TOWARDS THE NEXT GENERATION OF MODELLING TRIALS

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Report No. 124 ***September 2004***

Stand Growth Modelling Cooperative

Forest Research Output

No. 37268

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EXECUTIVE SUMMARY

The current Stand Growth Modelling Cooperative (SGMC) growth models are based on information from seedlings, and not from clones. As plantations in New Zealand move towards clonal forestry, there is a perceived need for SGMC models to move towards the incorporation of clonal measurements. These issues initiated the formation of a sub-committee to discuss the following:

- Do we need a series of clonal trials for future model development?
- Are there current clonal trials we could utilise?
- Should we plant our own clonal trials?
- Should we use a standard set of clones to control genetics (hold constant) and to explore other effects e.g. site?
- Should we include a standard unimproved seedlot as a baseline for comparison?

The primary result of the series of meetings held was that clones do need to be included in future model development, but that the first steps should take advantage of the current resources, and existing data, including both clonal plantations and clonal trials. PSP's can be set up to monitor clonal growth in both types of resources.

Assuming that clonal forests do have different growth parameters from those resources used in building the current SGMC's models, a need for new clonal trials was also clearly identified. A response-surface-type trial design, similar to designs instigated by Chris Goulding (Forest Research), was favoured by all. An interest in collaboration in such a trial series was expressed by the Radiata Pine Breeding Company and the Forest and Farm Cooperative.

A number of project proposals were proposed as a result of discussions. The project given the highest priority – a gap analysis- has already been approved for the 2004/05 financial year. This project will provide an extensive review of clonal trials, including information on the forest and IP owners, and trial designs. Current uses of the trials will be identified, as well as possible uses for the SGMC and whether the trials are suitable for PSP installation and subsequent measurement. Following this review, the gaps in the material available will be identified with respect to the SGMC's future need for clonal information. In addition, available data for analysis will be identified and subsequent projects using this data will be proposed.

Towards the next generation of modelling trials

Introduction

Currently, the Stand Growth Modelling Cooperative (SGMC) growth models are based on information from seedlings, and not from clones. As plantations in New Zealand move towards clonal forestry, there is a perceived need for SGMC models to move towards the incorporation of clonal tree measurements.

These issues initiated the formation of a sub-committee to discuss the following:

- Do we need a series of clonal trials for future model development?
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This report lists the issues identified by the sub-committee and gives recommendations for the next steps for the Stand and Growth Modelling Cooperative members to consider. Potential projects that would benefit the SGMC in this area and their prioritisation are also listed.

Sub-committee members

Brian Garnett (Pan Pac Forest Products Ltd.)
Doug Long (Rayonier NZ Ltd.)
Steve Dowman (Ernslaw One Ltd.)
Heidi Dungey (Forest Research; Chair)
Bob Shula (Forest Research)
Judy Hayes (Forest Research)
Grant Holden (Forest Research)
Jeff Tombleson (Forest Research)

First steps

All participants agreed that clones needed to be incorporated into the next generation of models. The main issues that need to be addressed for this to happen were then identified as:

1. *How to benchmark clones versus seedling material.*
    - Clones are expected to be more uniform. It was not known if clonal material would sit outside the normal model predictions, particularly for growth, because of this expected uniformity. It was not known whether a general purpose growth model would fit a variety of clones or whether their trajectories will be consistent with seedlings. Validation of the models for clonal data is required.
    - Creating growth-modelling statistics for all clones is impossible. Growth models need to be generalised for a core number of clones. New clones can be accommodated using a multiplier of some sort.
    - Repeatability and predictability of clones is also important.
    - When using clonal data in future models, it should also be benchmarked against seedling material.

2. *What would the future model requirements be for clonal material?*
    - Is growth data going to be enough? Many of the clones now being planted are selected for their excellent wood properties. Future models will have to incorporate wood properties as well as growth variables.
    - There was a perceived need to account for genetic gain in growth as well as wood quality.
    - Clonal data for future models could take several forms:
        i. Measurements from clonal stands
        ii. Measurements from existing trials
        iii. Measurements from trials that are established specifically for modelling purposes.
    - Data used to develop the current models does not cover the extremes of growth very well. Clonal trials may be able to fill some of those gaps.

3. *Do clonal trials or clonal stands exist that could be utilised?*
    - Permanent sampling plots (PSPs) could be set up in clonal stands or trials that already exist, as long as the specifications of the trees are suited for modelling.
    - Clonal stands do exist within the estates of individual companies and companies could be approached for stand measurements to be taken.
    - Clonal trials also exist, and for those owned by Cooperative members and Forest Research, they can be easily documented. Other trials owned by individual companies (e.g. CellFor, Horizon2), will have to be approached separately.

4. *What are the important elements in a trial design?*
    - Clones must be tested for uniformity and benchmarked against seedlings.
    - The trial must have replicated blocks.
    - Large-block trials are useful for taking stands to rotation age. This aspect is very useful for modelling purposes.
    - A clonal trial design needs to be proposed.

5. *Collaboration*
    - Collaboration will be advantageous to help keep some of the trial costs down. The ground-rules for collaboration need to be discussed.
    - Intellectual property (IP) issues for collaboration need to be laid down prior to any new trial series is commenced. Any likely IP issues need to be flagged.

Issues

A few key issues were acted on in order to obtain information on which to base the recommendations of this project. These were: what is an ideal trial design? What are the existing clonal trials and where are they situated? Collaboration was also seen as key to getting any new trials in the ground in order to minimise costs. However, collaboration needs to be clear and IP issues addressed up front. These areas are discussed in more detail below.

Trial Design

A draft trial design (Appendix 2) put together by Tony Shelbourne with contributions from Heidi Dungey and Steve Dowman. Environmental effects (ie. external to genetics) cause variation within clones and this needs to be captured.

Issues were:

- Planting in large blocks will enable the trials to be useful until rotation age.
- Single-tree plot trials may satisfy some aims, in particular to examine single traits such as density or stiffness.
- Site variation must be covered in any trial design and trial series.
- Benchmarking should be against control-crossed families.
- New trial establishment is not the first priority.
- Trial establishment must be a staged approach where ideas and ideals will need to be revisited in the future.
- The response surface design (by Chris Goulding) was seen as useful to cover both the extremes and the averages.
- Trial designs may be able to be imposed on current clonal stands.

Existing Trials

A list of known clonal trials already established was summarised (Appendix 1). These trials were established primarily by research cooperatives and by Forest Research. In addition, the Site Management Cooperative has an excellent series of trials at Puruki that may help answer many of the questions raised above. It was noted that the list in Appendix 1 was not complete and there were many other trials that could be available through individual companies and the respective forest owners e.g. Horizon2, Kaingaroa Timberlands.

Examples of trials already established:

1. Clone × site × silviculture trial planted in 1999 on 3 sites (Tarawera, Waimahia and Kaingaroa) with block plantings of 5 clones × 2 stockings × 3 sites. In addition, one clone has been planted at three different stockings. **This trial series sat originally with Fletcher Challenge Forests. Two sites (Waimahia and Kaingaroa) now sit with Kaingaroa Timberlands. The Tarawera site is now owned by the Kiwi Forest Group. Protection for this trial series was flagged as an important issue.**
2. Site interaction block plantings across the country established in 1996.
3. Puruki trial – clone vs family trials with the ability for testing site interaction.
4. 1986 clonal mixtures in Manawahe and Kaingaroa Cpt.60.
5. GEENZ family trials (to validate models for families).

Although brief site details are given here, permission for access or for use of trials for PSP's or for other purposes has not been obtained, and this would need to be done first.

These trials offer a unique opportunity for collaboration between Forest Research, Cooperatives, the Radiata Pine Breeding Company and forest owners.

Collaboration

It is important that there is collaboration towards development of data for the next generation of growth models. The larger the group involved, the greater the benefits. There was positive interest from all major companies represented by the sub-committee and invited participants (PanPac, Rayonier, Ernslaw, RPBC, CellFor, CHH, Horizon2 and KTML) at the meeting regarding this topic. In particular, data pooling and report sharing was discussed. While the Stand Growth Modelling Cooperative has initiated this project it is anticipated that the other Cooperatives and WQI may also need to be involved.

It was felt that pre-project agreements would be required to cover any IP issues. Standard protocol would include:

- Coding of clones to protect identification.
- Site access, OSH, contractor requirements.
- Publication - time constraints.
- Data storage and duration.
- Permission step for use outside original project.
- Copyright of model, access and terms of resulting model(s).

Given that this project could involve large sums of money, available funding was discussed and the following sources identified:

- Cooperatives
- WQI (short term)
- Tech NZ
- Industry 'In kind'
- FRST
- RPBC

Summary and Recommendations

The aim of this project was to determine the next steps towards developing growth models that incorporated clones and clonal information. This information aims to ensure that the models are realistic for predicting growth and performance in clonal forests.

The primary result of the series of meetings is that clones do need to be included, but that the first steps should take advantage of the current resources, including both clonal plantations and clonal trials. PSP's can be set up to monitor clonal growth in both types of resources. However, the maturation and root health of clonal plantings should be considered before being used.

Any clonal data that is already available and new data from the new PSP's should first be used to validate the current growth models. It is not known if clonal forests will fit within the growth model predictions, and it is important to know if they do, or don't. If clonal growth predictions do fit, then there is hardly the need to develop an extensive new series of trials.

While it was proposed that the growth models needed to be validated for clones, there was also an opinion that actually, the growth models had not been properly validated for families and that validating for clones was premature. There are a series of trials put together by GEENZ that could be utilised for this purpose.

Nevertheless, assuming that clonal forests do have different growth parameters, a need for new clonal trials was also clearly identified. A response-surface-type trial design, similar to designs instigated by Chris Goulding, was favoured by all. This entailed a set of clones being planted out on numerous sites across the country. This type of trial would, in particular, aim to fill some site gaps that were perceived to exist in the current growth models. The Radiata Pine Breeding Company (through Mike Carson) indicated that it would be interested in collaboration in these trials if clones used were also able to be used in benchmarking genetic material. The Forest and Farm Cooperative also indicated that is was very interested in developing trials that look to

contributing new data for models incorporating clonal information (through Jeff Tombleson). Collaboration would be needed for such an extensive trial series as is proposed here because of the costs involved.

The above outcomes led to the discussion of what were the next steps towards the next generation of models. The outcomes from these discussions were a number of project proposals that are outlined below. It is recommended that these projects be considered closely by the SGMC members for inclusion into the research programme. The highest priority is given to the gap analysis (project 1)[1].

Next steps - projects for consideration

1. Gap analysis
   - Review of all current clonal trials, all forest and IP owners
   - What trial designs/clones are not covered in existing trials
   - What analysis can be done with each trial

2. Validate existing models for families
   - Start with contrasting sites, validate sites for growth, diameter distribution and crown architecture.
   - GEENZ plus related trials may be useful for this purpose.

3. Validate existing models for clones
   - Establish PSPs or inventories in existing operational clonal stands (ex Fletchers estate)
   - Impose thinning regimes on existing stands.

4. Sites vs Clones (Genotype × Environment effect)
   - Issues of variation within a site.
   - Which sites contribute most to variance?
   - How to cover more sites than in the current PSP system?

5. Mixtures vs MonoClonal blocks
   - What are the clonal growth patterns when they are planted in mixtures versus in monoclonal plantings?
   - Tui Glen trial at Kawerau recommended for this purpose.

6. Next generation of modelling trials
   - Need a strategy for PSP sampling 'best clones' across NZ, could incorporate the Goulding 'response surface design'.
   - Need to capture site extremes.
   - Need to pursue collaboration.
   - Longer-term, to be developed in conjunction with collaborators.

[1] This project has already been approved for the 2004/05 financial year. More details are given in the section "Projects with the go-ahead for 2004-05"

Projects with the go-ahead for 2004-05

Gap analysis budget ~$15,000

This project will provide an extensive review of clonal trials, including information on the forest and IP owners, and trial designs. Ownership issues will be outlined and addressed where possible. Current uses of the trials will be identified, as well as possible uses for the SGMC and whether the trials are suitable for PSP installation and subsequent measurement.

Once the above list is complete, the gaps in the material available will be identified with respect to the SGMC's future need for clonal information. In addition, available data for analysis will be identified and subsequent projects using this data will be proposed.

Appendix 1.

SUMMARY of CLONAL TRIALS already established

CellFor Trials

Year Estab	Regions	No. trials	Plot Type	Clone type
1999	GS, HB, WM, SD	4	STP Block	Mixed
2000	GS, HB, WM, SD, NN	7	STP Block	Mixed
2001	BOP, GS, HB, WM, SD	8	STP Block	Mixed
2003	BOP	1	STP Block	Mixed
2003	BOP, SD	2	Large Blk	Single

RPBC Trials

Year Estab	Regions	No. trials	Plot Type	Clone type
1986	BOP	2	STP Block	Mixed
1987	BOP	1	STP Block	Mixed
1990	BOP	1	STP Block	Mixed
1990	BOP	1	Row pl	Single
1993	AK, BOP	2	Large Blk	Mixed?
1995	BOP	1	STP Block	Mixed
1997	AK, BOP	2	STP Block	Mixed
1999	AK, BOP, WK	3	STP Block	Mixed

Site Productivity Trials

Year Estab	Regions	No. trials	Plot Type	Clone type
1997	WK	3	STP Block	Mixed
1997	WK	1	Row pl	Single
2002	NN, HB, CY, WK	4	STP Block	Mixed
2003	CY, OT	3	STP Block	Mixed
2004	AK, BOP, WC	4	STP Block	Mixed
2005	AK, BOP	3	STP Block	Mixed

FFPM Coop + Growth & Quality Trials

Year Estab	Regions	No. trials	Plot Type	Clone type
1988	BOP	1	Large Blk	Mixed
1993	AK, BOP	2	Large Blk	Mix/Pure
1995	BOP	1	Large Blk	Mix/Pure
1992	BOP	1	Large Blk	Mixed

GTI Trials

Year Estab	Regions	No. trials	Plot Type	Clone type
1992	BOP	1	Row pl	Single
1993	BOP	2	Row pl	Single
1993	BOP	1	STP block	Mixed
1995	BOP, GS	3	STP block	Mixed
1995	AK	1	Row pl	Single
1996	BOP, NT	2	STP block	Mixed
1997	BOP, AK	2	STP block	Mixed
1997	AK, GS	2	Row pl	Single
1998	WM	1	STP block	Mixed
1999	BOP, AK, WM	4	STP block	Mixed
2000	HB	1	Row pl	Single
2001	AK, BOP, CY, NN, NT, OT, WC, WK	12	STP block	Mixed

APPENDIX 2

CLONAL TRIAL DESIGN

Aims:
-test clones vs. families for growth, mortality, diameter distribution, height/age, branching, wood quality, product quality.
-test the uniformity of clones vs. families.
-test a number of sites New Zealand-wide.
-test material to rotation age (hence large plot size)

Clonal trials are presented as 2 options:
1 – with 3 silvicultural treatments
2 – with no silvicultural treatments
and the following assumptions:

Assumptions:
Minimum of 12 trees needed at rotation in the internal plot (ie excluding buffer trees)
Initial stocking 1000 s/ha (3.18m spacing)
Final stocking 300s/ha
Assume monoclonal blocks

-inner measurement plot = 0.05ha
-whole plot (+ buffer) = 0.082 ha
-inner plot 7×7 rows, 49 trees at 1000 s/ha at rotation ~15 trees at 300 s/ha

Minimal design:
3 reps per site (better 5 reps)
10 clones (better 20 clones)
10 full-sib families (seedlings)
controls

Silvicultural treatments (in option 1 only)
Plant and leave
Thinning
- -middle of the road
- -higher stocking

Pruning to 6m for all treatments.

Additional treatments:
Bulk clone mix (this will also provide some basic clonal repeatability measurements)
Bulk family mix

Clones need to represent the range of clones that are planted now and will be planted in the future. This includes clones from the following breeds: Growth and form, Structural, Appearance, Long Internode, Dothistroma-Resistant.

Possible source of clones: Horizon2, CellFor, Forest Research