FORESTATION CONCEPTS AND PRACTICES

DEVELOPING IN NEW ZEALAND[1]

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In New Zealand government and industry are developing a new nursery system backed by substantial research facilities and budget. Beds of radiata pine are precision sown and thinned to square spacing of 7 x 7 cm. This permits "box pruning" which is horizontal undercutting plus vertical root pruning along and across the bed. When lifted, a box-pruned seedling retains virtually all of its roots, and almost every tree is shippable. Since culling and counting are not necessary seedlings can be lifted and packed in the field, eliminating the need for a packing shed. Reduction in exposure and handling of seedlings increases plantation survival and initial growth, and promises to reduce rotation age by 1 year and decrease nursery costs.

Radiata pine of all ages has been successfully propagated from cuttings.

In August 1979, I attended an International Union of Forestry Research Organizations workshop in New Zealand on "Techniques for Evaluating of Planting Stock Quality." I toured facilities where new concepts and products in forestation are being developed to meet New Zealand needs. Some of these practices seem applicable in this country.

New Zealand currently has about 750,000 h of planted radiata pine. This single, introduced species has become the major basis of New Zealand wood production for domestic consumption and export. Radiata pine is very fast growing in New Zealand, with a first thinning and pruning at age 7 and a rotation age of between 27 and 30 years. Final tree sizes are 60 cm in diameter and 30 m tall. On the best New Zealand sites, radiata pine reaches 40 m in 20 years. Because of New Zealand's distance from major international markets, New Zealanders need to raise trees very cheaply and efficiently. Hence, they invest a great deal of money and manpower in forestry research.

Slide 1. The federal Forestry Research Institute at Rotorua is engaged in many projects, but a great deal of effort is spent improving nursery practices. This is the only nursery I know of devoted solely to research.

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Slide 2. New Zealanders are developing a comprehensive regeneration system which begins in the nursery and is followed through transportation, planting, and aftercare. The concept begins with square spacing in the nursery beds. This is in contrast to conventional beds in which seedlings are much closer within the row than between rows. Research at Rotorua is in progress to determine the spacing necessary to produce the desired seedling.

Slide 3. Square spacing of these seedlings increases from 3 x 3 cm to 10 x 10 cm left to right. At present, it looks as though 7 x 7 cm spacing is optimum for radiata pine. [3]Square spacing is achieved by seeding precisely and thinning. For seeding the Ojyard seeder is used, which is good, but not perfect. Of course, the seed is also good, but not perfect. After germination, the beds are thinned. This expensive hand operation has not yet been mechanized, but at the moment it is the only way to achieve square spacing.

Slide 4. The purpose of square spacing is twofold: First, it enables the seedling to make very efficient use of the available space. Second, it permits "box pruning," which is pruning the root system of each seedling on 4 sides and the bottom. Undercutting and along-the-row pruning have been mechanized, but across-the-row root pruning has not.

Slide 5. Undercutting is for the purpose of developing a fibrous and compact root system in the soil zone that will be lifted. Undercutting severs the taproot cleanly. It is done with a thin, sharp blade on a reciprocating undercutter. The blade is similar to a bandsaw blade and is changed at the end of each row. Undercutting does not lift the seedlings. When undercut at a depth of 10 cm, you can barely see the tops wiggle as the blade passes under them. All radiata pine at Rotorua is raised as 1-0, and undercutting is generally done twice, first at a 10 cm depth, and later at 12-15 cm.

Slide 6. By switching to a heavy blade and tilting it about 20°, this same machine can be used for "wrenching." The wrenching blade need not be particularly sharp, because it does not cut anything. It passes completely under the seedlings, lifts them and the soil, loosening the root to soil contact. The purpose is to stress the seedling to stop the terminal elongation and enable the seedling to better withstand subsequent stress especially after outplanting.

Slide 7. A box pruned seedling is lifted with virtually all of its roots intact in a compact volume that can be planted with little root damage. There are no long stringy roots that need to be pruned at packing to prevent a poor planting.

Slide 8. In the New Zealand climate, radiata pine behaves similarly to southern pine. That is, it can be planted successfully with comparatively few roots compared to the shoot. If you look carefully at the seedling in this slide, you can see the two levels where it has been undercut. The pencil indicates the lowermost point of undercutting. The first cut was about 5 cm above that, immediately below the major horizontal spray of roots. Seedlings are first undercut at a shallow depth and later undercut somewhat deeper.

In North America, there seems to be disagreement among nurserymen as to the value of wrenching, and I can suggest several reasons why this is the case. First, not all nurseries have the proper equipment. A reciprocating undercutter is essential

[3]The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

for both undercutting and wrenching. Second, the soil must be suitable. The soil at Rotorua is a very friable volcanic ash soil with few rocks and very little sticky clay in it. Because of the soil, I see many difficulties in developing proper wrenching regimes at nurseries like Lucky Peak at Boise or Big Sioux Conifer Nursery at Watertown. Third, the timing of undercutting and wrenching must be in accord with the physiology of the tree. It is not possible to take the New Zealanders' schedule, transpose seasons to the northern hemisphere, and apply the schedule mechanically. Each species grown and nursery location may need research to develop an appropriate schedule.

Slide 9. A crucial aspect of the New Zealand concept is the reduction of seedling handling in the nursery, during transportation, and in storage. This has both biological and economic advantages. Having been thinned and box pruned by the time the seedlings are ready to be lifted, virtually every seedling is shippable. Thus, there is no need to grade and count them. The number of trees shipped can be computed from how many meters of bed are lifted. The seedlings can be packed in the nursery bed as they are lifted. The seedlings are packaged in rigid boxes which protect the seedlings from crushing. This eliminates broken buds and bruised tissues which release metabolites and encourage the growth of pathogens. The boxes filled with seedlings at the nursery bed are placed in insulated coolers and shipped to storage or to the field. At the planting site, the shipping box is clipped onto the planter's belt, becoming the planting box.

Slide 10. Shipping and storage containers are insulated but not refrigerated. Seedlings are not stored for more than a few weeks, often only a day or two. The weather is cool, usually cloudy, and frequently rainy during the shipping and planting season, so this method of storage has proven quite satisfactory. However, it could be readily adapted to refrigerated or frozen storage.

Slide 11. New Zealand foresters have good reason to believe that their proposed system will produce better trees in a shorter period of time. On the right side of the picture are trees produced and planted by the current operational system. That is, trees are lifted in the field, taken to a shed for culling, root-trimming, and packing into bags. Then they are stored and shipped out to the field for planting. On the left are seedlings that have been thinned, box pruned, and packed into boxes at the nursery bed and outplanted from these same boxes. Survival and growth of this group are clearly superior to those handled by the current system. This entire plantation was put in by the same planting crew.

Slide 12. Other plantings show the same comparison. These seedlings were packed in bags in the shed.

Slide 13. These seedlings were packed at the bed. Not only does the survival increase, but equally important is the increased growth that may shorten the rotation by a year.

Now with all this research, you would think that the new techniques would be quickly and readily adopted by the operational nurseries. However, as in other parts of the world, especially government operations, this is not necessarily the case.

Slide 14. Here we are at the Kaingaroa Nursery, which grows radiata pine seedlings for the Kaingaroa Forest. Notice that these seedlings do not look quite as good as the ones grown at the research nursery in Rotorua, partly because this nursery is 300 m higher in elevation and most of the stock produced is 2-0.

Slide 15. The spacing is not very uniform. The seedlings are not as large or as good in color.

Slide 16. The range of seedlings lifted at the nursery runs from excellent to just passable.

Slide 17. In the packing shed I saw much unnecessary root exposure. Fortunately, it was a cool, cloudy day.

Slide 18. After the trees are selected and bundled, the roots are pruned; thus maximizing the shock to the tree. This operation could be eliminated by box pruning.

Slide 19. The seedlings are assembled in half 15 gallon barrels,

Slide 20. And unceremoniously dumped into plastic bags, Slide 21.

Which are then moved by a rather ingenious conveyer,

Slides 22 & 23. Into a storage facility, which is well insulated, but not mechanically refrigerated.

Slide 24. New Zealand foresters do train their planters, however, and some of the devices for doing so might well be emulated. Here is a cartoon showing how to do everything wrong. I'm sure most of you already know the techniques.

Slide 25 & 26. Next, an illustration of how to do it right, starting with thinning in the nursery, packing in the bed in rigid boxes, storing the boxes in a large insulated container which is handled mechanically, and planting from the boxes at the planting site. Stress is layed on minimizing handling and exposure.

Slide 27. This is supplemented by photographs showing do's and don'ts.

Slide 28. Another aspect of raising radiata pine is that it can be propagated vegetatively.

Slide 29. Cuttings from trees under 7 years of age root readily in the field. Government and industrial foresters are using this method to extend the propagules of superior trees for commercial operations. The New Zealand climate and tree species permit this, but I doubt that it would be successful with most of the species we grow in the United States.

Old radiata pine, however, do not root readily, and rooting has all of the problems encountered with many other pine species. Researchers at Rotorua have found a way to root scions successfully, however. First, branch tips are girdled after shoot growth has been completed in mid-summer. The girdle is waterproofed with vaseline and covered with aluminum foil. This is not an air layer, however. The scion will callus at the base, but not root. At the same time, major buds are picked off the scion.

Slide 30. About 4 weeks later, after the girdle is well calloused and new small buds have developed on the terminal, the scion is cut and transferred to a small bedhouse covered with white poly. The scions overwinter unrooted. In the spring, rooting occurs, as well as bud break. After the scions appear to be established, they are lifted and the roots pruned back to within a few millimeters of the original callus, placed in jiffy pots and allowed to root again. This time they produce roots that are functional and have normal anatomy. When the roots penetrate the jiffy pots, they are considered ready to go to the field. I am testing this technique on Scotch pine and ponderosa pine, and will know in another year whether or not it will work.

Slide 31. It certainly works for radiata pine. One of these rows is from seedlings and the other is from cuttings. You can see they are equally good.

Slide 32. New Zealanders are also studying tissue culture and are at the point where cultures from cotyledons and the female gametophyte are expected to be used for operational plantings within 2 years.

Slide 33. Seedlings produced by tissue culture look normal, healthy, and very uniform.

Slide 34. Another of the facilities at Rotorua is probably the world's tallest growth chamber. There is room for a crowd of 12 people and 4 trees in a chamber 3 stories high.

Slide 35. The trees are growing in containers 3 m on a side with transparent walls, so that the roots can be inspected.

Slide 36. Another controlled environment facility is at Palmerston North--the Climate Laboratory, designed, built, and run by the Plant Physiology Division of the Department of Scientific and Industrial Research. The Forestry Institute is currently running experiments in this facility on hardiness, but the facility is available to the New Zealand scientific community in general.

Slide 37. To the greatest extent possible the machinery controlling the environment is outside the chamber.

Slides 38 & 39. The Climate Laboratory has displays showing what they can control in those growth chambers.

Slide 40. Seedlings can be subjected to both radiation and advective freezes. As a matter of fact, they can create snowstorms in this facility. Those of you who know anything about mechanical refrigeration will appreciate how difficult it is to create an event like this.

Slide 41. The Climate Laboratory now has for radiata pine curves of frost tolerance versus time of year. These are used to determine suitability of planting stock for a given site, for determining planting dates, and for tree improvement purposes.

Slide 42. The University of Canterbury at Christchurch is engaged in studies on the growth rate and potential of trees. There is a quarter of a million dollars worth of field equipment packed into two trucks and taken out to the field.

Slides 43, 44, & 45. A cuvette, for measuring photosynthesis and transpiration, is placed on the branch to be tested. Light can be added using a Xenon arc mounted on a boom.

Slide 46. The controls and data logging equipment are inside one of the trailers.

Slide 47. Not every tree planted in New Zealand is radiata pine. There are some areas where protection plantings are needed to control soil erosion on steep hill sides. The Forest Research Institute at Christchurch is testing many other exotic species and provenances, including ones that are important commercial timber trees in North America, such as lodgepole pine, ponderosa pine, Douglas fir, and western larch.

Slide 48. New Zealanders are not particularly impressed with the growth rate of these species, but it appears to me that they are growing as well here as they do in their native range. In other words, although the primary purpose of these plantings will be protection, it is quite clear that they are also producing very useable amounts of wood.

Slide 49. Biomass measurements are made to determine growth rate. This is Scotch pine being harvested, and the needles, branches, and trunk of each tree are being weighed.

Slide 50. In the short time that this stand of trees has grown, it has already made significant changes in the soil on the site. The brown A horizon has been added by the trees.

Slide 51. Many of these upland plantings have been container grown, and New Zealanders have discovered what others around the world have found, that the container is best removed before the tree is planted.

Slide 52. New Zealanders have made extensive studies which indicate that for them the styroblock is more suitable than either direct seeding or the Walter's bullet.

Slide 53. New Zealanders have also reinvented some planting tools: The brown one is a New Zealand version of the Finnish potiputki, which they claim is much more rugged, and cannot be broken even by the roughest planting crew.