Tree Planter's Notes, Vol. 38, No. 3 (1987)

Tree Improvement Comes of Age in the Pacific Northwest—Implications for the Nursery Manager

Richard F. Piesch

Manager, Western Tree Improvement Operations, Weyerhaeuser Forest Products Co., Centralia, WA

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 come opportunities as well as responsibilities for the nursery manager. The nursery manager plays an important role in "capturing," packaging, and transferring the potential for genetic gain in the integrated forest management system. Tree Planters' Notes 38(3): 3-8; 1987.

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 nursery manager. The handoff is critical, as is the race strategy. We need 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 this paper 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 nursery managers in this system and their opportunities to maintain or even enhance the potential of genetically improved planting stock.

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—by 1980 at least 82 orchards, representing more than a dozen species, had been established (3). There are about 90 orchards today, with about half of them growing Douglas-fir. Douglas-fir orchards cover about 1,700 acres, 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, with about 26,000 of them Douglas-fir. 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 federal and 3 U.S. Federal agencies, 3 State agencies, 1 Canadian province, and 3 universities. Although a few programs are independent, the majority are involved in IFA-PNW cooperatives (4).

The programs vary widely in their approaches, with different selection intensities, different approaches to seed production, and different levels of management and support. These differences in themselves have an impact on nursery practices and the management of improved seed, and will be discussed later in this paper.

Paper presented at the Combined Western Forest Nursery Council and Intermountain Nursery Association Meeting, August 12-15, 1986, Tumwater, WA

The Impact of Tree Improvement on Regeneration Programs

In western Oregon and Washington, more than 11 million acres are covered by a tree improvement program (1); in coastal British Columbia, more than 2 million acres (2). Each year, out of this 13 million total, about 263,000 acres are replanted.

The impacts of genetically improved seed on this annual planting stock requirement for some major programs are given in table 1. The situations of other programs not listed range from having no improved seed yet available to fully meeting their current planting stock requirements.

As shown in table 1, nursery managers will be having a progressively higher proportion of genetically improved seed coming through their nurseries in the near future.

Genetic Gain: Its Integration into a Forest Management System

To better understand what "improved" seed means to nursery managers, we need to understand the concept of genetic gain and its integration into a forest management system. Because genetic gain is integral to tree improvement, the goals of tree improvement must be defined. We can think of these goals as three interrelated functions:

1. To realize potential for genetic gain.
2. To "package and transfer" this potential into a regeneration system.
3. To optimize the benefits of this potential in terms of product value, throughout the nursery, stand culture, harvest and utilization phases.

Two points need to be stressed here. First, we are dealing with potential for gain. We may capture it at one stage, only to lose it at another. Thus, the onus of maintaining the potential for gain transfers from the tree improvement worker to the nursery manager, to the silviculturist and to the forest land manager, much like the example of the relay race cited in the introduction. Secondly, we use the word "optimize" rather than "maximize." Implicit in this distinction is the knowledge that economic constraints should and will play a role in seeking tree improvement benefits, a point that will be further developed later in this paper.

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

The first four leverage points —tree improvement program development through seed production and harvest—largely determine the amount of potential that can be captured. The last five-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, because the

Table 1—*Impact of improved seed on regeneration programs for several representative organizations in the Douglas-fir region*[a]

Programs	Current levels Acres	Current levels % PSR	Future projections Acres	Future projections % PSR	Future projections Year
IFA-PNW co-ops	18,000	12[b]	120,000	75	1995
(gov't. & private)	80,000	50[c]	160,000	100	2000
British Columbia					
(gov't. & private)	9,900	29	30,000	85	1995
Weyerhaeuser	19,000	62	40,000	100	1992

[a]Acres regenerated with improved stock and percent of total annual planting stock requirements (PSR).
[b]Five-year average through 1984.
[c]Projected 1986 sowing only. Reflects expectations of an exceptional cone crop for 1985.

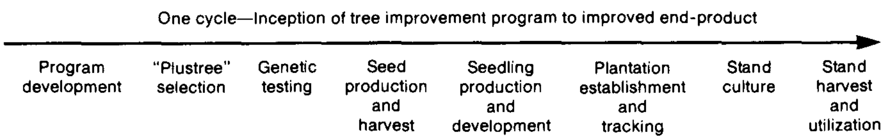

Figure 1—*Key leverage points to realizing, maintaining, or enhancing the potential genetic gain.*

nursery manager 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, that is, seed production and development, and plantation establishment and tracking.

Impact of Seed Production System on Nursery Management

Both potential for gain and seed availability will affect the management of improved seed in the tree improvement program followed. Seed derived from a "parent tree" program (that is, selected trees in natural stands used for seed supply) will probably become available sooner, have less potential for gain, and be less dependable in supply year-to-year than seed derived from a seed orchard program.

A clonal orchard typically will produce sooner, and with a higher potential for gain, than a seedling seed orchard. A rogued orchard will have a higher potential for gain than an unrogued 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 potential for genetic gain 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 potential for gain, 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 development strategy and directly affects nursery management practices. Some of the harvest options available to the orchardist include:

1. Whole orchard bulk mixes.
2. Specific mixes based on: seed zone/evaluation, tested versus untested status, elite versus average.
3. Family-level collections (that is, seed from individual clones).

Whole-orchard bulk mixes will result in the largest seedlot size possible, but will also have the lowest potential for gain. 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 potential for gain. The orchard harvest strategy therefore will affect nursery management by determining seedlot size and potential for gain, which in turn will affect nursery costs and practices.

Role of the Nursery Manager in Maximizing Gain Potential

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

1. Ability to manage small lots.
2. Potential to sow by family.
3. Optimum utilization of improved seed.
4. Cost control.
5. Tracking and follow-up.

Small lot management. The ability to deal with small lots is essential to maximizing potential for gain. As discussed earlier, there is a general inverse relationship between potential for

Table 2—*Changes in height performance rank of the fastest and slowest growing families (total = 45) of Douglas-fir seedlings in the Weyerhaeuser Twin Harbors progeny test*

	Performance rank								
	After 1 yr	After indicated years in test							
Family	in greenhouse	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	44	44	44	43	44	44	44	44	44
Z	42	41	43	45	45	45	45	45	45

The check value is the mean of two field check seedlots.

gain and lot size. Thus, smaller lots can be considered opportunities rather than liabilities, as is generally the case.

Two questions the nursery manager must address are: a) What constitutes the minimum size lost that can be efficiently managed operationally? and b) 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 potential for gain. In addition to this attribute, there are several other benefits from family sowings. By sowing "pure" families rather than mix- tures 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 test, they had risen to rank 2 and 3. Both would have been largely culled from a mixed lot after 1 year in the nursery, even though both proved superior performers in the field.

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

Traits other than growth response, for example, 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 development option of family block plantations. While this option is little used 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 potential for genetic gain in the acceptance and use of a system, including alternative stock types, that converts the most seed to plantable seedlings. Although 100% oversow factors are not unusual in a conventional nursery program, we should not be content to lose half of our high-cost seed with improved potential for gain to nursery fall-down and culling. Even though some level of culling will probably always be appropriate, other factors than potential genetic growth contribute to this fall-down. Also, as shown in table 2, 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 present value/cost ratio, 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, that is, 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, for example, dollars per 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:

Incremental cost per acre
= (trees per acre/1000) x (incremental cost per 1000 trees) x (improved yield factor)
= $10.

Incremental value per acres
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.

PV/cost ratio
Case I = 4:1.
Case II = 3:1.
Case III = 2:1.
Case IV = 1:1.

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. Although cost control is essential in any nursery operation, it has a special significance in maximizing potential for genetic gain 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 I being grown in the improved-yield system. Potential for genetic gain 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, for 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 nursery manager'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, achievement of the potential for genetic gain will most certainly be compromised.

Conclusions

Seed from tree improvement programs are becoming a major component of nursery sowing programs in the Pacific Northwest and within the next decade will become the exclusive component for many programs. Nursery managers are a part of the tree improvement effort and have a vital role in maintaining or enhancing the potential for genetic gain of improved planting stock. Of the many opportunities for nursery managers to help capture potential for genetic gain, perhaps their greatest contributions will be in optimizing the yields of improved seedlings. In so doing, they will positively affect the gene frequencies of desired traits in the integrated forest management system.

References

1. Cafferata, Stephen L. Douglas fir stand establishment overview western Oregon and Washington. Douglas-fir stand management for the future. Institute of Forest Resources Contrib. 55. Seattle: University of Washington; 1986.
2. Konishi, J. Personal communication. British Columbia Forest Service, Reforestation Division, Victoria, BC. 1986.
3. Wheat, Joe; Bordelon, Mike. Seed orchards of western Oregon, western Washington, northern California, and British Columbia. Olympia, WA: Industrial Forestry Association; 1980.
4. Wheat, Joe; Silen, Roy. 1982 Progress report for the IFA-PNW cooperative tree improvement programs. Portland, OR: Industrial Forestry Association; 1982. 29 p.