

Clonal Forestry:
Who Are You Kidding?

Commercialisation of Clonal
Forestry

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Commercialisation of Clonal Forestry

- What propagation technologies will be needed to produce material for Clonal Forestry?
- Can these technologies be integrated into existing plant production systems?
- What will it take to sell Clonal Forestry to the Industry?

A Fable

Clonal Forestry

Definitions

- Must know something about the clones (tested clones not just proven or promising families or populations).
- Well known reliable clones used on a range of sites.
- Management practices adapted to specific clones.

Clonal Forestry as Natural Progression in Tree Improvement

- Seed stands
- Seed tree selection
- Identification of elite individuals
 - Open pollinated seed orchards
 - Bulk propagation
 - Controlled pollinated seed orchards
 - Full Sib Forestry
- Clonal Forestry

Clonal Forestry

- Clonal forestry offers the greatest potential to deliver the benefits of the best genotypes from a controlled cross.
- Advantages of Clonal Forestry are attractive, but are the limitations manageable?

Advantages of Clonal Forestry

- Reduce time to get improved material into commercial production.
- Control of pedigree.
- Greater flexibility
- Substantial economic gains.
- Greater control over growth habit.
- Greater genetic gains.

Model for Clonal Forestry

- Tropical hardwood species (Eucalyptus).
- Short rotation species.
- No previous breeding programme.
- Hybrid vigour important.
- Maturation not a big problem.
- Pulp species.

Clonal Forestry

We may have been seduced by the concept of Clonal Forestry without fully appreciating:

- Maturation problems
- Propagation methods
- Costs
- Gains
- Time

Company “X”

“We grow your bottom line.”

Benefits	Seed Orchard	Clonal Forestry
Yield Gain	8 to 13%	30 to 60%
Value Gain	Some	More
Pest Resistance	Some	More
Uniformity	Random	Designed
Reproducibility	Low	Very High
Flexibility	Limited	Unlimited
Seed Costs	Low	High
Total Costs	Current	Lower

Meetings on Veg Prop/Clonal Forestry

- 1973 IUFRO Meeting on Veg Prop (NZ)
- 1975 Symp. On Juvenility (US)
- 1977 Veg Prop of Forest Trees (S)
- 1981 Symp. On Clonal Forestry (S)
- 1981 IUFRO In Vitro Prop (F)
- 1982 IUFRO Multiclonal Varieties (D)
- 1982 Imp. Veg Prop Crops (UK)

Meetings on Veg Prop/Clonal Forestry (cont.)

- 1983 Clonal Forestry (CTIA) (C)
- 1986 Radiata Pine Cuttings (NZ)
- 1989 Clonal Forestry Workshop (NZ)
- 1992 IUFRO/AFOCEL Symp (F)
- 1992 Clonal Forestry (book)
- 1997 IUFRO Radiata Pine (NZ)
- 2002 CF- Who Are You Kidding? (UK)

Clonal Forestry Concerns

- Biological concerns-maturation, loss of genetic diversity, deployment risks.
- Economic concerns-
production/management costs, return on investment.
- Social and Environmental concerns-public acceptance, regulation.

Biological Concerns

- Maturation/juvenility/rejuvenation.
- Loss in genetic diversity
- Risks may not manifest themselves for years
- Competition between clones
- Clone specific silviculture

Economic Concerns

- Propagule costs higher (propagation and tracking costs).
- Clonal testing costs as great or greater than family testing costs.
- Level of improvement is not documented

Clonal Forestry- Past Attempts New Zealand 1960s and 1970s

- Cuttings from 5 to 10 year-old trees
- Maturation effects-poor rooting, slow growth rates
- Loss of material in hedge orchards
- Large number of hedges needed to produce useful numbers of cuttings.
- Hedge management costs high

Clonal Forestry- Past Attempts

Ontario, Canada 1980s

- Bulk propagation of selected crosses
- No maturation problems
- No production problems
- Production costs high
- Foresters not convinced of benefits
- Programme was too far ahead of its time

Clonal Forestry- Past Attempts

Sweden 1970-1990s

- Weak demand for cuttings.
- High production costs
 - Labour
 - Maturation changes
- Concern over “Regulations”
- Tendency towards a more “Natural” forestry

Queensland, Australia 1990s

- Slash X Caribbean pine hybrids
- Field test and identify best clones
- Maintain original clones in hedges
- Three crops of cuttings per year
- All exotic pine hybrids produced in 2002 were clonal material

“Ideal” Propagation System

- Works with all genotypes.
- Limited somaclonal variation.
- Moderate C-effects.
- Broad donor plant age spectrum.
- Preserves donor plant age.
- High multiplication rate.
- Uniform multiplication rate across genotypes.
- Low cost.
- Produces plants with normal growth capacity.

Cuttings versus Somatic Embryogenesis

- Cuttings
 - Low relative multiplication rate
 - Low production costs
- Somatic Embryogenesis
 - High relative multiplication rate
 - High production costs (but decreasing)
 - Cryogenic storage possible
- Hybrid systems may be the best compromise

Sitka Spruce Rooted Cuttings versus Somatic Embryogenesis

Method	Time	Number of Propagules
Rooted Cuttings	6 years	2,400
Somatic Embryogenesis	3.5 years	35,000 to 180,000

Production Costs

- Rooted Cuttings- generally cost 2 to 2.5 times the cost of seedling propagated material.
- Emblings- limited data suggests they currently cost 3 to 6 times the cost of seedling propagated material.

Use of Emblings

- To be grown on to serve as stock plants to feed conventional rooted cutting production systems.
- To be grown on to produce planting stock that will go directly to the field.

Integration with Existing Nursery Practices

- Cutting in place of seed
- Hedge orchards in place of seed stores
- Rooting beds in place of seed beds
- Lifting and lining out the same
- Cuttings will probably cut 1 year off production cycle
- CF- more tracking of clones through system

Integration with Forest Management

- If planting mixtures of improved and unimproved material- problems
- Matching clones to sites
- Clonal management
- Mosaics easier than intimate mixtures
- Tracking of clones

Changes in Forestry Practices due to Clonal Forestry

- Will fit fairly well into existing plant production systems with some slight changes.
- Will require some changes in the planting, management and harvesting of forests.
- Effect on end product quality/uniformity will take time to demonstrate.

“Scientists, breeders and foresters tend to spend their energy on futuristic visions about clonal forestry instead of optimising the already available options for the benefit in the more near future.”

“Full Sib Forestry”

Carson and Lindgren

Bulk Propagation versus Clonal Forestry

- Bulk Propagation
 - Untested clones
 - Loss of clonal identity
 - Finite multiplication rates
- Clonal Forestry
 - Tested clones
 - Clonal identity maintained to field
 - Infinite multiplication rates

Bulk Propagation versus Clonal Forestry

- Conviction that CF has greater potential than BP of untested clones, but
- CF is more complex than BP and thus more expensive, therefore
- Assume it is possible to offset higher costs by greater yields.

Comparison of Progeny Testing versus Clonal Testing

	Gain	Cost (EUROS)	Time (Years)
Progeny Test (200 Fam.)	15 to 20%	264,000	9
Clonal Test (1,000 Clones)	30 to 60%	240,000	13

Clonal Forestry

Need for Continued Improvement

While you are testing and selecting the best clones, newer, further improved sexually produced material will be developed which will displace the material you are currently testing with such effort and at such expense.

Clonal Forestry

Testing Requirements

- The gains from Clonal Forestry come from using the best material available at the time.
- Will need to constantly upgrade clones in use.
- May need to combine clonal testing with family testing.
- Early selection methods could be helpful.

Clonal Testing

- Initial Screening- pick the best.
- Candidacy Testing- G X E interactions.
- Clonal Performance- productivity/unit area
- Compatibility Trials-mixtures.

Libby, 1987

What is Going to Sell Veg Prop Material to the Industry?

- Gains- greater and more specific than current products of breeding programmes.
- Versatility- ability to tailor gain to specific end user requirements.
- Uniformity- management and production benefits which should ensue.

Attitudes Toward Clonal Forestry

- It is never going to be able to pay for itself.
- It is too early and we really need more information and results to convince us
- It is going to work and we are testing it already.

“If we have to wait for the researchers to provide all the answers we would never go ahead. I am positive that clonal forestry is worth pursuing and it is already happening. It is more than just a tempting rainbow. We may get up to an 80% increase in value over a 25-year rotation using improved genetics and silviculture over conventional forestry and improved seed”...

“I believe this is where the dollars are and that is where we are headed. With a bit of tongue in cheek, I believe that the sun has set on conventional forestry and that clonal forestry has arrived. We are going to continue to progress and I urge you not to be left behind.”

D. Jamieson,
Dynamic Forestry Enterprises, Australia,
1989

Australian Clonal Forestry 2002

“We were all very much taken with clonal forestry in the antipodes back in 1991 and the NZ people have taken it further than we have. If we take clonal forestry to mean using tested and identified clones, then there is still very little going on in Australia. What is done here is family forestry, where all individuals of selected families are propagated by stem cuttings.”

Australian Clonal Forestry 2002 (continued)

“This works quite well, but we lose out on potential gain from using tested clones. Although there is some preoccupation with costs and returns, the proof of the pudding is in the eating.”

Colin Matheson
CSIRO

NZ Clonal Forestry 2002

“Clonal forestry testing is alive and well in NZ with radiata pine. It is being carefully evaluated. It is still not proven if selecting clones is going to give better gains than turning over another generation in the same time, but I guess the research will tell us that.”

Mike Menzies

NZFRI

“Clonal Forestry has been “promising” for half a century, but less than one percent of current forest plantations in Sweden are clones and there is no increase in sight, in spite of considerable efforts.”

Dag Lindgren

New Product Requirements

- Sufficient customer demand and market size
- Reliable, cost effective process
- Stable, effective, easy to use product
- Compatible with existing production and distribution systems
- Reliable, consistent, affordable product
- Sufficient sales to support market development and new product development

“The most important lesson is that to be commercially successful, we must change our focus from product-driven R&D to market-driven research and product development. Quite simply, this means that prior to making a corporate decision to proceed with product development and commercialisation,...

....we first have to accurately forecast customer demand for the product, calculate the total market potential, determine the customers' needs and benefits that the product will satisfy, and then use this information to make the decision to proceed or not to proceed further.”

Cross and Polonenko, 1996

Conclusions

- Almost everyone talks about Clonal Forestry, but very few do anything about it.
- We have perhaps oversold an idea that many tree breeders do not really believe in.
- We need to re-examine of assumptions and beliefs and collect data to address our concerns and uncertainties

Future of Clonal Forestry

- Clonal Forestry is NOT “just around the corner”!
- We should probably stop “pushing” clonal forestry until we have the facts.
- We need to consider other alternative systems (bulk propagation, family forestry).
- Best approach will depend on organisation, objectives, and level of commitment.

What Needs to Be Done?

- Need to design and plant trials aimed specifically at answering questions about yields as well as documenting production costs of a range of approaches (scientific trials).
- Compare cost/benefits of the different approaches.
- Establish trials also to show what the technology can provide (demonstrations).

Spruce

- Excellent species for Veg Prop
 - Rooted Cutting
 - Somatic Embryogenesis
- Know quite a bit about the genetics of the genera
- Well developed improvement programmes
- Important economic genera

European Spruce Veg Prop Network

- Look at all options
 - Family (Full Sib) Forestry
 - Veg Prop (bulk prop and clonal forestry)
- Document costs/benefits/times
- Demonstrate to end users
- Deal with management/regulatory issues
- Promote implementation

European Spruce Veg Prop Network

- Some members ready to move forward, others may not be ready.
- Common objectives
- Probably not exchange of material among all participants
- Exchange of ideas, test designs, data, conclusions.

Key Question- Clonal Forestry

- What are the benefits (gain vs alternatives)?
- What are the costs?
- How can it best be achieved?
- How does it fit into a breeding programme?
- How acceptable is it?

“A liar will not be believed, even
when he speaks the truth”