A New Technique for Estimating Forest-Land Areas by Ownership Class

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Ownership of forest land has been the subject of continuing research in the United States since about 1940, because knowledge of who owns this land, why it is owned, and what is being done with it is essential to development of appropriate forest-land management policies and programs. The accompanying list of selected references furnishes evidence of previous work in forest-land ownership research. Despite interest in this field, however, procedures used in these studies have shown surprisingly little variation. The study reported here, which is directly concerned with ownership of private forest land in Lane County, Oreg., represents a different approach. Specifically, it develops a new method for classifying private owners in the county and in other areas where similar basic data are available. This method may also have application in other regions.

AS CONCERN WITH EXTENT and quality of forest-land management became more widespread, research workers began to realize the need for knowledge about individual forest owners—who they were, what they did, why they owned forest land, how much they owned, and how and when they acquired it. Thus, an initial need was for intensive survey to identify and classify owners of forest lands, as illustrated by (*2*) and (*15*).[1]

But this knowledge about the owner's identity and characteristics did not shed a great deal of light on the extent and quality of management, so the next step was in the direction of intensive studies designed to relate ownership characteristics to forest management intentions and practices (*3*, *4*, *12*, *13*, *14*, and *16*).

More recently, the approach to forest-land ownership research has been from a different direction. Intensive studies such as those referred to above are significant but a growing need has developed for extensive surveys, which would gather much the same type of data but would cover large areas with less expense and time-consuming effort and would be designed to provide information on which land-management policies and programs can be based. Typical of this approach are current studies in California, begun in the mid-1940's on a county basis and later expanded to a subregion basis (*1*, *5*, *9*, *10*, *11*). Although these studies have not correlated ownership characteristics with management practices as yet, it is expected that they will be extended to do so in the future.

Other studies falling in this group have analyzed management practices (*7*, *18*, *20*). In addition, the U.S. Forest Service's reappraisal report of 1946, and its 1958 report, "Timber Resources for America's Future," were even more extensive; they covered the entire Nation. The reappraisal report related cutting practices and fire protection to type of forest owner, whereas the 1958 report (TRAF) classified recently cut areas by ownership on the basis of productivity status following cutting.

As to techniques, the studies show how objectives influenced the choice of procedures. The intensive type of survey was concerned with a relatively small area—parts of one or several counties;[2] hence, data were gathered directly from individual landowners, and statistical sampling designs were not employed. In effect, the entire universe was interviewed. Furthermore, the research workers were concerned with conditions in a given area; they had no intention of generalizing results for application to a wider area. With extensive surveys, on the other hand, a much larger area was involved, and time and funds prohibited a 100-percent canvass. Statistical sampling designs were therefore used, and these designs also permitted measuring the accuracy and reliability of results.

Only two types of sampling designs have been used in these extensive surveys. An article by

[1] Italic numbers in parentheses refer to Literature Cited.

[2] The projects reported in (*13*) and (*14*) are slight exceptions. Each covered an area of approximately 8 million acres, involving 15 and 14 counties, respectively.

James (*6*) discusses the two methods, area and line transect, but concentrates on the advantages and usefulness of the former. Hasel and Poli (*5*) and Poli (*8*) describe in detail the line transect procedure. This article offers a new point-sampling technique for conducting extensive surveys of forest-land ownership patterns.

Description of Technique

The present technique was developed [3] and used in conjunction with a comprehensive analysis of the forest resources and economy of Lane County, Oreg. (*17*). Details of this technique were considered to be of sufficient interest to merit separate publication.

For the last 25 years, the Forest Survey in the Pacific Northwest has gathered acreage data on the ownership of forest land in the region, but no information concerning the identity and type of private forest owners has been obtained. Hence this new technique was designed to obtain a breakdown of private ownership acreage figures by class of owner for the Lane County study, and to develop and test a technique that could be used elsewhere in the Pacific Northwest.

This was done by (1) identifying private forest-land owners by name, (2) classifying them according to whether they were industrial, farm, or nonfarm owners,[4] and (3) estimating the extent of forest ownership by stand-size classes within each owner class. Accomplishing this within the limitations imposed by available time and funds required some sort of statistical sampling design. Therefore, previous studies (*5*, *6*, *7*, *18*) using either the area or line transect method were analyzed.

It soon became apparent that neither method was suited to the objectives of this study. The universe of the present study was narrowly defined to include only owners of private commercial forest land, whereas the area and line transect methods include in their universes all landowners—public and private, forest and nonforest. For this reason, the analysis of results would have been unduly complicated had either of these methods been used.

After careful consideration, a random point-sampling technique was devised; it excluded from the sample all elements foreign to the universe. Use of the procedure in this study required an up-to-date Forest Survey type map of the county and township sheets showing in-place ownership of all public and private land. These two items are the basis for Forest Survey acreage estimates of forest and nonforest land within a county.

The following steps outline the technique in detail:

1. A numbered list of townships in the county was prepared, excluding those that contained no private land. Then three numbers were drawn from a table of random numbers to designate (*a*) a township, (*b*) a section in that township, and (*c*) a "forty" in that section. The center of the "forty" became the sample point for this study.

2. This point was then checked on the ownership sheets to determine whether or not it fell on privately owned land. If not, the point was discarded and another drawn.

3. Points that fell on private land were next checked against the type map and accepted as valid samples only if they fell on commercial forest land. Steps 2 and 3 were the means by which the sampling procedure was confined to the particular universe being sampled—private commercial forest land.

4. Each point finally accepted in step 3 was spotted in its appropriate position on blank township sheets, numbered consecutively, and the stand-size class recorded as obtained from the type map.

5. Next the State Forester's office and national-forest district offices were visited to obtain owners' names for all points recorded on the sheets in step 4. The State Forester's office also provided a list showing names and forest acreages owned by members of the two fire protection associations in the county.[5] This list became the basis for classifying industrial owners [6] by size according

[3] F. A. Johnson, chief of the statistical section at the Pacific Northwest Station, helped greatly in developing the technique and in computing results.

[4] For reasons discussed later, farm and nonfarm owners were combined in the final classification.

[5] These associations are voluntary protective organizations formed by forest-land owners, and most of the larger landowners are members. All other forest-land owners obtain protection under the State Forester's office.

[6] An industrial owner is defined as one who operates a timber-processing plant within the county, such as a sawmill, green veneer or plywood plant, pulp mill, or shingle mill.

to amount of forest land owned. The standard classification of small (less than 5,000 acres), medium (5,000 to 49,999 acres), and large (50,000 acres or more) was used. The district wardens of the two fire protection associations in Lane County and the Industrial Forestry Association also assisted in classifying industrial owners.

6. Lastly, the district wardens and the county forester classified farm and nonfarm owners.

These six steps completed the task of selecting, identifying, and classifying private owners of commercial forest land.

As this was a new study, there was no basis for estimating sampling error and determining a satisfactory sampling intensity. Therefore, from 400 to 500 points were arbitrarily accepted for reasonable coverage of the county. The following reasoning explains why this arbitrary number was selected: If 500 points were drawn, 60 percent should be industrially owned as about two-thirds of the private commercial forest land in the county was believed to be in this ownership class. Thus, 40 percent, or 200 points, would remain in farm and nonfarm ownership. This latter group promised to be the most difficult to classify and would require time spent in the field checking names with the county forester and district wardens. It was further estimated that perhaps half of these 200 points might not be classified by these men and would thus require on-the-ground checking. Two hundred points was believed to be the maximum the men should be asked to classify, and 100 points was thought to be about the maximum for which time and effort could be spent in field checking.

After drawing a total of 1,237 sample points, 65 percent of these (or 806 points) had to be rejected under steps 2 and 3. The remaining 35 percent (431 points) were thought to be sufficient for the final sample. Of the 431, 64 percent were classified as industrial, 20 percent as farm, and 12 percent as nonfarm—4 percent could not be classified immediately as either farm or nonfarm. This 4 percent (or 17 points) was far less than the preliminary estimate of 100 points that might require additional checking for positive classification. The reasoning governing the choice of the total number of points proved to be accurate with respect to the industrial sector, but greatly overestimated the number of farm and nonfarm owners that could not be readily identified.

At this point it was decided not to distinguish between farm and nonfarm owners because of inherent difficulties in defining precisely these two classes in Lane County. Farmowners would have had to be distinguished on the basis of the Census of Agriculture definition of a farm: a place of 3 acres or more producing agricultural products in 1955, and valued at $150 or more, home gardens excluded. This definition would have produced a distorted picture by including as farmers a great many individuals whose primary income came from off-farm sources. The situation in the county is somewhat unusual because of the concentration of industry in the Eugene-Springfield area and the number of forest industries throughout the county.[7] Many of those living on farms work full time in these plants and mills. Farming actually is a sideline. Classifying these individuals as farmowners would not have given a clear picture, so both farm and nonfarm owners were combined as "nonindustrial" owners.

Computation of Results

Table 1 is the net result of the sampling procedure; it shows the number of points that fell in each ownership—stand-size class.

The next step in the analysis was to convert numbers of points in each class to estimates of acreage. The total acreage in the large industrial class and acreages in each stand-size class (all ownerships) were known. These totals had been obtained independently of this study and were without sampling error. To incorporate this information in the analysis, data in table 1 were poststratified as follows:

1. Large industrial (all stand-size classes).
2. Sawtimber (all ownerships except large industrial).
3. Poletimber (all ownerships except large industrial).
4. Seedlings and saplings (all ownerships except large industrial).
5. Nonstocked (all ownerships except large industrial).

This poststratification permitted the calculation

[7] In 1955, more than 200 establishments in the county were classed as forest industries alone—sawmills, veneer and plywood plants, planing and remanufacturing plants, cut-up plants, a pulp and paper mill, shingle mills, and pole yards—with an average monthly employment of approximately 11,000.

TABLE 1.—*Classification of sample points by ownership and stand-size classes*

Ownership class	Stand-size class				
	Saw-timber	Pole-timber	Seedlings and saplings	Non-stocked	Total
Industrial:	*Number*	*Number*	*Number*	*Number*	*Number*
Large	85	18	37	8	148
Medium	53	6	38	2	99
Small	8	8	10	3	29
Total	146	32	85	13	276
Nonindustrial	61	46	46	2	155
All ownerships	207	78	131	15	431

TABLE 2.—*Results of statistical calculations for stratum 1 (large industrial—all stand-size classes)*

Stand-size class	Sample points	Estimated proportion of total area or (P)	Standard error of proportion or (S_p)	Estimated area or (A)[1]	Standard error of estimated area or (S_A)[1 2]
(1)	(2)	(3)	(4)	(5)	(6)
	Number			*Thousand acres*	*Thousand acres*
Sawtimber	85	0. 5743	0. 0406	186. 8	13. 2
Poletimber	18	. 1216	. 0269	39. 5	8. 7
Seedlings and saplings	37	. 2500	. 0356	81. 3	11. 6
Nonstocked	8	. 0541	. 0186	17. 6	6.
Total	148	1. 0000	----------	325. 2	----------

[1] Rounded to the nearest 100 acres.

[2] S_A is obtained by multiplying the total acreage in the stratum (325,200 acres for stratum 1) by the respective standard errors of proportions given in col. 4, or $S_A = 325{,}200\ (S_p)$.

of acreage estimates within each class, which when summed equaled the known total acreage for each class.

Table 2 shows the results of statistical calculations for stratum 1 and serves to illustrate how data from table 1 were converted first to estimated proportions of total area and thence into estimates of area. Standard errors of estimated proportions and of estimated areas are also shown. Column 3 shows the proportion that number of sample points in each stand-size class (col. 2) bears to the total of 148 points for the stratum, and these proportions provide unbiased estimates of corresponding true proportions. Standard errors of proportions (col. 4) were calculated by the formula

$$S_p = \sqrt{\frac{P(1-P)}{n}},$$

where P is the proportion and n is the sample size or in this instance, 148.

Estimated areas (col. 5) were obtained by multiplying the known total of 325,200 acres by the respective proportions in column 3. Standard errors of these areas (col. 6) were obtained by multiplying the total acreage in the stratum (325,200 acres) by the respective standard errors of proportions (col. 4).

The calculations for strata 2, 3, 4, and 5 differ somewhat from those for stratum 1 but are basically the same. Table 3 shows the results for stratum 2.

Estimating areas by stand-size class for stratum 1 (table 2) results in indirect estimates of area by

TABLE 3.—*Results of statistical calculations for stratum 2 (sawtimber—all ownerships except large industrial)*

Ownership class	Sample points	Estimated proportion of total area or (P)	Standard error of proportion or (S_p)	Estimated area or (A) [1]	Standard error of estimated area or (S_A) [1 2]
(1)	(2)	(3)	(4)	(5)	(6)
	Number			*Thousand acres*	*Thousand acres*
Industrial:					
Medium	53	0.4344	0.0449	105.1	12.3
Small	8	.0656	.0224	15.9	5.5
Nonindustrial	61	.5000	.0453	121.0	12.8
Total	122	1.0000	----------	242.0	----------

[1] Rounded to the nearest 100 acres.
[2] S_A is the product of 2 factors, both of which have sampling error. The formula used in computing it is explained in the text.

TABLE 4.—*Estimated areas, with corresponding standard errors, by ownership and stand-size classes* [1]

Ownership class	Stand-size class								Total	
	Sawtimber		Poletimber		Seedlings and saplings		Nonstocked			
	Estimated acreage	Standard error	Estimated acreage	Standard error	Estimated acreage	Standard error	Estimated acreage	Standard error	Acreage	Standard error
	thousand acres		*thousand acres*		*thousand acres*		*thousand acres*		*thousand acres*	
Industrial:										
Large	186.8	13.2	39.5	8.7	81.3	11.6	17.6	6.0	325.2	[2] 0
Medium	105.1	12.3	13.4	5.3	71.3	10.1	7.2	4.7	197.0	17.4
Small	15.9	5.5	17.9	6.0	18.7	5.7	10.9	5.4	63.4	11.3
Total	307.8	18.9	70.8	11.8	171.3	16.4	35.7	9.4	585.6	29.2
Nonindustrial	121.0	12.8	102.8	9.9	86.3	10.7	7.2	4.7	317.3	20.0
Total	428.8	[2] 0	173.6	[2] 0	257.6	[2] 0	42.9	[2] 0	902.9	[2] 0

[1] Rounded to nearest 100 acres.
[2] Zero indicates that corresponding total acreages were known exactly and are thus without sampling error.

stand-size class for each of the other strata. For example, an estimated 186,800 acres in large industrial sawtimber (table 2) gives an estimated 242,000 acres in stratum 2 (table 3) because total sawtimber area is known without sampling error (from an independent source) to be 428,800 acres. In table 3, the standard errors of proportions (col. 4) and estimated areas (col. 5) are obtained in the same way as for table 2. But the standard errors of these estimated areas (col. 6), unlike stratum 1, are the products of two factors, both of which have sampling error. Thus these standard errors are obtained from the formula,

$$S_A=\sqrt{A^2S_p^2+P^2S_A^2}.$$

in which

S_A=standard error of estimated area.
A=total area in stratum.
S_A=standard error of stratum area.
P=estimated proportion of area.
S_p=standard error of estimated proportion.

Here S_A^2, the squared standard error for the stratum 2 area of 242,000 acres, is the same as the standard error for large industrial sawtimber (13,200, table 2). This is because the two sawtimber areas constitute a whole, and logic indicates

that the standard error of one part must be the same as that for the other part.

Estimated areas and standard errors for the remaining strata were developed in a similar way. Final results of all calculations are summarized in table 4. Note that standard errors for the border totals in each stratum are zero, because these totals are the ones known exactly and thus were without sampling error.

Discussion

The technique outlined in this paper may appear to be of limited usefulness, depending as it does on a forest-type map and township sheets that distinguish between public and private ownership. But these two "crutches" were required only because of the nature of the universe sampled. Had the universe been different—all landowners in the county instead of just private forest owners, for instance—any large-scale map of the county showing townships and sections would have been sufficient. Under these conditions, of course, the universe would be the same as that sampled by either the area or line transect methods mentioned earlier. Thus, before adopting any one of these three methods, someone working in this field might want to consider their relative merits to see which one best meets his needs.

The poststratification used in the calculation of estimated areas and standard errors was dictated not by the nature of the sampling design but by the data—certain border totals were known. Had this not been the case, there would have been no basis for poststratification, but this would not have precluded estimates of areas and their standard errors. The only difference would have been that the border totals would then have depended on estimated areas and thus would have contained sampling error.

An advantageous feature of this technique is that if the total number of valid sample points originally drawn was for any reason found to be inadequate, the sample could have been "sweetened" merely by drawing additional points. This would not have entailed loss of time or effort already spent.

An analysis of time spent on this study shows that a total of 119 man-hours were required for the three operations of drawing points, identifying and classifying owners, and compiling results. Drawing points took 50 percent of this total, identification and classification took 20 percent, and compilation took the remaining 30 percent. Drawing points may appear to have required an unduly large proportion of total time, but this is offset by the fact that, once drawn, each of the 431 sample points was known to be valid. None was discarded later for not belonging to the universe.

Identifying and classifying industrial owners alone took 85 percent of the time spent on this one operation, whereas nonindustrial owners required only 15 percent.

One other feature of this technique was the proportion of time spent in the office compared with that in the field. Of the three operations referred to above, the first and last were carried out in the office, as was most of the time spent on the second operation in identifying and classifying owners. Less than 3 percent of the total time of 119 hours was spent in the field. This did not include travel time, which required less than 2 days.

No attempt was made in the study to determine owner characteristics other than to classify owners by type. Such things as age of owner, length of tenure, how land was acquired, why it was acquired, and educational background—all of which have been noted in other landownership studies—were not a part of the present study; nor was any attempt made to relate these characteristics to forest-mangement practices. Had additional time and funds been available, such information would have been obtained, and there is no reason why this could not have been done as a part of this technique. The effect of doing so would have been to increase materially the amount of time spent in the field.

Summary

1. Despite wide interest in forest-land ownership, past studies of the pattern of such ownership have shown little variation in objectives and procedures.

2. Objectives of these studies fall into three groups: (*a*) Concern only with identity and characteristics of forest owners; (*b*) relation of such knowledge to extent and quality of management practices of owners; and (*c*) use of both types of

data to provide a sound basis for development of land-management policies and programs in an area.

3. Concerning procedures, two groups of studies can be recognized: (*a*) An intensive type, which depends on a 100-percent canvass of all owners in a specified area and does not employ statistical sampling designs, and (*b*) an extensive survey using statistical sampling designs, with sample results expanded to an entire universe.

4. In extensive surveys, only two types of sampling design have been used so far as can be determined: (*a*) An area design that takes small blocks of land (in relation to total area covered) as the sampling unit, and (*b*) a line transect design that uses equally spaced lines running entirely across the area concerned. A new technique, reported in this paper, has been developed; it offers another means of conducting extensive surveys of landownership. It is based on a random point-sampling design.

5. A major argument in favor of this new technique is that it sampled only the particular universe concerned—private commercial forest land. This procedure precluded the possibility of obtaining elements such as public ownerships and all nonforest land, which were foreign to the given universe.

6. This technique is applicable only when detailed maps are available to define the universe being sampled. In this instance, had there not been a forest type map of the county and township sheets showing inplace ownership of public versus private land, the technique would not have worked. These two items were needed to define the universe for this study. A different universe might have required a different map.

7. The nature of the technique is such that additional sample points could have been drawn without loss of time had the original size of sample proved to be inadequate.

8. Officework predominates in use of this technique under conditions of the present study. Less than 3 percent of the total time spent was required for fieldwork, not including traveltime.

9. Owner characteristics and their relation to forest-mangement practices and intentions were not a part of the study, although with additional funds such information could have been obtained.

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