr. Bill McBride for permission to conduct this study on the area and for provision of certain facilities. Dr. J. D. Dodd, Range Science Department, Texas A&M University, provided many helpful comments on the preparation of the manuscript.

Manuscript received January 12, 1974.

Study Area

The study was conducted on the 119,526-acre Encino Division of the King Ranch, located in Brooks and Kenedy Counties, Texas. The actual study area was limited to a 19,200-acre unit in the northeastern corner of the Encino Division. The investigated area lies within the "Coastal Sand Dunes" vegetation region of Tharp (1939).

The soil is a deep Nueces sand (Carter, 1931) with live oak mottes covering about 50% of the area. The remaining portion is open grassland dominated by native annual and perennial grasses and forbs. Mesquite (*Prosopis glandulosa*) is thinly scattered over the open areas and in some live oak mottes. Granjeno (*Celtis pallida*), huisache (*Acadia farnesiana*), persimmon (*Diospyros texana*), and hercules club (*Xanthoxylum clava-herculis*) occur mainly as understory species in the mottes.

Methods

The PCQ, RP, NN, and CI methods were sampling techniques employed to sample the tree populations, using a height criterion of at least 15 feet for trees. Data recorded with the CI method were distances from the sampling point to the nearest tree. The NN method involved measuring the distance from the CI to the nearest tree. The RP method involved recording the distance from the CI to the nearest tree outside a 180° exclusion angle erected around a perpendicular line between the sampling point and the CI (Cottam and Curtis, 1955). To implement the PCQ method the area surrounding the sampling point was divided into four quarters, and the distance from the sampling point to the closest tree in each quarter was taken (Cottam and Curtis, 1956). The height criterion for trees was selected for compatibility with a companion study dealing with wild turkey (*Meleagris gallopavo intermedia*) roosting habits.

Three mottes were sampled with 20 and three with 12 sample points. Sample points were selected with the aid of a 5-digit random numbers table while walking a straight line along the length of the long axis through the center of each motte. The first two digits were designated as the number of paces to walk into the motte on the baseline. The next three digits provided the number of paces to be taken perpendicular to the baseline. An arbitrary decision was made to walk to the right side of the baseline if the last digit was an even number and to the left if odd. In no case was a number used that would cause a point to fall outside the motte. These numbers were rejected and the next set of three digits chosen. When the baseline reached the outer edge of the motte, the direction was reversed and the process continued until the desired number of points had been sampled.

Table 1. Tree densities (trees/acre) in six live oak mottes as determined by four distance sampling techniques and actual counts.

		Sample techniques				
Motte	Sample points	Point-center-quarter	Random pairs	Closest individual	Nearest neighbor	Actual count
No. 2 Mill	12	330.2	302.6	232.9	447.0	235.8
Mota Bonita	20	188.1	201.3	241.2	226.2	157.3
Viboras	12	276.3	287.2	344.4	367.6	187.4
Jim Mill	20	134.3	135.8	146.5	381.2	124.9
Avispa	20	129.5	135.8	129.7	141.6	165.7
Bonita Norte	12	438.2	478.6	571.6	745.0	502.0

This method provided equal probability of every tree within each motte being sampled.

Total counts by species of all trees occurring within the mottes were also conducted. This was done by walking a series of narrow transects, bounded with string, through each motte. Two observers walked in unison along each side of one of the narrow transects, counting all trees between them. This process was repeated on all adjacent transects until the entire motte was covered.

Results and Discussion

Total tree counts in each motte revealed that density differences ranged from 124.9 to 502.0 trees/acre (Table 1). The denser populations were invariably made up of individuals of smaller diameter and, by definition, closer together. Cottam and Curtis (1956) obtained excellent density estimations with these distance sampling techniques in three different forests ranging in actual density from approximately 100 to 600 trees/acre. There seemed to be no denisty dependent sampling inaccuracies involved in this study. There was a tendency for all methods to overestimate density, but the overestimates were generally no greater in the dense mottes than they were in the less dense mottes.

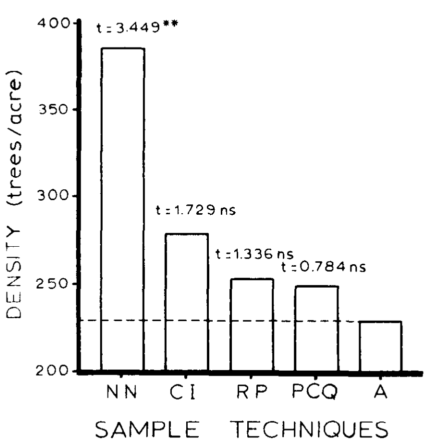

Fig. 1. *Average tree density estimates for six live oak mottes, as computed from four distance sampling techniques, compared to total counts, and with results of corresponding paired t tests. (NN = nearest neighbor, CI = closest individual, RP = random pairs, PCQ = point-center-quarter, A = actual count, ** indicates significance at the 99% level, ns indicates nonsignificance at the 95% level.)*

Average density estimates from the PCQ and RP methods (249.4 and 256.9 trees/acre, respectively) provided the best approximations of actual density (Fig. 1). The ±20.6 tree/acre deviation for the PCQ method was not significantly different (t = 0.784) from actual, nor was the RP (±28.1 deviation, t = 1.336). the paired t value of 1.729 obtained when comparing the CI method to actual was also statistically nonsignificant. This method produced an average deviation of ± 48.9 trees/acre. This represents a 21.4% overestimation and is likely approaching impracticality as a sampling tool. The NN method produced significantly different results compared to the actual count (t = 3.449, P<0.01). The ±156.0 tree/acre deviation of this method was a 68.4% overestimation of the actual average density.

Cottam and Curtis (1956) showed that the accuracy of density estimates, for the same number of sample points, increased in the order CI, NN, RP, and PCQ. A similar trend was observed in this study, except that the CI method was more accurate than the NN. One consideration should be that four measurements are required for the PCQ method, whereas only two are needed for the RP and one for the CI. If time was a major concern it is possible that the RP and the CI methods would have ranked close to the PCQ in overall efficiency. No time data were recorded since interest was centered on accuracy rather than efficiency.

The relative frequency calculations determined from each sample method also were compared to that of the total count. All methods produced results closely approximating the actual values of live oak and mesquite (Table 2). Rare species in the overstory, such as granjeno, huisache, and persimmon, were usually overestimated by all four methods. The PCQ method generated the most accurate relative frequency approximations for all species, followed in decreasing order by RP, NN, and CI. This is as expected since the number of trees involved in the PCQ method is by definition twice as

Table 2. Relative frequencies (%) of trees determined by four distance sampling techniques and compared to actual counts.

		Sample techniques				
Motte	Species	Point-center-quarter	Random pairs	Closest individual	Nearest neighbor	Actual count
No. 2 Mill	Live Oak	79.2	75.0	83.3	79.2	88.7
	Mesquite	10.4	12.5	0	0	8.2
	Granjeno	10.4	12.5	16.7	20.8	3.1
Mota Bonita	Live Oak	75.0	75.0	75.0	77.5	82.4
	Mesquite	21.2	22.5	20.0	17.5	11.8
	Granjeno	2.5	0	0	0	5.5
	Huisache	1.2	2.5	5.0	5.0	0.3
Viboras	Live Oak	100.0	100.0	100.0	100.0	98.8
	Mesquite	0	0	0	0	1.1
	Granjeno	0	0	0	0	0.1
Jim Mill	Live Oak	100.0	100.0	100.0	95.8	95.1
	Mesquite	0	0	0	4.2	3.6
	Granjeno	0	0	0	0	1.3
	Persimmon	0	0	0	0	tr
Avispa	Live Oak	83.8	85.0	80.0	80.0	86.0
	Mesquite	15.0	12.5	15.0	17.5	13.9
	Granjeno	1.2	2.5	5.0	2.5	0.1

great as the RP and NN and four times as great as the CI. Cottam et al. (1953) stated a minimum of 30 individuals of any species is necessary before any statement can be made regarding its relative density in the population. Live oak, the overwhelming dominant, was the only species recorded with as many as 30 hits. However, it appeared that in the live oak mottes, due to homogeneity, a relatively accurate frequency of occurrence could be computed with fewer than 30 hits.

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