

OPEN-POLLINATED FAMILY MANAGEMENT IN NURSERIES

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Carlson W.C. 2003. Open-pollinated family management in nurseries. In: Riley L.E., Dumroese R.K., Landis T.D., technical coordinators. *National Proceedings: Forest and Conservation Nursery Associations—2002*. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. *Proceedings RMRS-P-28: 151–158*. Available at: <http://www.fcnet.org/proceedings/2002/carlson.pdf>

Key Words

Genetic variation, target seedlings, crop uniformity, bud dormancy, cold hardiness, water stress, RGP

INTRODUCTION

Increasing the genetic specificity of seed sown in forest nurseries has been occurring for several decades. The first step was to collect seed from specific stands identified by geographic location and elevation (Munger and Morris 1936; Wakeley 1944; Isaac 1949). Over the past 25 years, seed orchards have come on line.

Availability of seed from these categories of genetic specificity allows nursery managers to have a fundamental decision in how to sow their seed. Sowing by family offers advantages in both nursery management and reforestation. Nursery management has traditionally only controlled aspects of chemical and physical environment. Sowing by family allows genetics to become a management tool. Reduced variance within family can lead to improvements in uniformity of nursery crops and improved yield of wood having known characteristics in the forest.

THE NATURE OF VARIATION AMONG OPEN-POLLINATED FAMILIES

Given that the relationship shown in Figure 1 is well accepted, the next question is what level of variation will be observed. Weyerhaeuser Company started

sowing loblolly pine by open-pollinated family in 1981. We have done extensive testing of the variation in many traits. Figure 2 shows variation in height growth activity between a slow growing southeastern Oklahoma seed source and a fast growing North Carolina Coastal (NCC) family growing under low or higher water stress conditions. Note that in low stress, both had 100% of the population with 3 growth flushes. Oklahoma source seedlings dropped to 57% of the population having a fourth growth flush while the NCC family had 80% in the fourth growth flush. Neither had a fifth flush. In high stress conditions, the Oklahoma source dropped to 70% of the population in the second flush and then to 0% in the third. The NCC had 93% of the population in the second flush under stress with 8% having 4 growth flushes. It is apparent that there is considerable genetic variation in response to drought, nutrition, and irrigation.

If one were managing the seedlings referred to in Figure 2 in one irrigation unit in a nursery, then one would expect considerable variation in response to water stress used as a management tool. Managing them in separate irrigation units would allow differential irrigation to be used to reduce variation in the seedlings produced. Genetic variation affects the



Figure 1. Genetics and environment control physiological processes which determine rate, timing and duration of growth.

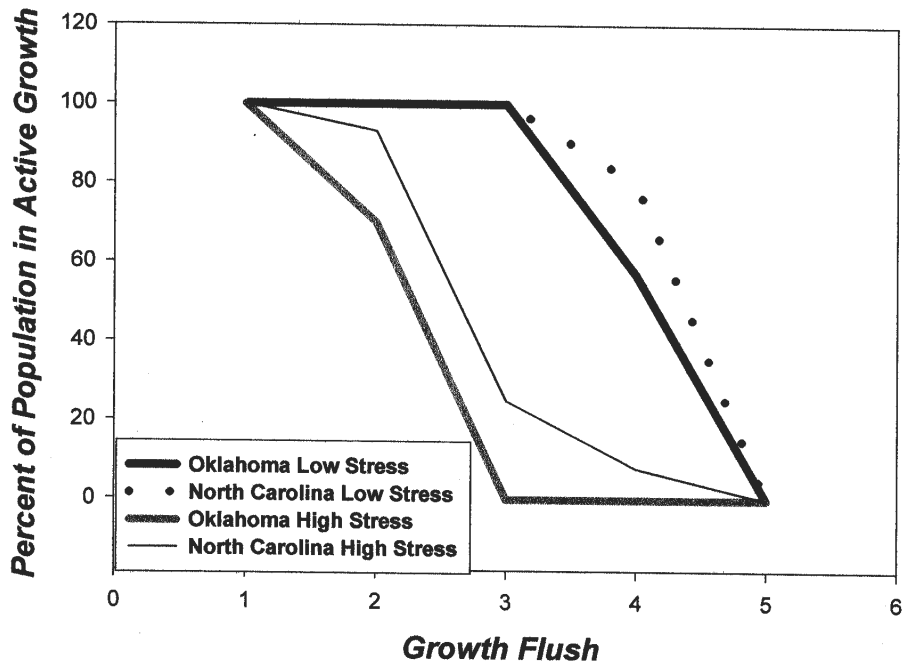


Figure 2. Comparison of height growth response to water stress between a southeastern Oklahoma seed source and a North Carolina Coastal OP family. Low stress seedlings were drip irrigated daily. High stress seedlings were irrigated once at planting then left for the season. Experiment was done under a roof to prevent rainfall from reaching seedlings. Soil was a coarse sand. Water potentials dropped throughout the experiment in the high stress seedlings. They reached predawn water potentials of <-1.2 MPa, whereas low stress seedlings were >-0.3 MPa.

outcome of what nursery managers do. They can improve their products by managing with knowledge of that variation.

Genetic variation occurs in most traits, but one must know if the differences are critical to management. In the early 1980s, it was suggested that differences in bud dormancy status would drive differences in seedling root growth potential (Ritchie and Dunlap 1980). We observed considerable family variation in bud dormancy status (fig. 3) and therefore concluded that we needed to understand if this would cause variation in lifting date and storage responses in root growth potential (Carlson 1985).

Bud dormancy could be released equally well by chilling in a seedling cooler after lifting, or by leaving the seedlings outdoors in the nursery bed (van den Driessche 1977; Carlson 1985). Comparing root growth potential of seedlings receiving their chilling requirement for release of bud dormancy either in storage or outdoors gave very different results (fig. 4). It was apparent that bud dormancy status was not the controlling factor driving root

growth potential. This is an example where considerable genetic variation occurs, but that difference is not critical to nursery management decisions.

Root growth potential (RGP) varies by family and by the temperature at which the test is done (Nambiar and others 1979; Carlson 1986). Figure 5 shows the nature of family variation in loblolly pine RGP at 3 soil temperatures. This points out that the commonly used root growth potential test is a simple index of physiological status at the time of the test rather than an estimator of number of roots anticipated upon field planting where, for example, soil temperatures would differ substantially. Figure 6 shows that similar family variation in root growth occurs under field conditions after planting.

FAMILIES CAN BE SORTED INTO RESPONSE GROUPS

Does genetic variation between families mean that we need to manage each one separately in the nursery? The critical biological variables for nursery

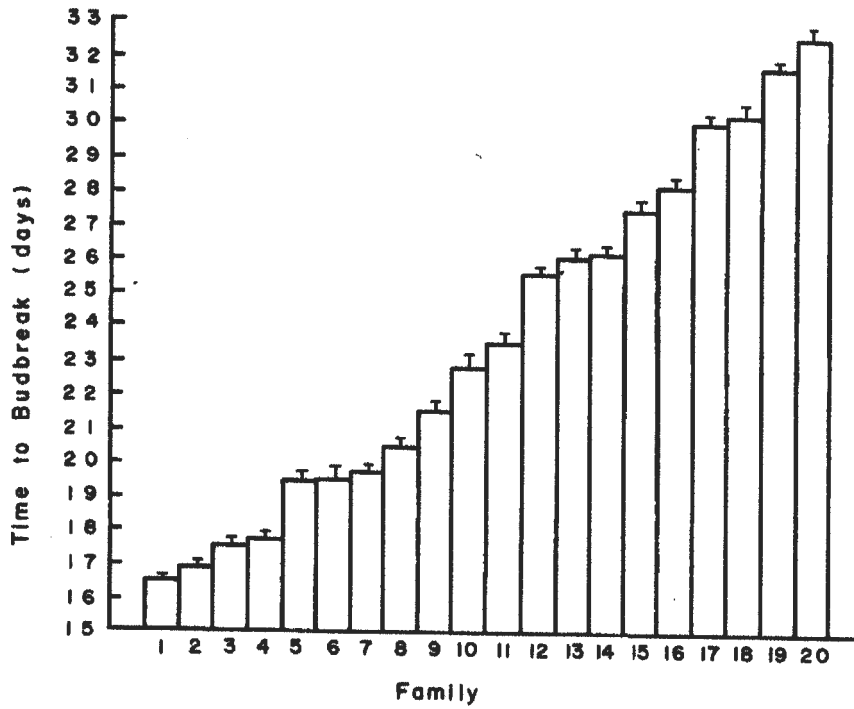


Figure 3. Bud dormancy status of 20 open pollinated families of loblolly pine measured as time to bud burst under warm long day conditions. Differences were highly significant at 207 chilling hours (November 23) but became non-significant as chilling released buds from dormancy at 1234 chilling hours (from Carlson 1985).

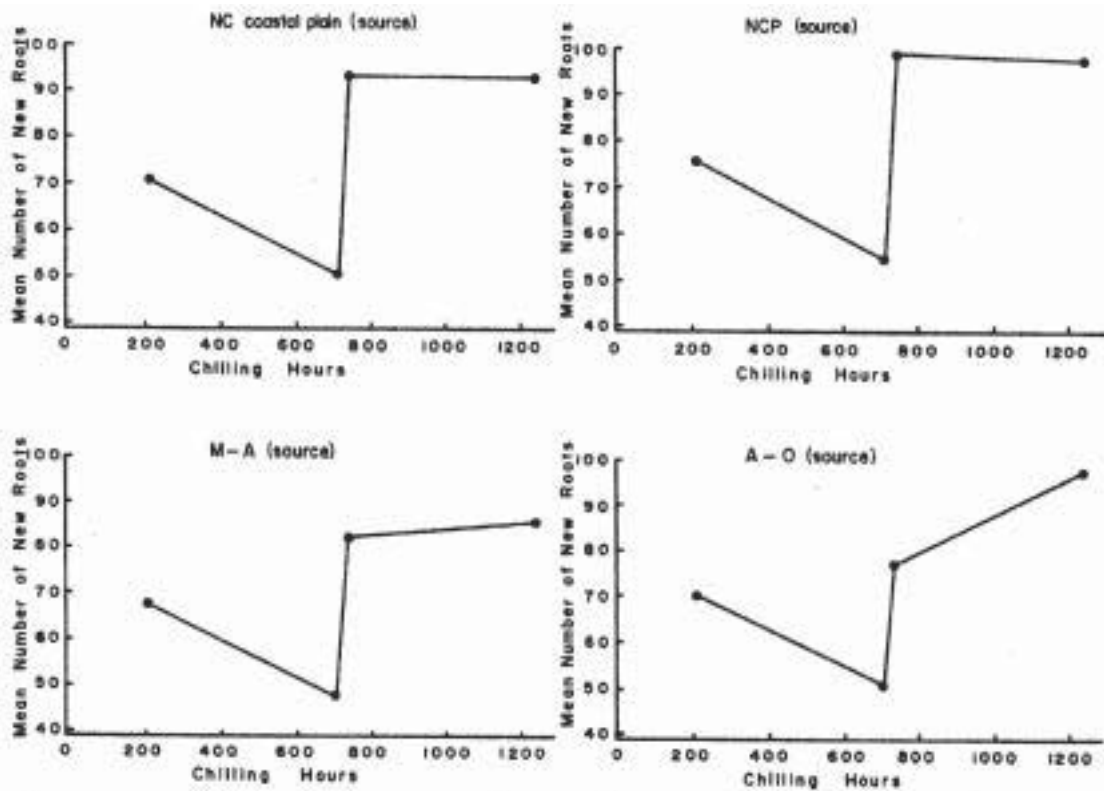


Figure 4. Changes in root growth potential with storage at 2 different points in bud dormancy release as indicated by chilling sums. Results are averaged over families for each seed source but represent the same families shown in Figure 3 (from Carlson 1985).

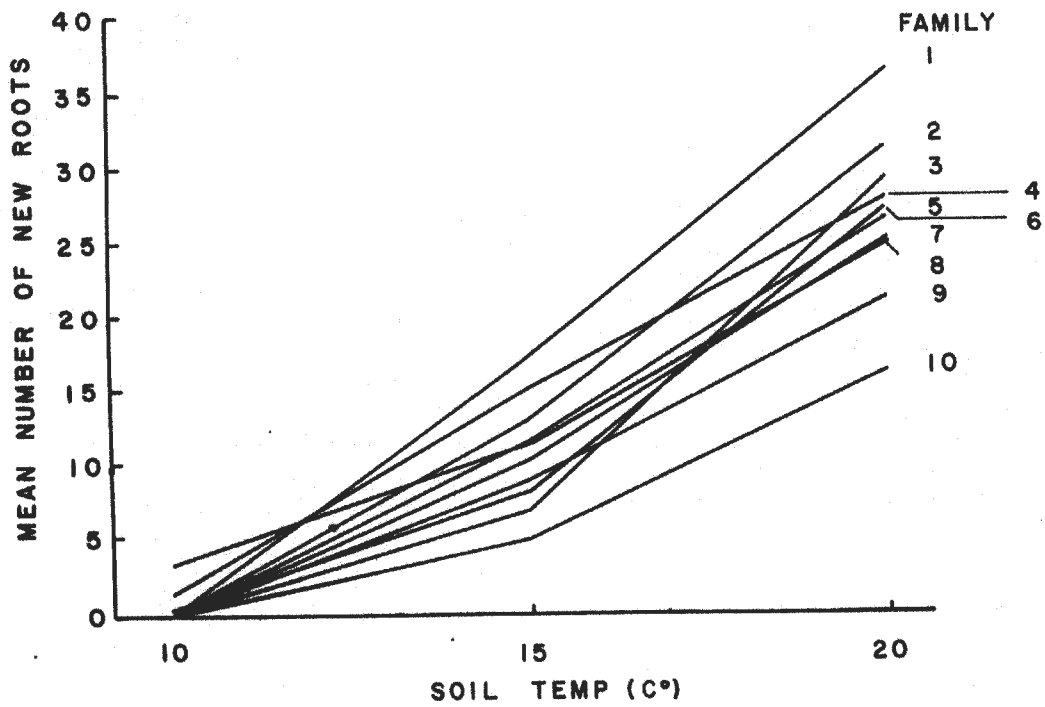


Figure 5. Root growth potential varies with family and the soil temperature at which the test is done.

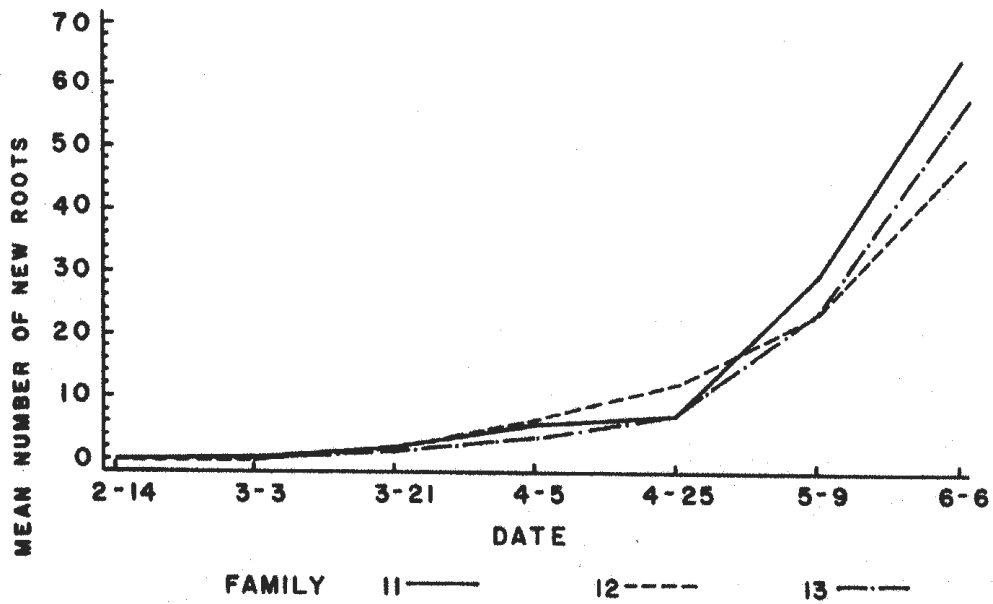


Figure 6. Families also vary in their root growth after outplanting. Ranking changes with time and probably with the soil temperature of the site.

culture are germination rate and height and diameter growth rate. If one considers the alternatives, the choice is to harvest and handle seed orchard produced seed in bulk mixes or as separate families. If you sow a bulk mix, it will have the same range in variation as the group of families would have collectively. We therefore can conclude that all the families will have ranges that are subsets of what would be observed with a mix. For example, take the pattern of shoot growth. Loblolly pine has the capacity to multiple flush in the growing season. The first flush of growth after germination ends in a budset that generally occurs in mid-August (fig. 7). Families differ in what proportion of the family enters another growth flush and when that flush ends. There are 4 types of budset patterns that occur, but most families are in either the "early" or "late" budset groups. These budset pattern groups are typical of nursery management response groups. Whereas there can be many families present in a nursery, they can be separated into a few

management response groups for the variables that affect crop development.

RESPONSE GROUPS CAN BE DIFFERENTIALLY MANAGED TO MEET COMMON TARGETS

These response groups can then be sown in different irrigation units to facilitate differential management (fig. 8). Selection of the location of response groups on the nursery should consider the relative point in crop rotation. Slower developing response groups with more conservative phenology might be selected for sowing in first year post fumigation soil; whereas, the most rapidly developing groups might be targeted for fields that are further along in the soil rotation. Irrigation, fertilization, root wrenching/pruning, and so on can then be differentially applied to guide the response group into the target morphology and physiology.

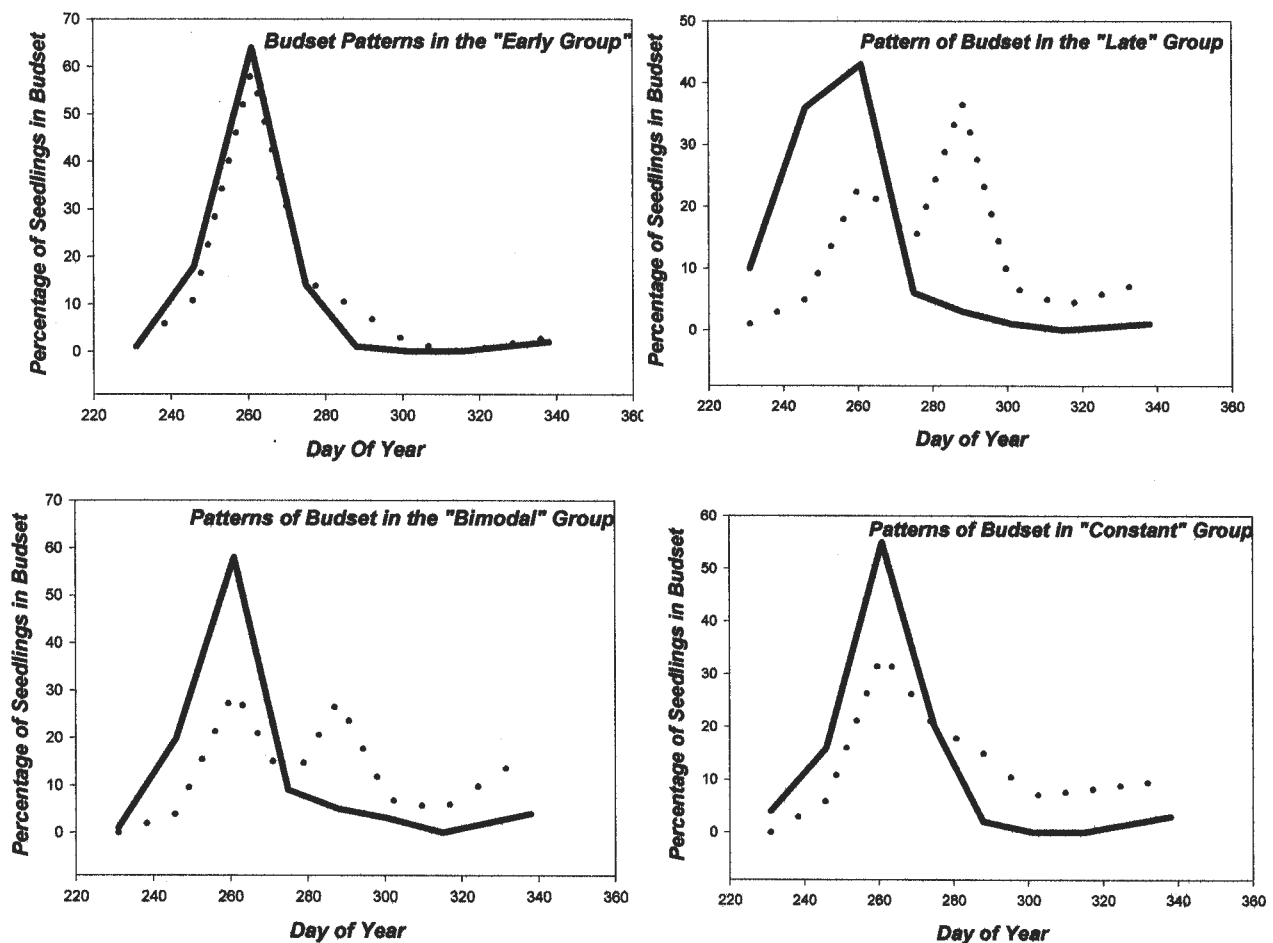


Figure 7. Budset patterns in 1+0 loblolly pine families growing in bareroot nursery beds.

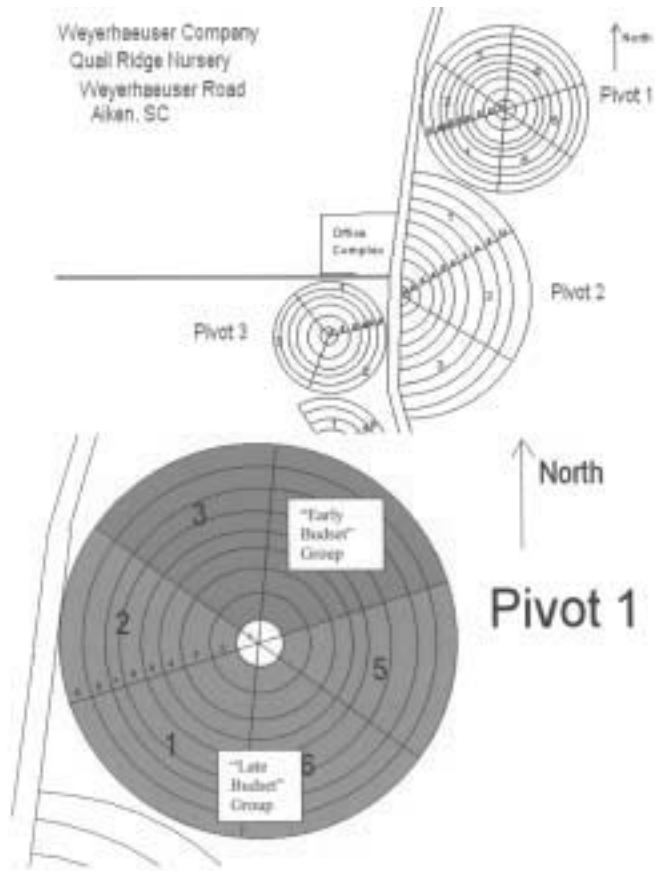


Figure 8. Response groups applied to sowing Pivot 1 of Weyerhaeuser's Quail Ridge Nursery. If a group is very large, it could be an entire pivot in size or it could be as shown here in one or more blocks. Individual families are seldom more than a few units in size. Each unit within a block is 25 to 28 nursery beds wide.

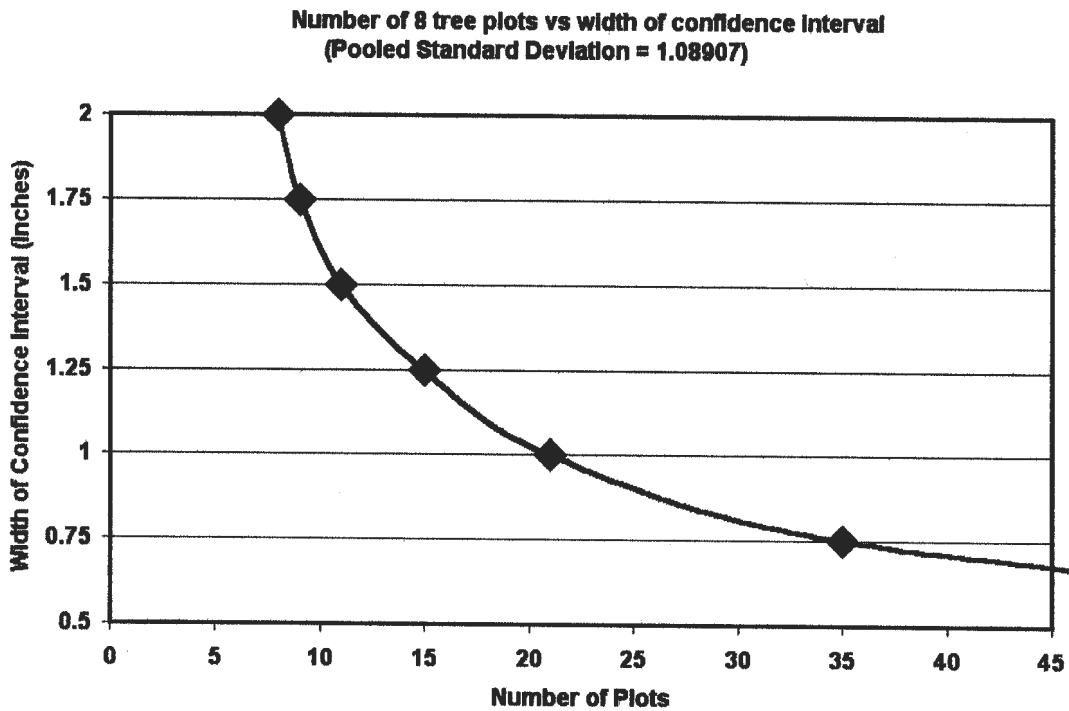


Figure 9. The influence of number of sample plots on width of 95% confidence interval for height in loblolly pine 1+0 bare root seedlings. (Figure provided by John Browning, Weyerhaeuser Company.)

Collaboration of foresters and researchers is necessary to set the criteria for target seedling morphology and physiology (Rose and others 1990). Managing differentially toward a common target is critical to achieving quality goals. Use of target growth curves and seedling sampling through the year can allow growers to make proper decisions on which portions of the crop need acceleration and which need holding back. Stratified sampling of nursery areas should be done understanding the required number of plots/strata necessary to achieve a planned confidence interval around the mean of the variable to be measured. Figure 9 shows a typical relationship for sampling height in loblolly pine.

Growers need to understand size distributions for seedling populations before making a management decision. Cumulative frequency graphs done at each

sampling date allow one to visualize how the population looks against target at any point in development (fig. 10).

SUMMARY

Managing open-pollinated families in conifer nurseries is a positive step in reducing nursery variation. A combination of nursery experience and research can separate the families into response groups that will simplify the process. Once response groups are chosen, all nursery management decisions can be used to help meet targets for each group. This would include selection of the field in which to sow the groups, sowing date, fertilization, irrigation, and root cultural practices. Crop monitoring by stratified sampling can be used to understand crop development and guide management decisions.

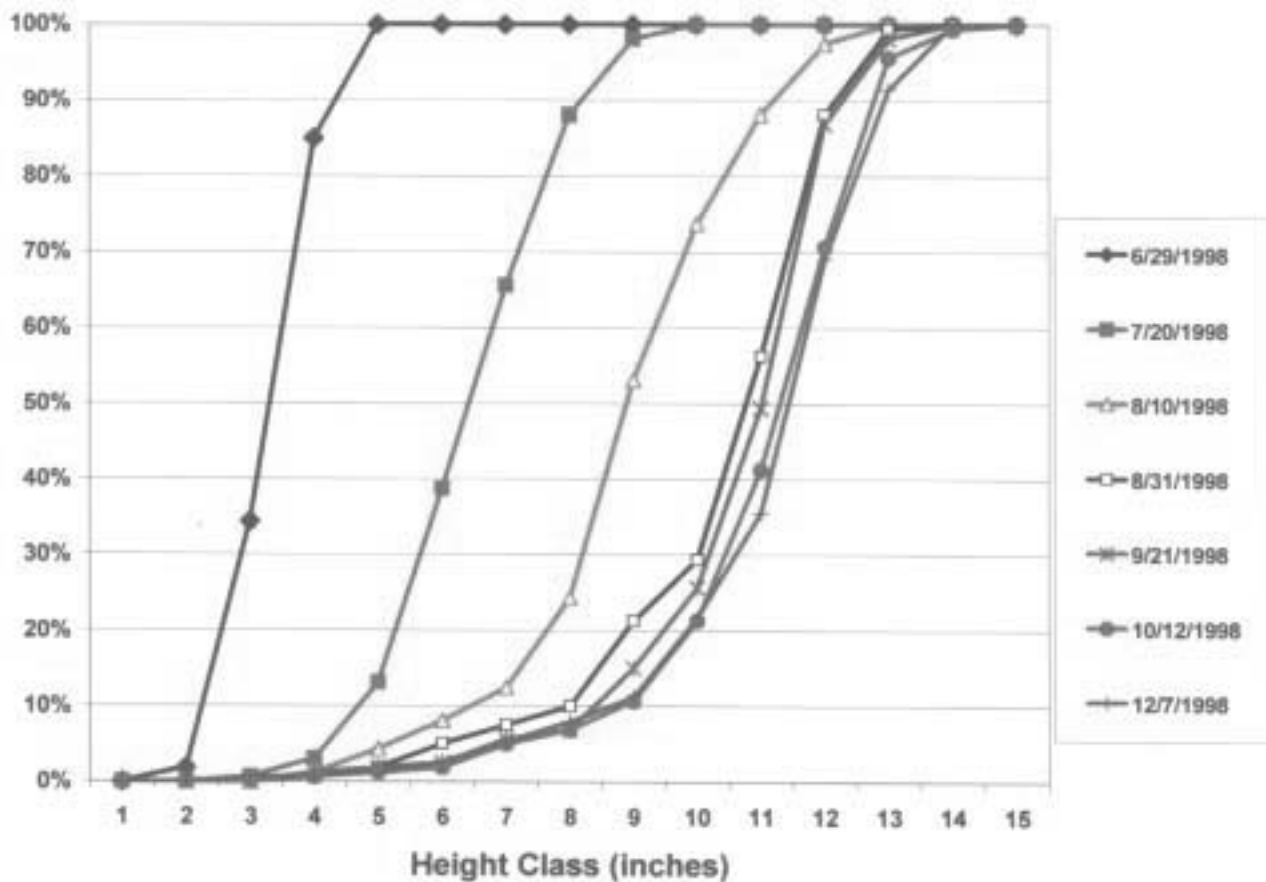


Figure 10. Cumulative frequency distributions for height in a loblolly pine bare root 1+0 seedling crop by sampling date. (Figure provided by John Browning, Weyerhaeuser Company.)

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