Presented at the Biennial Meeting Research Working Group No. (Forest Genetics)
Australian Forestry Council, Coffs Harbour, New South Wales. Sept. 1978.

AUSTRALIAN FOREST TREE IMPROVEMENT

ACCOMPLISHMENTS AND CHALLENGES

E. C. FRANKLIN

Southeastern Forest Experiment Station, U. S. Forest Service
Charleston, South Carolina 29407 USA

Introduction

As I travelled throughout southern and eastern Australia in the late winter and early spring of 1978, an enormous spectrum of accomplishments and challenges in forest genetics and tree improvement was presented to me. The person who undertakes to consult is often tempted to become an academic reactionary, travelling about giving over-simplified pat answers to extremely complex problems. There is limited time for reflection and deep thought from day to day as a myriad of activities and specimens pass in review. I found the experience very exciting and intellectually stimulating, but I have also enjoyed a few weeks to reflect and hopefully place in perspective a number of the sights, sounds, and scenes that passed so graphically before my eyes. Perhaps this intellectual tempering of such an exciting experience will make these summary considerations a bit more useful to those who wish to consider them.

The first and most important accomplishment which I would like to single out for praise is the fact that tree improvement is accepted in Australia as an integral part of silviculture and stand management. This is not to say that all the intricacies have been worked out in detail or that there is universal agreement on priorities, but it is to say that the principles of tree improvement are generally accepted. The job is never really accomplished because as administrations and politics change, as funding rises and falls, education and good salesmanship must always be part of an on-going program in research application of any kind.

Species testing with a wide range of northern conifer species has been done over a wide range of sites and elevations throughout Australia. The Pinus pinaster Ait. program in Western Australia is a model in exotic forestry where species testing was followed by provenance testing within the best species, followed by within species selection. It is certainly fair to say that with exotic conifers, the pilot phase of species testing has been well accomplished. Further testing, when necessary, can be done on a very selective basis, according to previous experience. Species testing with native trees, especially with eucalypts, is getting underway, but is far less advanced.

In general, with most selection programs the quickest and most rapid gains are made from provenance testing within species that show promise of adaptation. The establishment of provenance regeneration zones, seed movement strategies, and the eventual movement of provenances into non-native but more productively suitable zones must be done to achieve maximum early gains. Testing is being done in certain of the major eucalypts of the Ash group, the Karri forests of southwestern Western Australia and with *Eucalyptus grandis* Hill ex. Maiden and *E. pilularis* Sm. of the east. The importance of elevation and soil types in this enterprise is well recognized.

Family plus within family selection within provenance-species zones is well underway in many species. This third and most intensive level of genetic selection for tree improvement will provide continued genetic gains in future generations of recurrent selection.

The accomplishments which I have cited serve as a status report in terms of where tree improvement is as I saw it. So where do the major challenges lie in the immediate and distant future.

Education

One of the most important and fundamental challenges has already been mentioned, that is of maintaining enthusiasm and understanding at all levels, from administration to field application of tree improvement practices. Programs must receive official approval and funding at the highest levels of administration, but if the field application phases are not accomplished, then no gains will be obtained.

The first and perhaps most fundamental step in laying a basis for a tree improvement program is education of professional foresters at all levels as to what tree improvement is about, what it aims to accomplish, and what are realistic appraisals of its value in the overall forest management system. This starts with one or more forest genetics and tree improvement courses in each forestry school curriculum. In this regard, the forestry profession in Australia is well served by the way in which tree improvement and forest genetics is presented in the forestry schools.

An important challenge is to devote more effort to continuing education in tree improvement to keep field foresters and middle and upper management up to date on the latest research and application possibilities in tree improvement. There are many ways to accomplish this type of continuing education but certainly not the least of these are adequate yield trials and tree shows which demonstrate, on the ground with real plant material, the accomplishments and goals for tree improvement. Graphically illustrated short and long range plans for tree improvement are good planning and teaching documents. Seminars and workshops are equally important to maintain knowledge and skills. If you feel that this topic of continuing education for forestry professionals is quite apart from your day-to-day work as a tree improvement researcher or specialist, this may prove that your contribution to the profession in this regard is yet to be accomplished. Foresters must have knowledge of the principles of tree improvement and be convinced of their efficacy if the application of results in the field is to take place.

Turning now to some difficult problems confronting tree improvement specialists and researchers, I would like to first discuss seed production. Seed production is that vital point where tree improvement researchers and specialists impact the world of the forest managers. It is so fundamental that it is impossible to overstress the fact that if seed or other suitable propagules are not produced, the accomplishments of the best research and application programs in tree improvement are nonexistent. I was uncomfortable in many areas of Australia with the lack of emphasis on this particular point. The prediction of seed needs was often not a part of orchard planning or was often made with little or no reference to other types of forest management planning. Opportunities to purchase seed of proven or reasonably predictable quality were often overlooked, especially in radiata pine (Pinus radiata D. Don). Establishment and testing of seed production areas were typically not done, and the vastly inferior alternative of collecting seed from clear-felled stands was widely practiced in many areas. Even where a district forester may not be wildly enthusiastic about genetically improved trees, he will often be quite receptive to the easiest obtainable source of seed for regeneration. Certainly, a well managed, productive seed orchard can be just that source.

These points are made not so much to be critical of current and past practices but to point out the opportunities that now exist to get genetically improved seed rapidly into current plantings. The key to the accomplishment of this goal is to vastly increase the intensity of seed orchard management. Research to provide the knowledge to do this must receive highest priority. Selection of a seed orchard site is vastly more important than was earlier recognized by most people in tree improvement throughout the world. Site selection is critical and a failure at this point dooms to little or no success all remaining efforts. Fertilization and irrigation as integral parts of seed orchard management can be vastly simplified by selecting manageable sites. The most easily manipulated and most routinely overlooked opportunity in Australian seed orchard management, in both native and exotic conifers, is that of spacing. Virtually every orchard I saw was too crowded for high seed production.

There was far too much emphasis on the idea of maximum production per unit area in orchards. If area of orchards were tripled, the number of hectares in orchards would be minimal compared to the importance of producing sufficient numbers of genetically improved seed. A key element in production of both cones and pollen is adequate sunlight on lower branches of the whole crown surface which has the potential to produce cones. Adequate spacing throughout the life of the orchard is essential to guarantee sufficient light to the crowns. Final orchard spacing of from 12 to 15 meters is not too much and promotes wide, low crowns for adequate cone production at heights easily reached with available climbing equipment.

Traits for Selection

Returning now to elements of selection strategy, one of the fundamental questions that arises is, "What traits are to be considered the most important for selection?". These questions always involve many considerations such as species, product goals, long and short-term selection strategies. I will take one important species as a typical situation. Radiata pine in general must be considered to have poor form with large limbs and especially poor wood quality in the juvenile core. You obviously want to obtain fast growth rate and should therefore not consider reducing juvenile growth rate as an alternative for reducing the size of the juvenile core. Therefore, regarding pulp and sawtimber yields, you might consider the following traits to be most important--growth rate per unit area, higher density and longer fibers in the juvenile core-wood, straightness and small, flat-angled branches, and no tendency to fork. These may be considered as short-term criteria for selection, i.e. those in which significant gains can be expected in one to two generations.

What about provision for important traits for the future? What are the expected trends in long-term tree improvement? The traits just mentioned as short-term should eventually be given less emphasis as genetic gains are obtained. Other wood quality traits such as lack of spiral grain, lack of checking with seasoning, and low-compression wood will receive more emphasis. But perhaps the more important, longer term selection criteria will center on the use of wood as a basic chemical raw material. This will require indepth genetic examination of cellulose and lignin as chemical substances, plus the production and utilization of other by-products such as terpenes, resin acids, fatty acids, phenolics, etc. Research is making rapid progress in production and use of all of these products at the present time, so it is not at all unrealistic to consider them now as future criteria for selection. In this regard, it is essential to maintain a broad genetic base in each important species to provide the potential for future selection in these traits.

Progeny Testing and Advance Generation Breeding

Progeny testing is one of the most important steps in a selection program because it is usually the first opportunity to carry out genetic rather than phenotypic selection. Phenotypic selection, that is, selection in stands with unknown parentage or genetic relationship, is effective only when heritable variation exists in the stand. In general, this has proven to be true, but levels of heritable variation are often low. Progeny testing is an opportunity to genetically test parents already in orchards, or to produce new orchards based on progeny tests. It seems fundamental to me that low-cost methods of progeny testing such as open-pollinated tests should always be used to test trees initially, before more expensive methods of control-breeding are used to move trees into advanced generations for selection. Open-pollinated tests can provide economical and reliable tests of parent trees before the trees are integrated into more costly control-pollinated designs. I would like to emphasize that simpler and less elaborate schemes of testing and selecting are often quite adequate and more justifiable for forestry than those used for selection and breeding in agronomic crops.

Discovering and Maintaining Genetic Diversity

In general, the challenge of forest genetics is not to create genetic diversity, but to sort out the extremely large amounts of diversity that are available on all sides. However, this generality might not apply to radiata pine as much as to many other economically important species, such as the native eucalypts. Thus, the recent effort at collecting and testing a range-wide collection of radiata pine from the native stands of California is well worthwhile and continued efforts to exploit variability in naturalized stands of radiata in Australia is equally well founded. Enriching gene pools and sorting out native and naturalized variability are important efforts in understanding and maintaining genetic diversity.

Equally important, and perhaps a step further advanced, is the genetic tailoring of provenance and family variation to the spectrum of stand establishment and management practices which are prevalent for the provenance or seed orchard locale. This implies that within a geographical area served by a particular seed orchard, the best understanding possible should be obtained of the general purpose genotype suitable for that area. It is probable that certain orchards can adequately serve a number of areas, but this must be proven through tests. With more intensive testing, site by genotypic interactions may be found, but one must be alert to the large costs of testing and selection to overcome specific problems of site quality such as high salt content, low sulphur or low levels of micro-nutrients. If these nutritional problems can be solved by additions of organic or inorganic soil amendments, it is much better to accomplish the solution this way than to go into intensive testing and breeding programs to accomplish the same objectives. Another consideration of special importance with narrow, site-specific selection is that such selection usually affords little emphasis to adequately test other traits such as form and wood quality. Moreover, the genetic solution to growth on problem sites is much longer termed than possible solutions through soil amendments or changes in management practices. However, these considerations should not rule out the genetic solution as a possibility where other approaches have repeatedly failed.

Finally, I want to discuss what I feel are the implications of sawtimber as a final product on selection criteria and strategies. It has certainly been proven in many parts of the world that large quantities of pulpwood can be grown in what is essentially a sawtimber rotation, and that sawtimber as a final product is most profitable in the overall production system. Therefore, I feel that the decision to manage for a sawtimber rotation is a good one. However, I saw two problems--one on the part of geneticists, the other on the part of politicians, in dealing with the sawtimber rotation strategy. First, the politicians--it seems to me that rapid and progressive changes must take place in royalty schedules to reflect differential values for sawtimber, poles and piling, versus pulpwood. As these take place, it will help both tree improvement specialists and managers to realistically sort out selection and management strategies on an economic rather than an academic basis. The second point relates to selection criteria and valuation principles of genetically improved trees. Given that the final product is to be sawtimber, much more emphasis needs to be given to the economic weighing of traits important to sawtimber volume rather than relying heavily on small plot volume estimates from sapling stands. I personally feel, based on recent research, that such results are unreliable and that either new short-term progeny testing methods must be used, or longer term results must be obtained before evaluation for selection purposes. I would suggest that anything short of 75% of rotation age must be regarded as suspect relative to genetic selection for large value, high volume products of the final harvest cut.

Summary

I have not tried to exhaust all the topics which could be discussed after such a vast and wide-ranging experience. I have tried to emphasize those points which I feel are most important and perhaps in most need of early attention. Upon request, I have written special reports based on specific questions presented by various Australian agencies. I am quite willing to respond in that way to additional questions which may arise on these or other areas for discussion. I personally will make those reports available only to the requesting agency who may distribute or use the reports any way they see fit. Thus, if this summary report seems to be rather general, I hope that you will respond with more specific questions which I will attempt to answer or at least discuss.

Many thanks to all of those who made my stay in Australia a very enriching experience. I hope the rewards to you are in some way commensurate.