INVENTORY PROCEDURE FOR SMALL OR SPECIALIZED FOREST NURSERIES

John W. Duffield[1]

Applying sampling theory to inventory problems requires, among other matters, a clear recognition of the limits of the populations to be sampled. In inventories of forest nurseries, a population to be sampled is sometimes assumed to consist, for example, of all the 2-0 seedlings of a given seed lot growing in a part of the nursery with a given soil type and treatment history. This definition of the population[2] may be entirely satisfactory for the purposes of nursery cost analysis or for planning reforestation operations. It may, on the other hand, not satisfy the nurseryman who often wishes to know not only how many seedlings of a given lot he has in the ground, but also just which beds he will have to lift to fill an order for a specific number of trees.

The procedure outlined below has been developed in an effort to meet the needs of the nurseryman who must ship specific amounts of stock on relatively short notice. It is not designed for the nursery that lifts its stock in an orderly manner and places it in cold storage. This method may be described as a stratified systematic sampling procedure.

The statistical basis for sampling nursery populations is given in the works of Johnson[3] and Mullin et al .[4]

Operation of the Industrial Forestry Association Nurseries

The Industrial Forestry Association operates two nurseries, one established in Washington in 1941 and one in Oregon in 1961. Both nurseries operate on an advance sale or contract basis. Each serves approximately 20 individual contractors. Seed is furnished by the contracting companies, who assume the responsibility for suitability of seed origin. Douglas-fir dominates production in both nurseries, accounting for about 85 percent of the output.

Seed origin is specified in many instances by 500-foot-elevation zones, and for large Tree Farms there may be two or three subdivisions based on locality as well. For species other than Douglas-fir, subdivision into seed lots is generally not so complex, because most of them do not cover the range of sites and altitudes encompassed by Douglas-fir. These include Abies procera, A. grandis, Picea sitchensis, Tsuga heterophylla, Chamaecyparis lawsoniana, and others. All together, there is a total of 10 to 15 species.

Each nursery may handle 100 seed lots each year. These seed lots produce 10 to 15 million 2-0 trees in each nursery. Therefore, the nurseries are rather complex in makeup and contain many rather small sowings. Seedbeds at the Greeley Nursery vary continuously from 190 to 450 feet in length, to achieve maximum utilization of a piece of land with irregular boundaries.

1 Technical Director, Col. W. B. Greeley Forest Nursery. Industrial Forestry Association, Nisqually, Wash.

2 Wakeley, P. C. Planting the southern pines. Forest Service, U.S. Dept. Agr., Agr, Monog. 18, 283 pp. 1954.

3 Johnson, F. A. A statistical study of sampling methods for tree nursery inventories. Jour. Forestry 41: 674-679. 1943.

4 Mullin, R. E., Morrison, L. M., and Schweitzer, T. T. Inventory of nursery stock. Ontario Dept. of Lands and Forests. Res. Rpt. 33. 64 pp. 1955.

Inventory Procedure at the Col. W. B. Greeley Forest Nursery

Inventory of second-year seedlings is taken in late August. At that time most of the mortality affecting young conifers will normally have occurred, and experienced seedling counters, who also are experienced at grading and packing, can recognize seedlings that will be plantable after growth has ceased for the year. Preliminary inventories of first-year seedlings may be taken in the autumn, and may be repeated the following spring. As a rule, preliminary inventories are taken at a low level of sampling intensity.

The overhead irrigation pipeline system is used to facilitate systematic location of sampling points. These pipelines, which run the length of the seedbeds, are supported at 15-foot intervals by posts numbered from 1 to 30. During inventory operations, the support post numbers are shown on large plywood placards, which can be read at a distance up to 200 yards. This makes it possible to locate sampling points at multiples of 15 feet from the start of each seedbed and to designate which of these sampling points are to be used.

A 5- by 8-inch marginal-punched card (fig. 1) is made for each seedbed (or segment of a seedbed which contains more than one seed lot). Each card represents a population to be sampled. About 250 such cards and populations comprise each year's inventory of 2-0 seedlings at the Greeley Nursery. These cards are then taken into the nursery for three preliminary operations: (1) measurement of length of seedbed occupied by each population; (2) division of each population into heavily and lightly stocked strata and measurement of the length occupied by each; and (3) assignment of sampling points by number to each stratum.

These three operations are done simultaneously by two men who walk the length of each bed with a land-measuring wheel that reads to the nearest foot, and on which is mounted a clipboard to hold the inventory cards. One of the men walks a few feet ahead of the wheel to recognize and identify the transition from light to heavy stocking or vice versa, and to carry extra cards and the nursery map, which is needed for

CO. Apex SP. D.F. CLASS 2-0 LOT 3165 BLOCK IV BED 6 DATE 8/25/62

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
E/N	X	103	X	92	X	55	X	92	X	83	X	92	60	62	55	85	45	59	37	65
W/S	X	102	X	91	X	83	X	96	X	90	X	102	86	91	73	90	61	78	60	80
HVY		205		183		138		188		173		194	X	X	X	X	X	X	X	X
LT		X		X		X		X		X		X	146	153	128	175	106	137	97	145

← 174' Hvy → ← 190' Lt

Lt → ← 71' Hvy →

	21	22	23	24	25	26	27	28	29	30
E/N	74	87	54	71	X	104	X	83	X	120
W/S	61	32	31	87	X	124	X	128	X	135
HVY	X	X	X	X		224		211		255
LT	135	119	85	158		X		X		X

INVENTORY & PACK ANALYSIS

	1 SAMPLE TOTAL	2 SAMPLE LENGTH	3 STRATUM LENGTH	4 3/2	1 X 4
	1771	9	245	27	47,817
	1584	12	190	16	25,344
INVENTORY					73,161
PACK					74,500
DIFFERENCE					1,341

COUNTING FRAMES 1' LONG

Figure 1.--Form used for planting stock inventory at the Col. W. G. Greeley Forest Nursery. This is multilithed on 5- x 8-inch marginal-punched cards to facilitate compilation and analysis.

reference. The operator sets the measuring wheel back to zero at each stratum boundary, designates on the card those stations at which counts are to be taken, and records on the card the length of each stratum, both in feet and graphically with reference to the spaces for the counting stations. These operations can be done almost as quickly as the operator can walk the length of the bed.

The decision as to the level of sampling is made during the measurement of strata. In general, it follows the rule for choice of sample sizes in individual strata given by Cochran (see Chapter 17).[5] This rule is "- - - take a larger sample, as compared with proportional allocation, in a stratum that is unusually variable, and a smaller sample in a stratum where sampling is unusually expensive." Since all samples, in this instance, are equally costly, the only variable factor affecting the decision is variability within the stratum. Thus, if the stratum appears variable, and this is generally true of strata rated as lightly stocked, the decision will be for a relatively high level of sampling, that is one sample per 15 linear feet, or 6.7-percent coverage. For more uniform strata, which are generally heavily stocked, the decision will be for one sample per 30 linear feet, or 3.3-percent coverage.

The seedling counters go to the positions indicated on the bed inventory cards (fig. 1) and count all plantable seedlings within counting frames 1 foot long and 4 feet wide. Other lengths might be appropriate, depending on degree of stocking and sizes of plants. The counting frames used at the Greeley Nursery are divided so that each counter in a team counts the seedlings in an area 1 foot along the seedbed and half the width of the seedbed. One of the team records the counts.

The calculations necessary to convert the bed counts to inventory estimates are self-evident (fig. 1). These cards are summarized to give total inventories by species, seed lot, and contractor. Marginal punched cards maybe used to facilitate sorting by such categories as contractor, species, and nursery block. The cards are retained for reference by the nurseryman, who uses them to find the amounts of seedlings needed for specific orders, to record the amount of stock yielded by each bed, and thus to check on the accuracy of the inventory. As a rule during the past several years, the pack has overrun inventory by 2 to 5 percent.

Discussion

This procedure was developed largely from a study of colored aerial photographs of the Greeley Nursery made in September 1960.[6] These transparencies, at a scale of 100 feet to the inch, showed the possible gains in accuracy to be made by dividing the samples into at least two classes of stocking--heavy and light. For the 1960 inventory the nursery was stratified and stratum lengths determined entirely from these photographs. In 1961, several disasters combined to eliminate many parts of seedbeds and in an irregular manner. This created a problem in measuring population areas. The measuring wheel offered a less expensive and more flexible method than aerial photography. Thus, the present procedure was developed. Its effectiveness in the 1961 inventory prompted its use in 1962.

Since the estimation of sampling error is not an object of routine nursery inventories, the use of systematic sampling is often justified on the basis of sampling accuracy.[3] Nevertheless, it is not possible to use the data accumulated in such an inventory to make a statistically rigorous evaluation of sampling accuracy. A rough test has been made, however, by comparing standard deviations of the strata separated and combined. The results of this test are about what would be expected; the heavily (i.e. uniformly) stocked samples show lower standard deviations than the lightly (i.e. nonuniformly)

[5] Snedecor, G. W. Statistical methods. 5th ed. Iowa State College Press. Ames. 1956.

[6] The Weyerhaeuser Company cooperated in making the photographs.

stocked samples, while samples of both kinds generally, but not always, show lower standard deviations than the unstratified or combined samples.

The practical effectiveness of this sort of stratification depends heavily on the judgment and care of the team that measures strata and assigns sampling points. Unless this work is done well, single counts will be found in the lightly stocked samples that are higher than some of the counts in the heavily stocked samples from the same population. On the other hand, a population may be subdivided too minutely for practical purposes. The use of two rather than three or more strata is again a matter of practical expediency. Stratification enables the nurseryman to make a good estimate for the wellstocked parts of his beds. Here the bulk of his production is found; the remaining poorly stocked areas are inventoried separately so as not to impair the accuracy of the crop estimate.

That nursery inventory is more than a simple quantitative problem is of course, widely recognized. The only inventory that has much practical utility specifies numbers of plantable seedlings. Simple quantitative definitions of plantability can be drawn up and may be useful in some instances. Their usefulness is highly questionable in a nursery where seed from a wide range of altitudes and latitudes is used. At the Greeley Nursery, decisions as to plantability are left to the counters, who are experienced tree packers. This is not entirely satisfactory, because users of the seedlings have individual and variable standards of plantability, and the nursery management attempts to conform to these standards in packing. In any event, variable standards of plantability account for a large and unpredictable part of the discrepancy between inventory estimates and quantities of trees shipped.