Tree Improvement Comes of Age in the Pacific Northwest: Implications for the Nurseryman[1]

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Abstract.--Tree improvement programs in the Pacific Northwest have reached the stage of supplying limited, but ever increasing, quantities of genetically improved seed to nurseries for regional regeneration programs. With this seed comes opportunities as well as responsibilities for the nurseryman. This paper explores the role of the nurseryman in the capture, packaging and transfer of genetic gain potential in the integrated forest management system.

INTRODUCTION

The status of tree improvement today in the Pacific Northwest can be likened to a relay race. The tree improvement worker is nearing the end of the first lap, and is about to pass the baton onto the nurseryman. The handoff is critical, as is the race strategy. We are here today to give thought to both these elements, and to better understand how our concerted efforts will make our investment in tree improvement a winner.

In keeping with this theme, the objectives of today's presentation are threefold:

1) To briefly review the status of tree improvement in the region and its impact on regeneration programs.

2) To develop the concept of genetic gain, and its capture, packaging and transfer into an integrated forest management system.

3) To explore the role of the nurseryman in this system, and the opportunities he or she has to maintain or even enhance the gain potential of genetically improved planting stock.

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THE DEVELOPMENT AND STATUS OF TREE IMPROVEMENT IN THE REGION

Tree improvement programs, as we think of them today with selection, breeding, testing and seed production functions, started in the Pacific Northwest in the mid-1950's. By 1960, several Douglas-fir seed orchards had been established, representing both federal and private organizations. During the 1960's, few new orchards were established. However, with the 1970's came a surge of activity, such that by 1980 at least 82 orchards, representing more than one dozen species, had been established (Wheat and Bordelon, 1980). This has risen to an estimated 90 orchards today, for which Douglas-fir accounts for more than one half. There are approximately 1700 acres of Douglas-fir orchards, or about 75* of the total orchard acres for all species.

To support this very large production activity, much effort has been placed on selection of parents from natural stands. In the Douglas-fir region alone, close to 30,000 "Parent" or "Plustree" selections have been made. Douglas-fir accounts for about 26,000 of these. More than 700 genetic tests have been established, with the primary purposes of evaluating these selections as parent trees and/or providing advanced-generation selections.

Participation in tree improvement in the Douglas-fir region is broad-based, involving at least 40 private landowners, 1 Canadian and 3 U.S. federal agencies, 3 state agencies, 1 Canadian province and 3 universities. Although a few programs are independent, the

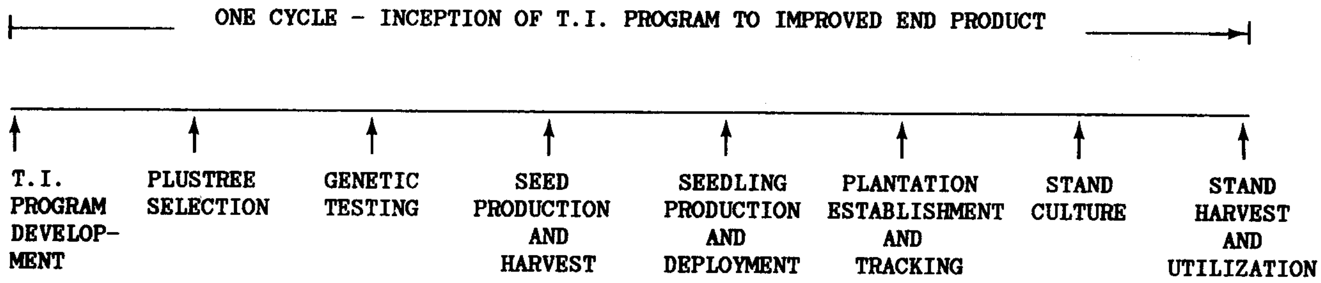

Figure 1.--Our key leverage points to capturing, maintaining or enhancing genetic gain potential.

We have many key leverage points at which we can capture, maintain and enhance genetic gain potential, from the time a tree improvement program is planned to the time the end product is utilized (Figure 1).

The first four leverage points, i.e. T.I. Program Development through Seed Production and Harvest, largely determine the amount of potential that can be captured. The last five, i.e. Seed Production and Harvest through Stand Harvest and Utilization, determine largely how much potential is maintained. The Seedling Production (Nursery) phase can also effectively enhance the potential, since the nurseryman manages populations of seeds and seedlings, and as such, can manipulate gene frequencies in a directed way. For today, we will restrict our discussions to those leverage points most directly affecting nursery management, i.e. Seed Production and Harvest, Seedling Production and Deployment, and Plantation Establishment and Tracking.

IMPACT OF SEED PRODUCTION SYSTEM ON NURSERY MANAGEMENT

Both gain potential and seed availability will impact the management of improved seed in the nursery, and both depend on the type of tree improvement program followed. Seed derived from a "Parent Tree" program (i.e. selected trees in natural stands used for seed supply) will probably become available sooner, have less gain potential and be less dependable in supply year-to-year as compared to seed derived from a seed orchard program. A clonal orchard typically will produce sooner, and with a higher gain potential, than a seedling seed orchard. A rogued orchard will have a higher gain potential than a non-rogued orchard but at the expense of total seed production at various times during the production period.

It is important to recognize here that a seed orchard is not simply a seed orchard, nor is the objective of an orchard simply to provide genetically improved seed. Rather, the orchard should strive to strike a balance between maximizing genetic gain potential and meeting planting stock requirements. The seed orchard and the seed it produces represent a very dynamic system. As the quantity of seed produced increases, so should the gain potential, due to the increasing ability to rogue inferior parents or selectively harvest from the best.

Perhaps the key leverage point at the seed orchard affecting the nursery system is seed harvest strategy. The strategy adopted for harvest sets the stage for the deployment strategy and directly affects nursery management practices. Some of the harvest options available to the orchardist include:

- whole orchard bulk mixes;
- specific mixes based on:
    - -- seed zone / elevation
    - -- tested vs. non-tested status
    - -- elite vs. average
- family level collections (i.e. seed from individual clones.

Whole orchard bulk mixes will result in the largest seedlot size possible, but will also have the lowest gain potential. As we progress down through the options we tend to decrease lot size (fewer parents or trees contributing per seedlot) but we also increase our ability to maximize gain potential. The orchard harvest strategy therefore will impact nursery management by determining seedlot size and gain potential, which in turn will affect nursery costs and practices.

THE ROLE OF THE NURSERYMAN IN MAXIMIZING GAIN POTENTIAL

Within the nursery system there are several key leverage points for maintaining or enhancing genetic gain potential. Among these include:

- ability to manage small lots
- potential to sow by family
- optimum utilization of improved seed - cost control
- tracking and follow-up

Small Lot Management

The ability to deal with small lots is essential to maximizing gain potential. As discussed earlier, there is a general inverse relationship between gain potential and lot size. Thus, smaller lots can be considered opportunities rather than liabilities, as is generally the case. Two questions the nurseryman must address are (1) what constitutes the minimum sized lot that can be efficiently managed operationally? and (2) what changes in nursery technology might be possible to change this? Answers to these questions will bear on the orchard harvest strategy chosen.

Family Sowing

Sowing by individual family represents the probable extreme case of small lot management with its associated high gain potential. In addition to this attribute, there are several other benefits from family sowings. By sowing "pure" families rather than mixtures of families, the chance for disproportionate culling could be avoided. Progeny test data have shown that some families, although excellent performers over time, start very slowly in the nursery. For example, families B and C in Table 2 ranked 40 and 39, respectively, of 45 in height at the end of the first year in the greenhouse. However, by year 8 of the field progeny test, they had risen to rank 2 and 3. Both would have been largely culled from a mixed lot after one year in the nursery, even though both proved superior performers in the field.

This example well illustrates how differential culling standards may be appropriate, particularly in those cases where subsequent field performance potential has been demonstrated. Differential culling standards here translates into improved yields, which means an increased contribution by superior families to the regeneration program.

Table 2.--Family performance rank in height over time. Weyerhaeuser Company Twin Harbors Progeny Test.

	Rank								
	After One Year in Greenhouse	Year in Test							
Family		1	2	3	4	5	6	7	8
A	27	14	9	8	3	2	2	1	1
B	40	40	22	6	4	3	1	2	2
C	39	20	5	7	7	7	8	3	3
D	29	7	2	1	1	1	3	4	4
E	5	2	4	2	2	4	4	5	5
W	45	45	45	44	43	43	43	42	41
X	37	38	38	40	41	41	41	41	42
Y	35	39	41	42	42	42	42	43	43
Check[1]	44	44	44	43	44	44	44	44	44
Z	42	41	43	45	45	45	45	45	45

[1]Check is mean of two field check seedlots.

Traits other than growth response, e.g. frost tolerance, susceptibility to herbicides, etc., also may be more observable when seeds are sown as families rather than mixes. Thus, family sowings become the key to identifying and managing unique opportunities or problems at the nursery stage.

Another benefit of family sowing is that it allows for the deployment option of family block plantations. While this option is practiced little in the Pacific Northwest, it is the main deployment strategy on large forest ownerships in the southeast United States. Limiting its use at present in the Pacific Northwest are the unknowns relative to opportunity and risk.

Optimum Utilization of Improved Seed

Perhaps the key leverage point in the nursery to maximizing genetic gain potential is the acceptance and use of a nursery system, including alternative stock types, which converts the most seed to plantable seedlings. While 100% oversow factors are not unusual in a conventional nursery program, we should not be content to lose one-half of our high cost, improved gain potential seed to nursery falldown and culling. While some level of culling will probably always be appropriate, other factors than genetic growth potential contribute to this falldown. Also, as Table 2 illustrated, genetic potential may not express itself yet in the nursery phase.

Economics of Improved Seed Utilization

In weighing the alternatives for improved seed utilization, the economics of the system must be considered. Decisions to maximize seed utilization are not "justifiable at any cost." One approach to economic evaluation is the <u>Present Value : Cost ratio,</u> an approach commonly used for long-term investment decisions in forestry. To determine a PV : Cost ratio, several factors must be considered and quantified.

- Incremental yields, i.e. how many more plantable trees per pound of seed are achievable.
- Incremental costs to produce this incremental yield.
- Estimated incremental gain of improved seed; which may vary by harvest strategy or level of improvement, and will be estimated by genetic test results.
- Estimated value, e.g. $'s/acre, of incremental gain; which may vary by site class and can be estimated from economic and growth and yield models.

Once these factors have been estimated, the PV : Cost ratio can be calculated. A hypothetical example follows:

<u>Incremental Cost Per Acre</u>

= (Trees per Acre/1000) x

(Incremental Cost per K Trees) x

(Improved Yield Factor)

= $10

<u>Incremental Value Per Acre</u>

Case I Improved Seedlot 1, Site I = $40

Case II Improved Seedlot 1, Site II = $30

Case III Improved Seedlot 2, Site I = $20

Case IV Improved Seedlot 2, Site II = $10

<u>PV : Cost Ratio</u>

Case I = 4 : 1

Case II = 3 : 1

Case III = 2 : 1

The calculated PV : Cost ratios must be then compared to values considered as investment decision thresholds by your organization. PV : Cost ratios equal to or above these thresholds would suggest a sound economic decision within your organization to improve. yields while accepting the increased associated costs.

Cost Control

While cost control is essential in any nursery operation, it has a special significance in maximizing genetic gain potential as it pertains to improved seed utilization. The lower the cost to produce a given stock type, the more opportunity there is to increase yields within given economic constraints. Reduced costs can directly impact the PV Cost ratio just described, thus potentially qualifying additional seedlots for the improved-yield system. For example, if the incremental cost per acre was reduced from $10 to $7, and the organization's threshold value for investment was 4:1, all Site II land would now qualify for Improved Seedlot 1 being grown in the improved-yield system. Genetic gain potential would be enhanced because a higher proportion of plantation acres would be impacted with improved seed.

Tracking and Follow-up

This leverage point is certainly not restricted to the nursery phase, as the genetic components of any seedlot must be trackable from the orchard through the nursery to the plantation, as well as from the plantation back to the orchard. Nurseries and plantations should be considered as extensions of the genetic testing program. Both time and number of traits measured are limited in genetic tests, and little or no testing is possible for unique and infrequent climatic events.

The nurseryman's role in this "extended testing" is vital. Not only must opportunities or problems related to improved seed be identified, but also they must be reported and followed up. Without this continual awareness by all those involved with improved stock, the genetic gain potential will most certainly be compromised.

CONCLUSIONS

Seed from tree improvement programs are becoming a major component of nursery sow programs in the Pacific Northwest, and within the next decade will become the exclusive component for many programs. Nurserymen are t part of the tree improvement effort and have e vital role in maintaining or enhancing the genetic gain potential of improved planting stock. Of the many opportunities for the nurseryman to impact genetic gain potential, perhaps his greatest contribution will be in optimizing the yields of improved seedlings. In so doing, he will positively effect the gene frequencies of desired traits in the integrated forest management system.

LITERATURE CITED

Cafferata, Stephen L., 1985. Douglas-fir stand establishment overview -- Western Oregon and Washington. In Proceedings, Douglas-fir: stand management for the future. University of Washington, Seattle. (In Press)

Wheat, Joe and Mike Bordelon. 1980. Seed Orchards of Western Oregon, Western Washington, Northern California and British Columbia. Industrial Forestry Association, Olympia, Wash.

Wheat, Joe and Roy Silen. 1982. 1982 progress report for the **IFA-PNW** cooperative tree improvement programs. Industrial Forestry Association, Portland, Ore. 29 pp.