FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

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EXECUTIVE SUMMARY

TARGET TIMBER PRODUCTS FROM FERTILE FARM SITES: A CASE STUDY USING THE TARGET TREE SYSTEM

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A fertile ex-farm site at Tikitere (near Rotorua) was used as a case study to test and further develop the methods of a Target Tree system.

For the case study, two sawn timber product goals were set for the Target Tree system. These were:

1. 60% or more of the timber as appearance grades
2. 60% or more of the timber as premium structural grades

As several components of the Target Tree system are still to be developed, this study has used manual inputs into STANDPAK to demonstrate the potential results the system might achieve. Breeding traits and silvicultural regime options were manipulated through a series of interations to establish target trees that are predicted to provide the goal products. The resulting breed, silvicultural regime, and tree quality specifications are given in terms of seedlot GF Plus ratings by trait, pruning and thinning schedules, and log quality description.

This study indicates that through the joint manipulation of tree breed and silvicultural regime two quite diverse timber products (60% appearance timber or 60% structural timber), can be produced on the same site.

Improvements to the Target Tree methodology are suggested. These include computer control of the process using optimisation techniques under batch mode. These improvements are considered necessary to solve for desired goals while testing a large array of potential combinations of driving factors .

A definition of the target tree system is suggested: For each site type, target tree is the average tree within a stand that produces the desired proportion of the goal product or products at least cost.

Although the general approach taken for this Target Tree analysis has not included an economic analysis, it is suggested that the profitability of forestry projects should be evaluated using the usual discount cash flow techniques.

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INTRODUCTION

The target tree approach (West *et al*, 1998) was developed to provide a descriptive interface between the growing and processing activities of the forest industry . It recognises that there are considerable gains to be made by the careful matching of site, genetics, and silvicultural practice to provide trees suited to a desired end use.

A key link in the integration of these factors is the wood property attributes required by each product within the tree or log type. This requires the prediction of the influences of site, genetics, and forest growing practices on wood properties. It also requires the prediction of the effect of wood properties on product performance. To date this work has not been completed.

The target tree concept recognises that site and genetics influence inherent wood properties, and that wood quality can be further manipulated by management practices to suit target end uses. The target tree concept therefore provides a synthesis of numerous influences and interactions on tree growth and quality.

Recent timber grade studies on trees from the first agroforestry trials in the Central North Island have indicated that if sawn to structural dimensions the resulting sawn timber is low grade and lacks stiffness (Cown and Knowles, 1991). However in the same study regrading structural timber according to board rules showed that good quantities of dressing grades were possible.

Measurements of wood density indicate that wood density on these sites is reduced by approximate 5% and that some tree breeds may reduce wood density by a further 5% (McConchie *et al* ,1990).

Branch size by log height class has been measured for a range of stockings on many farm sites. When analysed, branches on farm sites fit the same pattern as data collected from unimproved forest sites, ie branch size is correlated with tree diameter at age 20 years, indicating faster grown trees have larger branches. A single predictive model has been fitted to both data sets (Kimberley and Knowles, 1993) and incorporated into STANDPAK (Whiteside,1990).

The current expansion of plantation forests is, in most regions, resulting in the planting of fertile farm land. Also as trees on farm sites mature and the second rotation is planted, questions of what breed to plant and how should these stands be managed arise. For some existing stands on farm sites, it is possible that a mis-match of site, breed, and silvicultural regime may have occurred. For example; trees with short internodes grown at low stockings on fertile sites with late pruning, appear to have produced little high quality structural <u>or</u> appearance timber. This highlights the need for a system that better integrates the influences of site, genetics, and silviculture and links wood quality to product performance.

Typically forest investment and planning questions are examined with the help of a predictive computer modelling system such as STANDPAK and involve an economic analysis that tests a broad range of scenarios. With the lack of definitive data on prices for future log and timber markets it is difficult to apply appropriate price gradients and confidently optimise financial returns. The Target Tree System allows an alternative approach to be taken which places more emphasis on growing stands for specific products or product attributes.

In this report a case study is used to demonstrate the Target Tree approach and further develop the methods and components of the system. An attempt is made to rationalize combinations of tree breed and silvicultural regime required to produce specified timber products from an ex-farm site at Tikitere (near Rotorua).

METHOD

Two diverse options for timber products were selected as goals in this study. They were:

1. To produce timber for structural uses.
2. To produce timber for uses that require appearance attributes.

Structural timber clearly involves wood with an emphasis on strength and stiffness, whereas timber for appearance uses requires an emphasis on clearwood or minimal visual defects.
As the Target Tree System has not been completed this study was achieved by making manual inputs into the current stand modelling system - STANDPAK, and running the system iteratively using the following steps:

1. Target grade minimums were developed to deliver products with desired attributes. These are given in Table 1.

Table 1: Target timber grades for each product attribute.

Product	Target
Appearance timber	60^{+}% sawn timber in Factory or Clears grades
Structural timber	60^{+}% sawn timber in F5 grade or better

2. Using the Quick Grades facility in the SAWLOG EVALUATION Module of STANDPAK, log quality variables (sed, branch size, internode index, wood density, etc) were tested at a range of levels for their impact on timber grades . Results were examined, and levels were determined for each log variable to provide timber that met the above criteria.

3. Values for breeding traits and silvicultural regimes were then developed and implemented into STANDPAK. Where necessary, modifications were made and the regime re-run. As recommended by West (1991) all regimes for this site were run using EARLY at the High basal area increment level followed by NAPIRAD as the later growth model. A nominal rotation age of 28 years was used for all regimes and all logs were made using the standard "NZ Domestic" Log Making and Grading specifications. Log grade output for each regime was run through the SAWLOG EVALUATION Module. Settings for this module were chosen from past experience and were chosen as logical methods of optimising the target products. Table 2 gives the settings for this module.

Table 2: Options used in the SAWLOG EVALUATION Module

Regime	Clearwood	Structural
Grading criteria	Visual grading Maximise value	Machine grading Maximise value
Mill type	Carriage Bandmill A	Carriage Bandmill A
Saw Pattern	Pruned logs = 25mm Unpruned = 100x40mm	All logs = 100x50mm
Conversion standard	2	2

RESULTS

Breed and Regime

Log quality characteristics and silvicultural regime variables were modified in a series of interations using the author's experience in silviculture and knowledge of the STANDPAK system. A more structured approach would normally be required for this process and would involve testing a very large number of runs involving combinations of tree breed, silvicultural regime, and processing options. Logically clears grades will be best achieved from long internode trees (uninodal branch habit), of large diameter, with moderate to large branch sizes, and pruning of the butt log. Structural grades will be best achieved with short internode trees, small branches, and high wood density. Trees arising from the breeding programme with long or short internodes have been generally classified into Clear cutting/Long internode breed or General Purpose/Multinodal breed. Table 3 gives the resulting breed, silvicultural regime, and tree quality requirements that will deliver the desired target products.

Table 3: Target product requirements in terms of Breed, regime detail, and average tree and log quality specifications

Target products	Appearance grades			Structural grades		
General Breed	Clear cutting or Long Internode - ca. LI28 (GF18)			General Purpose or Multinodal - ca. GF23		
Planted stems/ha	2 x final crop			3 x final crop		
Pruning	4 lifts to 6.5m, 18cm DOS			No pruning		
Thinning	1 thin @ 11m MTH to waste			1 production thin @ 19m MTH		
Final crop	300			400		
Rotation length	28 years			28 years		
	Log 1	Log 2	Log 3&4	Log 1	Log 2	Log 3&4
Branch Index (cm)	0	5.8	6.5	3.2	4.0	4.4
Wood Density (kg/m^3 MBD)	395	380	372	465	445	422
Sweep (mm/m)	10	5.5	5.5	2.5	2.5	2.5
Internode index	.45	.60	.40	.10	.12	.10

DOS = Diameter Over pruned Stubs
MTH = Mean Top Height

Tree breed

The database of performance values for the national breeding population was interrogated to resolve whether the log quality characteristics defined for each product could be achieved by the current tree breeding population. With the assistance of Mr G. Vincent, GF Plus™ values (Vincent and Buck, 1998) were used to assemble a list of parents that would be combined to provide a seedlot that could theoretically produce the desired target trees. Table 4 gives the details of the seedlots using the GF Plus™ ratings.

Table 4: GF Plus™ ratings by trait for each target product seedlot and for an unimproved seedlot (GF1-2)

	Appearance grades	Structural grades	Unimproved†
Growth	20	21	11
Straightness	19	21	17
Branching	11	22	17
Dothistroma	15*	18	15
Wood Density	17*	23	19
Spiral Grain	18*	22	18
Needle retention	13*	15	-

* Estimated by Mr G. Vincent because of limited data

† From Vincent and Buck, 1998

The analysis of the database revealed that the appearance grade seedlot could be produced by 16 parents and the structural grades seedlot by 14 parents. This assumes equal contribution from each parent. These results will need to be validated with field evaluations at the case study site.

Growing costs

The growing costs of comparative regimes has not been calculated in this study but should be considered when determining the breed and regime combination. Obviously the regime that delivers the target product for the least cost per m^3 is the optimum solution.

Log Grades

Results by log grade as described by log variables are given in table 5. The log variables values essentially describe the notional Target Tree when averaged across aggregated log grades. The Target Tree would in practice be the average tree in a Target Stand. Volumes and grades from production thinning have not been included.

Table 5: Log variables by regime and log grade at age 28 years

Regime	Log Grade	Volume (m3)	%Total Volume	Sed (mm)	Length (m)	Taper (mm/m)	Sweep (mm/m)	Branch Index (cm)	Mean Basic Density (kg/m3)	Inter-node Index (mm)	Pruned Log Index (PLI)
Clearwood	PRUNED	260.3	34.2	454	6.3	14	8	0	395	0.47	7.3
	S1+S2	94.1	12.4	374	5.4	9	5	4.8	380	0.52	0
	S3+L3	96.4	12.7	258	5.3	12	4	6.0	374	0.42	0
	L1+L2	238.6	31.4	391	5.3	11	5	6.9	379	0.48	0
	PULP	71.4	9.4	320	5.7	13	21	4.7	384	0.44	0
	Total	760.7									
Structural	PRUNED	0	0	0	0	0	0	0	0	0	0
	S1+S2	488.3	61.2	399	5.5	11	2	4.1	454	0.11	0
	S3+L3	195.3	24.5	261	5.2	10	2	4.2	433	0.10	0
	L1+L2	73.6	9.2	408	5.4	12	2	6.2	439	0.10	0
	PULP	40.3	5.1	164	5.2	12	2	4.1	419	0.10	0
	Total	797.6									

Timber grades

The SAWLOG EVALUATION Module was used to predict timber grades. Timber grade results by log grade are given in table 6. Over all log grades, Factory, Cuttings, and Clears grades (ie appearance grades shaded in grey) are shown to total 57.2% of the sawn timber products from the Clearwood regime. This is slightly under the goal of 60% but adequate for the purposes of this study.

Over all log grades, F5and F8+ (structural grades shaded in grey) are shown to total 68.9% of the sawn timber products for the Structural regime. This exceeds the 60% goal and indicates that there is a potential buffer to absorb any unforeseen decrease in density that may occur with the site.

Table 6: Sawn timber grade by regime and log grade

Regime	Log Grade	No.1 Fram-ing	No.2 Fram-ing	Box Fram-ing	F8+	F5	F4	<F4	No.1 Clear	No.2 Clear	No.1 Cutts	Fact-ory	Boards	% Conversion
Clearwood	PRUNED		0	0	0	0	0	0	52.1	8.6	4.5	12.8	21.9	54.4
	S1S2	16	14.6	17.2	0	0	0	0	1.0	1.3	15.4	32.2	2.3	54.5
	S3L3	11.9	22.6	34.8	0	0	0	0	0	0	5.2	17.2	8.3	46.4
	L1L2	7.5	11.0	27.8	0	0	0	0	0.5	0.3	14.8	36.1	2.1	55.3
	Overall	6.4	9.0	16.8	0	0	0	0	20	3.5	9.6	24.1	10.5	53.6
Structural	S1S2	0	0	0	44.9	27.4	10.4	9.0	0.4	0.1	1.0	2.3	4.4	56.8
	S3L3	0	0	0	34.2	30.6	11.5	10.8	0	0	0.5	1.4	11.0	47.6
	L1L2	0	0	0	19.9	37.3	15.2	19.2	0.4	0.1	1.0	2.8	4.1	57.2
	Overall	0	0	0	39.7	29.2	11.1	10.5	0.3	0.1	0.8	2.1	6.1	54.5

DISCUSSION

The Target Tree system as described by West *et al* (1998) and methodology outlined here clearly requires further refinement and consolidation. Funding bids to FRST for work starting in July 1998 have outlined new projects that will make considerable progress in this area.

Genetics

For the radiata pine breeding populations, much of the current trait information is in terms of rankings rather than absolute values. Therefore it is difficult to be certain that the tree quality criteria given in this study for each target product will be achieved at the case study site. An estimate of the genetic gain achieved in wood density on other sites was used to confirm the goals in this trait are reasonably achievable. However, for branch size estimates this is not possible although it is widely accepted that branch size is smaller in more multinodal trees. The branch sizes used in this study are as predicted by the modelling system and may be considered to be conservative, ie the branchs of a long internode breed may be larger than predicted and the converse for multinodal. In a study comparing the economic returns from differing breeds, Carson (1990) adjusted the branch size predictions in STANDPAK. The branch index of the long internode breed was increased by 1.0cm and decreased of 1.0cm for the multinodal.

Actual values for genetic gain in mean internode length can be estimated from breeding values using a relationship developed by Turner *et al*, (1998). Breeding values for branch cluster frequency (BCF) were averaged for the seedlot and converted to mean internode length using this relationship. This process has indicated that the appearance grade seedlot would produce a second log internode index of 0.57 and the structural grade seedlot would produce a second log internode index of 0.34; both are reasonably close to the levels used in defining the target tree.

Economics

The general approach taken in this study is to assume that the goal products will attract the highest prices in the future. Therefore maximum profit will be achieved with the lowest growing and manufacturing cost for each target product. Calculating these costs should therefore be part of the process of regime selection.
This study has not attempted to calculate the economic implications of the regimes developed. However it is logical that some sensitivity analysis with a range of scenarios for future timber prices should be undertaken to compare the two options in terms of NPV. Also the general profitability of the forest project should be assessed in economic terms, particularly when making comparisons between alternative sites with differing levels of absolute productivity.

Optimisation

A question still remains regarding how to derive the optimum combination of factors in producing target products or target trees. The possible combinations from: sites * clones * silvicultural regimes * processing options, is extremely large. A potential answer is to include in the design of the future system a method for optimising to achieve a set goal. Such an approach could use a "Solver" or Operations Research techniques such as Dynamic Programming (Taha,1976) to achieve a objective function given a series of constraints. This approach would require the system to be structured to allow multiple runs in batch mode as well as allow interactive sessions.

Validation

As the results from this study have involved numerous assumptions and may involve unknown interactions, these predictions should be validated with field trials and processing studies. To achieve this, a new trial has been planned for both farm and forest sites in the Bay of Plenty (R.L. Knowles, pers. comm.). Similar trials are also planned in the shelterbelt research programme.

CONCLUSION

This case study has further developed the Target Tree system as a method of rationalising the combination of site, breed, and silvicultural factors to achieve desired timber product goals. For this study the major steps in the process have been:

1. Define target products
2. Define the processing method
3. Define target logs that will deliver the products
4. Define (for the given site) the seedlot parents and silvicultural regime that will deliver the target logs.

Through the manipulation of tree breed and silvicultural regime two quite diverse product goals can be produced on the same fertile ex-farm site at Tikitere. This is of contrary to common perception and should be validated with field trials.

This study has used the Target Tree methodology in a number of manual iterations to achieve results reasonably slowly. However better computer control of the process with optimisation techniques under batch mode is envisaged that will solve desired goals quickly .

This study has helped clarify the processes involved in the target tree pathway and has help to formulate a definition of the system, ie For each site type, target tree is the average tree within a stand that produces the desired proportion of the goal product or products at least cost.

Although the general approach taken for this Target Tree analysis has not included an economic analysis, it is suggested that the profitability of forestry projects should be evaluated using the usual discount cash flow techniques.

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