Improvement objectives for short rotation forestry

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Introduction

Will this be a good investment? This is a common question asked by buyers of 'superior' genetic material. Why the quotation marks? Because the statement brings to mind the question 'Superior for what?' Before dealing with the initial question, we have to recognise a few things about tree improvement that have an effect on the answer.

The observed properties of a tree can be explained as the result of its genetic make up (the genotype), where it is growing (the environment) and the interaction between genotype and environment. That is, the expression of traits like stem volume, wood stiffness or pulp yield will depend on the genetic value of the trees (often expressed as a GF Plus rating in NZ), the site and silviculture that constitute the growing environment, and the interaction between genetic value and environment.

Genetic value is end-use dependent; the characteristics of a good tree for structural wood may differ, for example, from a good tree for the appearance or pulp markets. This is recognised in breeding programs where - in theory at least - the first step is to define a breeding objective: a list of traits that have an effect on profit and their relative economic importance.

With hindsight it was a really unfortunate idea to call 'breeding objectives', well, 'breeding objectives'. The name implies that such objectives are useful only for breeding; however, their definition makes no reference to breeding at all. Maybe a more appropriate name would be 'improvement objectives', because they reflect the marginal benefit of changing a trait by any means. Thus, these objectives can be used to evaluate any silvicultural or technological tool that aims to change the intrinsic characteristics of trees.

The definition of improvement objectives is fraught with difficulties: processors are much more outspoken on what they dislike than on what they want, the relationships between wood characteristics and profit are somewhat opaque, there are asymmetric information problems, to name a few (see Apiolaza and Greaves 2001 for an extended list of issues). However, it is always possible to obtain a very long list of traits that people would like to see improved. The real problem comes when trying to estimate the relative economic importance of each trait.

There have been many attempts to side step the problem of estimating economic values, because it is difficult to obtain them. However, to avoid the estimation process is to tacitly accept unknown values. In other words, 'if you choose not to decide, you still have made a choice' (Peart 1980).

A typical economics-free alternative is to come up with ideotypes, an idea introduced in agricultural crops by Colin Donald in 1968. The original concept considered physiological indicators that would allow varieties to be good yield performers in a communal situation, that is, to compete with many individuals of the same variety. The concept was later extended to forestry, where the situation is akin to a Christmas shopping list of desirable traits (see, for example, Martin et al. 2001). It is tempting to base breeding only on such a list but:

- Industry profit depends on multiple traits,
- There are trade offs between traits, and
- The degree of genetic control and association between traits somewhat limits the space for changing traits.

Therefore, we require both a list of characteristics that we want to improve and their relative economic importance.

Those pesky interactions

Considering that environment encompasses both site and silviculture, we can split the interaction between genotype and environment into genotype by site and genotype by silviculture. Most studies in interaction have focused on the former, where results have been encouraging - in that they show little interaction - but they were based on a limited number of sites, families and traits. There is ongoing work to extend the coverage of such research.

But what is the effect of silviculture on the performance of superior material? There are few answers to this question; however, there are indications that silvicultural effects may have been poorly recognised. For example, higher initial stockings induce higher wood stiffness, both for pines (Lasserre et al. 2005) and eucalypts (Warren 2006). The heterogeneity of planted material is also relevant, as the best growing genotypes in a mixed stand are not necessarily the best ones in pure stands (as pointed out by Sharma 2007), which should affect our testing schemes. Similarly, this result should have a profound effect on deployment, particularly of clonal varieties.

From an operational point of view the value of a tree is the aggregated sum of each trait weighted by its relative economic value. I am not aware of any studies in New Zealand that track the interaction of this composite value trait rather than studying single variables, but this is exactly what we should care about from a practical point of view.

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While we may be surprised by the changes to silviculture and targeted final product (another form of interaction) in the last twenty years, one thing is clear: more changes are coming. Some of these changes - particularly in processing technology - will fall in the 'unknown unknows' type popularised by Donald Rumsfeld[2]. How will a breeding program cope with future unknown objectives, which may involve different economic weights and new traits?

It may well be that we need to maintain large diverse populations (including hybrids and under represented populations) in addition to the current breeding population. A large base population that we can always go back and screen for new traits, even if it implies sacrificing some gain for current objectives.

Wood density and wood quality are not identical

After the wood quality debacle of the 1990s, the reaction of New Zealand companies has been mostly to extend rotation, aiming to increase the proportion of outerwood in the final crop. But breeders could so improve the trees as to permit growers to follow more tolerable shorter rotations.

One of the first reactions of breeders was to look at the wood quality world. There, wood basic density was presented as the canonical characteristic (Zobel and van Buijtenen 1989 is a classical example). It was not only an important variable but, luckily, there was plenty of variation; it had a high degree of genetic control; and it was easy to assess. Some may argue that it became important because it was easy to assess. Pine breeders around the world started assessing, and breeding for, basic density only to find that the intrinsic quality of trees did not change significantly.

A short detour to understand what happened. Tree breeders make, hopefully, a clear distinction between characteristics that are assessed in progeny trials (termed selection criteria) and the characteristics that we want to breed for (called objective traits). Because we are impatient creatures and time is money, we do not wait until rotation age, but we measure trees from around 6 to 8 years of age.

Stiffness and stability can be explained by basic density (DEN) and microfibril angle (MFA), but the relative contributions of these traits change with age. Thus, in the early life of trees MFA is more important than DEN, while DEN becomes more important in older trees. Life becomes interesting because we have been assessing young trees for DEN (our selection criterion) just when stiffness is dominated by MFA. The correlation between MFA and DEN is far from perfect, so making selection for wood quality problematic. This has changed only recently, with the introduction of operational acoustic velocity screening in breeding programs.

Chemical properties are another example of selection criteria that were neglected for a long time. In the last couple of years there has been a high level of interest in the role of galactans in wood longitudinal shrinkage, a relationship first reported by Stan Floyd (2004) of Weyerhaeuser in the USA. There is also a lot of interest in near infrared reflectance analysis (NIR); it has been in use in Australia for several years (Raymond et al. 2001, for example). We are unlikely to find something if we are not looking for it, and we have not payed much attention in the past.

Lesson: we cannot always rely on 'the official story'. Complacency about our understanding of wood quality delayed progress for at least ten years. We always need to be open to alternative explanations.

A stopover on the way to China

On 24th September 2007, a Chilean newspaper published an opinion piece by Aldo Cerda, forestry manager for Fundación Chile. Mr Cerda made an interesting observation: Chilean foresters now consider New Zealand 'a stopover on the way to China', referring to business trips with stopovers in Auckland. His diagnosis: betting too much on the sale of technological services (consulting, software, etc), a lack of investment, poor processing infrastructure, limited ability to pay for raw materials, over regulation and arrogance. The irony of Mr Cerda's own arrogance is somewhat comforting.

The purpose of this story is not to annoy people, but to point out that today many Chilean foresters are looking to Brazil with admiration and preoccupation. If you think that 22 year rotations on good Chilean sites are a threat, what will you think when Brazilians turn their attention to solid wood? They are already growing pine on rotations shorter than 20 years in Southern Brazil. This raises the question: Can we afford to continue to think that 30 years is an adequate 'short' rotation?

Sorensson and Shelbourne (2005) presented a very interesting graph in the clonal forestry chapter of the NZ Forestry Handbook. They plotted value of logs versus wood stiffness, showing a non-linear relationship. There is a big jump of price when moving from industrial grade to structural wood, which then tapers off for better grades. There is an immense amount (around 50% of volume) of poor performing wood, which derives mostly from corewood.

How do we pull together all this information? We can

[2] *The full quote is 'Reports that say that something hasn't happened are always interesting to me, because as we know, there are "known knowns"; there are things we know we know. We also know there are "known unknowns"; that is to say we know there are some things we do not know. But there are also "unknown unknowns" - the ones we don't know we don't know', which was part of a United States Defense Department briefing on 12th February 2002.*

restate our improvement objective to maximise the value of corewood: as outerwood is already good enough. This simple approach has important implications: as shorter rotations become feasible, the assessment of selection criteria is a lot closer to the objective traits (a bonus) and we can look for trees that meet quality thresholds very early in life. Trees do not need to be spectacularly good on average, but good enough very early on.

Will we adopt this perspective? I do not know, but it is one reason for writing this opinion piece. It offers a chance to regain some competitiveness, although it flies on the face of current thinking that 30 years is short enough.

Epilogue

Coming back to the original question, of course genetics is a good investment if we are aiming for the right objective. However, breeding may not make a difference when considered in isolation. Achieving superior forests will depend not only on good genetics but also on site selection and silvicultural regimes aimed to provide decent wood quality in a reasonable time frame.

Breeders' objectives can be adapted to include not only biological traits but also technical efficiency characteristics, converting them into improvement objectives. In this way we can value the effect of changing trait averages by any means. This makes the comparison of alternative genetics, silviculture and technology 'projects' not only possible but desirable.

This essay could be interpreted as an opinion dealing mostly with radiata pine, but this is far from the intention. Most, if not all, issues are applicable to other species. There have been analogies relating the small number of species in agriculture and the dominance of radiata pine in New Zealand. However, when pushing the comparison with the agricultural world one can see that few people are making a lot of money with staple crops (at least when ignoring subsidies). The money is on the specialty crops and I think that one of our mistakes has been to think of alternative species that will have a role as important as radiata pine's. Probably a reasonable strategy is to provide diversification targeting niche markets.

Breeding is grounded on a vision of the future and my bet is that that future will be based around short rotations. Thus, when I say a reasonable time frame I mean a short, competitive one. We will have to aim for corewood quality: the rest of the tree will sort itself out.

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