A STRATEGIC PLAN FOR NEW AND EXISTING SILVICULTURAL TRIALS

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FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

EXECUTIVE SUMMARY

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Over the last year a working group has been convened to review existing trials and develop a strategic plan for new silvicultural trials. The working group, consisting of five industry members and one FRI researcher, has developed terms of reference and sought input from Cooperative members, Managers of other Cooperatives, and other senior FRI scientists. It has been recognised that silvicultural research is inherently long term and this group has taken the approach of addressing the question "What silvicultural questions will the forest owner/manager of 2010 want answered?"

One issue that has remained unsolved is site classification. It is suggested that the Cooperative adopt a short term strategy on this issue and use a similar classification system to that used in the current silviculture/breeds trial series. It is proposed that this issue is reviewed in two years time after the present site research programme improves our knowledge in this area. In the interim it is suggested, whilst existing planned trial series should be completed, that no new trial series be initiated.

Numerous research issues have been suggested to the working group and these have been recorded mostly without critique. Instead a set of recommendations have been made that synthesises the key elements and ideas.

A matrix of treatments has been developed that include: Genetics, Site type, and Silvicultural treatment. Each of these categories or layers have been further refined to provide a matrix of factors to be examined. Existing trials will be applied to these matrices to identify duplication and deficiencies. This task will not be completed until May 1997.

A number of single issue trials are also suggested. These are issues that do not fit the matrix, but have been identified as of considerable significance. These include environmental issues, silviculture to eliminate manual methods, clonal silviculture, convergence/divergence growth trends, and silviculture x disease effects.

Research priorities have not been set by the working group, rather it has been left to the membership of the Cooperative to vote for competing projects in the usual way. However three projects have been identified that may be funded this financial year. These projects may save considerable time and cost in the future. The are: analysis of final crop stocking trials, crown biomass studies, and crown health assessment.

Collaboration between Cooperatives has been highlighted and the working group considers that this could be substantially improved. It is suggested that Cooperative Managers and Chairpersons could meet on a regular basis and that joint workshops on direction and strategy would be constructive.

INTRODUCTION

Silvicultural practice in New Zealand's plantation forests is characterised by early and intensive stand tending aimed at enhancing stem quality and maximising profitability. Decisions on stand tending that manipulate the final crop are often completed in the first 10 years of the stand's life. Research trials into the effects of such silvicultural treatments are therefore, by the nature of forest growing, long term experiments, with considerable strategic implications. These trials need to answer questions that may be asked one or two decades into the future. Where such a long term view taken it is clearly important to plan carefully and to update strategies on a regular basis.

In 1991 the Stand Growth Modelling Cooperative completed a review of current and past Permanent Sample Plots for growth modelling purposes. A strategy for future PSP requirements was then developed and suggestions were made on levels of experimental design (Hayward *et al*, 1991) . For the issues of initial stocking, timing of thinning, and final stocking, a "core" framework was developed and documented. Plots for this frame work could be from within experiments or as growth monitoring plots. For other silvicultural issues such as breed, fertiliser, pruning, and number of thinnings, it was suggested that specific trials be designed and located on representative site types. This working group found that classification of sites was not possible.

In 1994 a review of research trials with silvicultural treatments was undertaken within the Forest and Farm Plantation Management Cooperative (F&FPM Cooperative). This has resulted in the collation of a database describing trials (West, 1994). Analysis of this database has indicated that a number of issues and site types were inadequately covered by the current trial series and that the balance of the number of trials by treatments needed to be addressed. Currently there are some 72 designed silvicultural experiments (54 on forest sites and 18 on farm sites). Some rationalisation of these trials may be needed and consideration given to how they will contribute to our future knowledge. New trials may be needed to fill gaps in data sets or to improve knowledge.

In the 1995/96 year a project was accepted by the Cooperative to fund the development of a strategic plan for silvicultural trials. A working group was formed consisting of five volunteers from the Cooperative membership and one member from FRI. The members of the working group (with meeting substitutes) were as follows:

Dave Elliott	Forest Woodlot Management	Rotorua
Mike McLarin (Peter Thomson)	CHH Forests	Tokoroa
Paul Smale	Rayonier New Zealand	Auckland
Phil Taylor	City Forests	Dunedin
Mike Kater (Stu Nash)	Fletcher Challenge Forests	Rotorua
Wink Sutton (Ollie Kemp)	Fletcher Challenge Forests	Rotorua
Graham West	NZFRI	Rotorua

Objective of Working Group
To develop a strategic plan for new and existing silvicultural trials.

Terms of Reference
A first task for the group was to define what could realistically be achieved, and to develop guidelines and limitations. The following terms of reference were adopted:

1. Only silvicultural trials planted with the species *Pinus radiata* would be considered.

2. Current silvicultural trials established by NZFRI, F&FPM Cooperative, SGM Cooperative, Site Management Cooperative, and Radiata Pine Breeding Cooperative were to be summarised and reviewed.

3. Utilisation of data and knowledge arising from the above trials was to be examined.

4. Recommendations on remeasurement of current trials will be made.

5. A strategy detailing new trials by site and treatment will be developed.

6. The working group will liaise with other Research Cooperatives to develop agreement on sharing of intellectual property, data, and field experiments.

METHODOLOGY

1. It was decided that the New Zealand common usage or restricted use of "silviculture" would apply, ie the issues of interest would pertain to **stand management** rather than site management or establishment issues. Fertiliser treatments were considered part of the Site Management Cooperative and hence not an issue for this group. The issues given by Hayward *et al*, 1991 were taken as a useful guide ie Initial stocking, timing of thinning, final stocking, breed, pruning, and number of thinnings. However it was decided that the group take a broad view of silviculture and not be constrained to present treatments.

2. Because of the long term time scale in forestry it was recognised that a useful approach was to provide research results that were required in 10 to 15 years. Therefore the strategy should attempt to address the following -
"What silvicultural questions will the forest owner/manager of 2010 want answered?"
or
"What issues will he or she need to evaluate to develop the best silvicultural regime in 2010?"

3. It was suggested that input, ideas, and vision be sought from the managers of other relevant Cooperatives, ie the Radiata Pine Breeding Cooperative, Site Management Cooperative, Stand Growth Modelling Cooperative, and Forest and Farm Plantation Management Research Cooperative. Also comment from several senior scientists at NZ FRI would be invited.

RESULTS

Although the working group has met on five occasions, the task of developing a long term strategy has proved to be very large and difficult. Through a process of discussion and liaison with numerous Cooperative managers and researchers, a large number of issues have been identified for research. Results presented here are the best conclusions that could be achieved in the time available. The contribution of time by industry members on the working group has been generous but can not be considered unlimited. Clearly any strategy developed here requires later review and may be considerably modified as knowledge and techniques are developed.

Short vs Long term strategy

A problem that has remained unresolved despite lengthy discussion and review is the issue of site classification. Our knowledge of the major site factors that drive tree growth is still somewhat limited. This inhibits our ability to classify sites or draw boundaries around unique regions of tree response to silviculture. Some effort is currently focused on this issue in the Site Management Cooperative and within a specific FRST bid that examines indicators of forest sustainability. Therefore, a possible solution to the problem is to develop a short term strategy for the next two years until more is known about this issue. The working group could then be reconvened and a more complete strategy developed. Over the next two years it is suggested that no new trial series be established while this issues is clarified. This will not preclude the completion of existing trial series.

For issues other than site classification, a long term strategy could be attempted. The strategy for new and existing trials should be reviewed on a regular basis. Suggestions made by this working group should therefore be viewed as part of a continuing programme which endeavours to make the research as relevant and useful to the Cooperative members as possible.

SUGGESTED RESEARCH ISSUES

Numerous ideas have been put forward by the Cooperative Managers, F&FPM Cooperative members, and the working group. The merit of some of the ideas is difficult to judge, however most ideas have been recorded here for future reference and evaluation.

From the multitude of view points, input, and discussion, four themes have emerged:

1. Tree Breeding

In experiments that examine breeds x silviculture effects, results will inevitably lag behind the best available genetic stock by 7 - 10 years. Emphasis on traits rather than breed may be a more enduring approach, ie where any given breed (eg Growth and Form) will be mixture of traits (eg , growth rate, branch habit, wood density, etc).

The forest industry will soon have access to indices of traits for designing their own seedlots using a new trait selection tool.

For the year 2010 at least two genetic improvement options will be available:
1. New selections of full sib family seedlots
2. Clonal forestry

For future silvicultural trials, interaction with propagation method needs to be considered. Fascicle cuttings were considered the best option if treatments had to be limited.

2. Environmentally sustainable silviculture

Silvicultural systems that are environmentally sustainable may be required in the future. Although many of the following silvicultural treatments may not provide improved profitability, forest growers may be required to justify why they can't be practiced. The following list gives the silvicultural practices that may require research and the reason they may be needed.

- mixed aged stands - loss of clear felling / continuous forest cover
- high initial stockings for weed control - loss of herbicides
- mixed clonal blocks - biodiversity
- self thinning mixtures - health & safety
- mechanised out-row thinning - health & safety
- nutrient efficient breeds/clones - loss of fertiliser
- Totally sustainable silviculture - Green accreditation

3. Main stream silviculture

Stand Management - How confident are users of STANDPAK that:
- current growth models accurately predict silvicultural influences?
- site interactions with silviculture are accurately predicted?
- all site types will be adequately covered?

Has the issue of Convergence / Divergence in basal area trends been adequately researched?

Forest health
- Is the modelling of health impacts on growth adequate?
- Silviculture x forest health eg
  - Diplodea in pruning wounds
  - prune and thin effects on Dothistroma - validate existing function
  - timing of thinning on Cyclanuesma
  - selection ratio on Armilleria

-Should all silvicultural trials be assessed annually to quantify disease effects?
-Should future silvicultural modelling systems be linked to the Forest Health database or expert system?

Forest Nutrition
- Does silviculture and forest nutrition interact?
- If we fertilise stands should we change the silviculture?
- Can current growth models with fertiliser and silviculture effects be improved?
- Should growth models warn users of the nutritional consequences of regime choice?

4. Fringe ideas in silviculture

- Planting configurations with specialised crops identified in rows, (partitioning of crop for specialisation) eg clones for pulpwood production thinnings identified in an out-row system.
- Understorey cropping in place of weeds - flax, Ginseng, Shitake mushrooms
- Silviculture for chemical production - Ligno-chemicals
- Silviculture for energy production - clones x stocking
- Treatments to improve timber appearance - copper nails, wire banding, to create wood characteristic that improve its marketability.

Market and Processing considerations

Considerable thought and discussion was given to the concept that "silviculture should be market led". Our conclusion was that future markets were largely unpredictable and that silvicultural research can only attempt to cover extremes of treatment when designing trials, ie rather than attempt to guess what regimes will be practiced in the future, the design of trials should facilitate the development of growth models which can predict reliably across a very wide range of silvicultural treatments. A positive suggestion was that we can only hope to influence future markets but not predict them.

RECOMMENDATIONS

Treatment Matrix

As developed in previous reviews or strategies this working group has worked on the development of a core matrix of treatments within which the Cooperative has an interest in understanding how trees grow and what log qualities will result in the year 2010. This range of treatments will provide data to test existing models, build new models where required, and generally aid in the development of silvicultural decision support systems, such as STANDPAK, of the future.

Such a matrix would allow the distribution of existing trials to be examined with some rigour. Through this process any duplication or deficiencies would be self evident. The major areas identified for each "layer" of the matrix were:

1. Genetics
2. Site type
3. Silvicultural treatment

Within each layer there are a number of factors to be examined eg within silviculture, issues such as pruning, thinning, and final crop stocking.

Through this approach one of the major issues that can be examined will be the interaction between these layers, eg Will a selected genotype behave differently depending on site type? Will a certain silvicultural regime influence tree growth or quality differently depending on site type or genetics? or Will the optimum silvicultural regime vary with genetics and site?

In taking this approach there are some problems. Not all of the issues raised will easily fit such a matrix and therefore some trials may augment the framework.

Some factors are not easily characterised into matrices.

Genotype
As the tree breeding programme develops new genotypes or breeds on a regular basis there is a concern that any new trials planted in the next few years will provide information in 2010 on what then will be "old" breeds. As an alternative approach it has been suggested that we examine traits ie internode length, wood density, etc. This would allow us to study the interaction of a particular trait within a site type or silvicultural regime. While this appears sound conceptually, it has some practical problems in that trees have multiple traits and it will be difficult to maintain all except one trait constant in an experimental design without going to clones. While using clones may be possible, the risk here is that the results may be specific to the clones used and can not be generalised. Further knowledge on the practical range of a desired trait maybe required before this aspect is finalised. A more pragmatic approach my be to select logical combinations of traits that are desirable to maximise a desired wood product. eg structural timber = high density, small branched, short internode, fast growth.

For the existing silvicultural trials very few have used the trait approach, therefore these can only be classified by breed. It is proposed to sort the existing trials by GF or LI rating.

Site type
To develop a matrix of where future trials may be located a fundamental issue of classifying site types requires resolution. This has proved to be difficult and frustrating. Our knowledge of what drives forest productivity on a site by site basis is still very limited. Current thinking is in terms of forest vs farm sites, or estimates of height growth - site index. In the current silvicultural/breeds trials (Carson, *et al* 1991, Skinner and Carson, 1994), sites have been classified by growth model region and (high, med, low) site index plus a high basal area level. As a short term strategy a similar approach has been taken here.

Site type has been classified as:

1. Region - using largely the provincial boundaries
2. Site Index - aiming to achieve a range of 22 to 34m
3. Basal area increment level

Basal area increment level- as in the EARLY growth model, is classified as - low, med, and high, for sites respectively characterised by: low growth rates usually attributed nutrient deficiencies, average unimproved forest sites, and ex-farm or high fertility sites.

Silviculture
Silvicultural treatment is quite diverse in radiata pine and therefore not all possible treatments can be fitted into a matrix approach. Issues such as pruned height and number of thinnings have not been included and may be treatments that augment core treatments identified below. Silviculture has been classified into:

1. Selection ratio - the ratio of the stocking planted : final crop stocking - 1:1, 2:1,3:1
2. Final crop stocking - 100 - 200, 200-400, 400 - 1500
3. Timing of thinning - by stand MTH - <10, 10-20, >20m
4. Pruning severity - by crown remaining - <4.5, 4.5-6, >6m, unpruned.

Matrix of treatments.

A matrix of the above factors and treatments is given in appendix 1. Genotype, site, and silviculture should be considered as layers, with each layer containing a surface of treatments. Each plot will therefore be identified in a multi-dimension, within a surface and by each layer. Existing trials will be fitted to these matrices to identify duplications and deficiencies. This task involves sorting more than 3000 plots and will therefore be delayed until the new Windows version of the PSP database is completed in early 1997. Existing trials will be fitted to these matrices by the May 1997 Cooperative meeting.

Additional Single Issue Trials

A number of issues raised during this strategy development do not fit into a matrix approach. These are given as single issue trials that probably do not need to be repeated on all sites and with all genotypes. They are:

1. Environmental Issues
   - Continuous forest cover - no clearfelling, (the light demanding characteristic of radiata pine is not likely to allow this silvicultural approach.)
   - Weed control with high initial stockings - no herbicides

2. OSH silviculture - eliminating manual methods
   - Mechanised out-row thinning
   - No thinning - matrix treatment
   - Mechanisation of pruning - see existing project
   - No pruning - long internode clones - see matrix

3. Clonal silviculture
   - mixed vs pure clone stands
   - Clones x silviculture (final crop stocking) x site

4. Convergence/Divergence in Basal Area Growth models.
   - Comparing, at the same crop stocking, basal area growth trends after pruning or late thinning has depressed growth . These treatments are rarely in the same trial or the same site (Maclaren *et al*, 1992). Existing trials are to be checked to record how many examine this issue.

5. Silviculture x disease -
   - Pruning and thinning on Dothistroma - validate existing functions
   - timing of thinning on Cyclanuesma - extend limited existing trials
   - selection ratio on Armilleria - extend limited existing trials

Immediate action proposals

Some funds have been held in abeyance in the 1996/97 year, for key issues that may arise as a result of the working group's review. The following are three proposals that may save the Cooperative considerable time and money. The working group suggests that projects 1 and 2 be undertaken in the current financial year if scientist time is available. Project 3 could be included in the next financial years programme.

1. Analysis of final crop stocking trials

A proposal to the Cooperative for next financial year is to analyse a mature final crop stocking trial in Kaingaroa. This proposal is very close to answering a key question discussed by the working group ie does the effect of final crop stocking on tree growth differ with site type. (ie is there an interaction between final crop stocking and site). By extending this proposal to include a larger series of semi- mature final crop stocking trials we may be able to answer this question satisfactorily and avoid further trials.

2. Crown Biomass studies

Preliminary work examining the relationship of pruning definition to crown dry matter remaining, has indicated that this technique could provide a valuable indicator of the effect of site and genetics. Previous work by Madgewick and Beets at FRI has indicated that the response of trees to added nitrogen fertiliser is to grow more foliage. Therefore on farm site, for example, trees of a standardised age and stocking, are likely to maintain a higher dry matter of foliage for a given crown length. Such a method may provide an indication of basal area increment level from a point sample of biomass.

Similarly the changes that are occurring with improved tree breeds may be measured in their crown biomass. This may give some understanding and prediction of the growth rates of selected traits.

To further evaluate this technique it is suggested that biomass studies are extended to include a range of site types and within one or two sites, a range of breeds are also measured

3. Crown health assessment.

Recent research results by Beets and Jokela (1994) and Bulman, (1995) have indicated that crown disease or needle retention can have substantial effects on tree growth rate. The incidence of crown disease can be very localised and may sometimes be the result of specific silvicultural influences. The consequence of this is that silvicultural treatments can often be masked by disease effects, adding unexplained variation to data, and possibly confusing the analysis and interpretation of results.

A solution to this problem is to regularly assess the crown health of silvicultural trials and use the assessment results to make appropriate adjustment to the growth data when it is analysed . Crown health is generally assessed in October or early November.

To evaluate the crown health of the current series of trials it is proposed that an assessment next financial year be costed and put to the Cooperative for approval.

Collaboration

During the process of developing this strategy the managers of the Radiata Pine Breeding Cooperative, Site Management Cooperative, Stand Growth Modelling Cooperative, and the Forest and Farm Plantation Management Research Cooperative were invited to give there ideas and vision on future direction. These discussions have clearly indicated that these Cooperatives act independent of one another and in some cases may be in competition. This indicated a clear need for greater collaboration between Cooperatives and between some FRI research programmes. It is suggested that Cooperative Managers and Chairpersons could meet on a regular basis to harmonise research direction and strategy. Another possibility was to collaborate through joint workshops on specific issues and goals. Joint projects have been undertaken in the past and there may be considerably more potential in this approach.

Silviculture clearly overlaps into many areas such as site, health, genetics, and growth modelling. The role of the F& FPM Cooperative may be to integrate many aspects of work in other Cooperatives and provide a synthesis of results into "What does this mean for forest management".

Clearly the delivery of technology through STANDPAK is convenient and unifying.

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Appendix 1. Matrix for Genetics x Site x Silviculture Factors

GENOTYPE

For existing trials these are best classified by breed as there are very few trials using the trait approach at present.

Breed

Growth & Form (GF)	7-14	15-21	22 - 28
Long Internode (LI)	7-14	15-21	22 - 28

Traits

Short Internode

Branch size

	Growth Rate		
	Slow	Med	Fast
small			
medium			

Long Internode

Branch size

	Growth Rate		
	Slow	Med	Fast
small			
medium			

Matrix could be enlarged to include Straightness & Wood density. However these factors will probably be linked to the Growth trait.

SITE
Region

Northland

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

BOP/Waikato/Taranaki

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

Hawkes Bay/Manawatu

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

Nelson/ Marlborough

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

Canterbury

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

Otago/Southland

Basal Area Increment

Site Index	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

West Coast Sands

Site Index	Basal Area Increment		
	Low	Med	High
<24			
25 - 28			
29 - 32			
>32			

SILVICULTURE

For selection ratios: 1:1, 2:1, 3:1

Final crop stocking) - 200

Timing of thinning(m)	Pruning Severity (crown remaining) <4.5	4.5 - 6	>6	Unpruned
<10				
10 - 20				
>20				

Final crop stocking 200 -400

Timing of thinning(m)	Pruning Severity (crown remaining) <4.5	4.5 - 6	>6	Unpruned
<10				
10 - 20				
>20				

Final crop stocking 400 - unthinned 1500

Timing of thinning(m)	Pruning Severity (crown remaining) <4.5	4.5 - 6	>6	Unpruned
<10				
10 - 20				
>20				

Existing trials are to be entered into this matrix by May 1997.