ARTICLE

New information tools for the forest manager

Bruce Manley*

ABSTRACT

Tools for quantitative analysis now available to the forest manager range from techniques to provide more accurate data through to modelling systems which allow comprehensive analyses using that data. This paper reviews the evolution of information tools over the last 25 years from manual procedures to largely computer-based methods. Processes for forest mapping, inventory, management of stand records, stand and forest estate modelling are reviewed, recent trends are discussed and future opportunities are described.

INTRODUCTION

Methods for assessing, recording, evaluating, planning and controlling forestry operations (i.e. 'information tools') have evolved in New Zealand over the last 25 years. For example, stand record keeping and forest planning methods have developed from simple manual paper-based procedures to complex computer-based systems. This evolution has been facilitated by the development of computing technology together with a range of other technologies.

The stimulus for the development of such methods arises from the forestry environment. Important factors have been:

- a substantial plantation forest estate;
- a second large afforestation programme since the late 1960s which has produced an expanding, largely uncommitted resource;
- the dominance of radiata pine, a fast-growing species which responds to a wide range of treatments and which is versatile in its end-use;
- political influences such as changing taxation legislation and the corporatisation and privatisation of the State-owned plantation forests.

The first three factors have meant that the forest manager has generally had a wide range of options to evaluate. The fourth factor has meant that forest management has taken place in an environment of rapid change.

Forest managers in some regions have had limited silvicultural and end-use options because of the need to sustain a large, established, wood-using industry from a resource which has substantial variation in quality between stands, between trees in a stand, and within individual trees. Here the need for accurate yield projection and control has been a prime motivating factor in the development of information tools.

A further stimulus to the development of information tools has been the focus on forest valuation over the last 10 years, both for the purpose of sale and purchase and for the purpose of company accounting. This has placed increasing pressure on the quality of forest data and led to greater standardisation of data collection and recording systems.

This paper reviews the evolution of information tools for the forest manager over the last 25 years. For ease of presentation, tools are considered by area of application:

- Mapping and determination of areas
- Inventory
- Stand record systems
- Stand models
- Forest estate models.

For each category, past developments are summarised and future opportunities are outlined.

INFORMATION TOOLS

1. Mapping and determination of areas

(a) Base mapping

Until the 1970s, analogue stereoplotters were used to produce base maps. The analytical stereoplotters used in the 1970s and 1980s were a major advance enabling direct mapping into Geographic Information Systems (GIS). These machines converted the photo-coordinates on hardcopy photographs into ground coordinates using a computer to carry out photogrammetric calculations. The advent of digital photogrammetric systems in the 1990s heralded a new era of photogrammetry. Softcopy systems, which utilise digitally scanned photographic images in place of hardcopy, offer the advantage of a completely digital work flow for map production. This allows the use of specialist image processing tools for such applications as digital terrain mapping.

(b) Updating forest base maps

A similar approach has been followed for 50 years with the use of simple optical or mechanical transfer instruments such as the Sketchmaster to transfer changed features from aerial photos onto base maps. Recent developments are:

(i) GPS (Global Positioning System)

GPS (see Eggleston, 1992) provides the opportunity to capture ground coordinates directly in the field. Data can be fed directly into GIS (Geographic Information Systems) or plotted out and traced onto the forest map.

(ii) Airborne video

The use of airborne video has potential for a range of applications including resource mapping and characterisation as well as resource monitoring and assessment (Hosking 1994). Because airborne video is less sensitive to weather conditions than conventional aerial photography, it has application in situations where updated information is needed quickly (e.g. after a cyclone). It is also appropriate in situations where lower accuracy is required (e.g. sketch mapping).

(iii) Laser rangefinders

Tools such as the Criterion allow boundaries of physical features to be mapped. They can be used to measure the bearing,

* *NZ Forest Research Institute, Rotorua, New Zealand.*

elevation and distance to boundary trees relative to the fixed reference point.

(iv) Orthorectification

Instruments such as the Sketchmaster which allow a simple scaling and rotation of an aerial photograph essentially apply an average adjustment to the whole photograph. They do not allow for relief displacement (i.e. the apparent shift in position of features due to height differences).

Differential rectification software is now available which resamples the whole image so that each pixel can have a different scaling. The correction of each pixel is based on a digital terrain model (DTM) which provides the 3-dimensional coordinates for each pixel. The end result of this orthorectification is an orthophoto which has the same properties planimetrically as a map.

2. Inventory

Inventory has been classified by Gordon and Lawrence (1995) as:

- silvicultural inventory to plan, schedule and control silvicultural operations through rate setting and quality control;
- management or mid-rotation inventory to monitor growth and to provide starting points for the prediction of growth and yield;
- preharvest inventory for planning and administering harvest operations.

A common trend for all types of inventory has been the increasing use of hand-held computers such as the Husky Hunter for data recording (see Gordon, 1991). Another feature has been the increasing level of spatial detail. Whereas extensive inventory concentrating on the level of growing stock in a forest had been the norm until the late 1970s (see Lees, 1967), today most inventory is done at the stand level.

For management and preharvest inventory, there has been an increasing emphasis on assessing volume by log product type. This is reflected by the development of the MARVL inventory system (Deadman and Goulding, 1979) to assess the potential volume by different log grades from clearfelling stands and applying different cross-cutting strategies.

A complementary development has been the evolution of methods for pruned resource evaluation. The New Zealand pruned resource can be characterised as being extremely variable as a result of the range of silvicultural treatments which have been applied and also as a result of the natural variability in tree size at pruning and in subsequent growth rate. Pruned log quality depends on both external features (size, quality, sweep, taper) and internal features (defect core profile, resin pockets). A sawing study method (Park and Leman, 1983) and a cross-sectional analysis technique (Somerville 1985) have been developed to determine pruned log quality. Data from these methods allow the evaluation of pruned logs via processing simulation models (e.g. AUTOSAW: Todoroki, 1990).

New developments

(i) Integrated forest inventory system

The recently released Version 3 of MARVL (Gordon *et al.*, 1995) is an integrated harvest inventory system. Features are:

- tree measurement data are stored in a structured relational database;
- flexibility for the user to define the area of interest or 'view' which is a collection of plots organised by strata;
- linkage with GIS which allows the view to be specified from within a GIS;
- the ability to incorporate plots measured in different inventories at different times;
- incorporation of growth models to enable the automatic projection of inventory data through time for re-analysis;
- the ability of the system to generate yield tables for a range of cross-cutting strategies as input to other systems for short- and medium-term harvest planning.

(ii) Projecting inventory data

Currently the MARVL system allows inventory data to be 'grown' forward by simply scaling individual tree basal areas by the same percentage as the predicted stand basal area increment. Research has been initiated on the development of tree diameter increment models to provide a more robust method for projecting inventory data for periods up to 15 years (Gordon and Lawrence, pers. comm.).

(iii) Quantification of tree quality features

One aspect of forest inventory receiving attention is the development of methods to more objectively quantify tree quality features such as branch size and stem straightness, which are currently visually assessed. The opportunity exists to capture images of the stem using different techniques and to use image processing to provide descriptions of the quality along the length of tree stems.

3. Stand record systems

Up until about 1980, stand record systems were largely manual with a map for each operation carried out being added to the file for that stand. Allison and Barnes (1964) provide an account of such a clerical system which featured:

- a Stand Plan showing the current subdivision of the forest into operational units;
- a Stand Index providing a current description of each stand;
- Operations Sheets which were essentially maps describing what had to be done in each stand;
- Record Files in which operations sheets were placed on completion of the prescribed operation.

In 1980, a computer-based system called the Stand Record System (SRS) was developed to store forest stand information for the NZ Forest Service (M. McKenzie, pers. comm.). The system contained information about the land occupied by each stand and about the tree crop or crops on that land. It incorporated treatment histories and measurement details for each crop. Growth models integrated with the system could be used to automatically project a forest to the current point in time and provide a 'book' estate description (Shirley, 1983).

The SRS was originally based on flat files in a relational structure. The system was enhanced in 1987 for use by NZ Forestry Corporation Ltd on VAX computers, by which time Database Management Systems (DBMS) were available. Consequently SRS was rewritten using a relational database, thereby allowing the linkage of other applications into the database without detailed knowledge of the system. For example, the VAX Datatrieve utility could be used to interrogate the database and provide ad hoc reports.

In 1987 FRI, in conjunction with Carter Holt Harvey Forests Ltd, developed a PC-based information system which was compatible with the SRS. This system called The Stand Master, which was written in dBase III+, stores forest information and has reporting features to allow the selection of stands based on current or past forest information (Tennent, 1988). It was superseded by The Forest Master (Tennent, 1992) which incorporates growth models to generate future yield predictions as well as links to other forest management packages.

New Developments

The advent of Geographic Information Systems (GIS) provides the potential for an extra dimension in stand record systems. GIS allows for the entry, storage, manipulation, analysis and display of spatial data. The linkage and even incorporation of stand record systems within a GIS framework provides the opportunity for map records to be stored digitally rather than on paper. Even with the computer-based SRS and The Forest Master systems, a physical file containing maps for each operation carried out in each stand has been retained. This spatial information can now be stored in a GIS.

The stand record system/GIS linkage also allows for analysis and reporting features ranging from mapping functions such as displaying the operations to be carried out in a year through to analysis such as slope classification for harvest planning and impact assessment using 3-dimensional visualisations generated in the computer.

4. Stand models

Stand models are subdivided into:

(a) Growth models that project stand growth and yield.

(b) Economic stand models that enable economic or financial analyses to be carried out.

(a) Growth models

The evolution of growth and yield projection techniques in New Zealand has been influenced by:

- changing management practices;
- advances in statistical techniques and computing technology;
- the availability of data.

Lewis (1954) was the first to formalise a general yield table for radiata pine in New Zealand. Prior to his work, a number of local normal density yield tables had been prepared in response to the needs of various regions. These tables provided estimates of the volumes and other properties to be expected in fully-stocked stands. Beginning in 1952, Lewis developed a variable density yield table he considered applicable to unthinned stands of radiata pine growing throughout New Zealand.

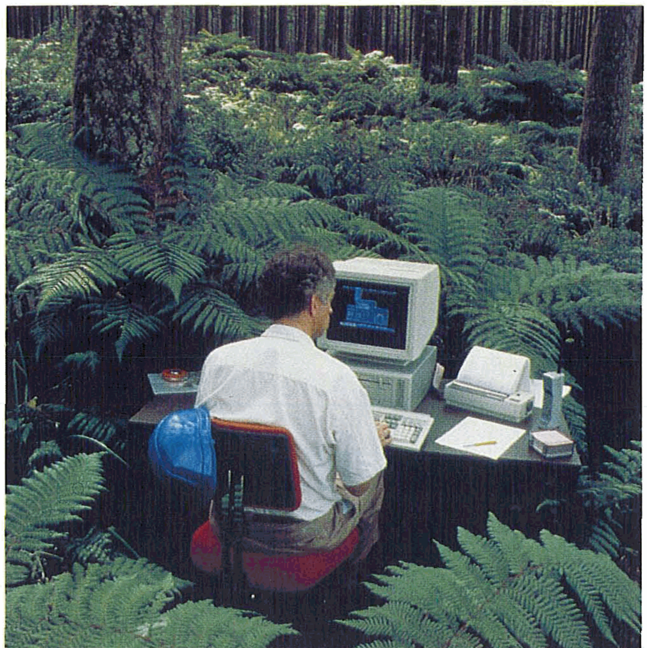
In view of the pioneering nature of Lewis's work, it is hardly surprising to note its limitations. Lewis was forced to work only with temporary plot data because no continuous plot measurement data were available. Consequently, Lewis did not have time series of data to reveal long-term growth trends.

As more intensive forest management became the norm in New Zealand, at least on NZ Forest Service forests, the utility of Lewis' yield table for unthinned stands quickly diminished. This led to the work of Beekhuis (1966) who developed a variable-density yield model based on periodic remeasurements of a series of thinning trials throughout New Zealand. These trials had received frequent, relatively light thinnings.

The Beekhuis growth model was widely used throughout New Zealand in the 1960s and 1970s. Following the proposal of Fenton and Sutton (1968) for a heavy early thinning regime for radiata pine, considerable debate arose within the NZ Forest Service as to its merits. Unfortunately there was little relevant growth data available on which an evaluation could be based.

Because of its restricted database, there was doubt about the ability of the Beekhuis growth model to adequately predict the development of stands subjected to such extremely heavy thinning treatments. Beekhuis had warned that his model should not be relied upon when the basal area in square feet was less than the top height in feet as was the case for the proposed regime.

Elliott and Goulding (1976) developed a growth model for radiata pine in Kaingaroa Forest. They had available to them a large pool of permanent sample plot data including early measurements of plots established specifically to help clarify the regime controversy. Similar methodology was used to develop radiata pine growth models for stands growing on coastal sands north of Auckland and for Nelson and Southland. These models were incorporated within the modelling system developed by the Mensuration Project Team (1976-78). This group of researchers and foresters was set up in 1976 by the NZ Forest Service to design and to subsequently develop a computer-based mensura-



tion and planning system (covering forest inventory, growth prediction and forest modelling) which would provide regional planning staff with the necessary software to develop regional management plans for State plantation forests (Elliott, 1979a). An increased rate of afforestation over the previous 10 years had made apparent the need for the development of better tools for management planning and yield control. In addition "supplies of wood from pre-war stands were becoming constrained for the first time in relation to the demand of domestic industries" (Kirkland, 1985). The need for accurate and detailed resource information had become critical.

As part of the Mensuration Project Team, Goulding and Shirley (1979) developed a stand volume generator (PROD) which predicts yield by log product type using stand model projections as input. This procedure used in tandem with the stand growth models is able to provide information on tree diameter distributions and log assortments.

The trend towards intensive silvicultural treatment in the first 10 years of a stand's life led to concern that the growth models should accurately predict the effects of pruning and early thinning on growth. The EARLY stand growth model (West *et al.*, 1982 and 1987) was developed to model the growth of radiata pine stands until top height 18 m. The total length of green crown per hectare is the major predictor variable in EARLY and helps to explain both pruning and thinning effects on yield. A feature of the model is that it covers all of New Zealand with site treated as an input variable.

A major part of the growth modelling effort at FRI over the last 15 years has been the development of a series of regional stand-level models using the methodology of Garcia (1979). These models use a state space approach, with the state of the stand at any point in time described by three to five variables. All models have net stand basal area, stocking and top height as state variables. Some models have the degree of canopy closure and nutrient level as additional state variables. The underlying assumption is that the current location of a stand in the state space plus any subsequent operations (e.g. thinning) completely determine its future development independent of its past history (Garcia, 1988). The changes in the state variables through time are described by a set of transition functions which are stochastic differential equations. Models have now been developed for seven regions of New Zealand based on biogeoclimatic zones (Goulding, 1994).

NZ Forest Products Ltd (NZFP – now Carter Holt Harvey Forests Ltd) has developed its own growth models for its Kinleith estate. NZFP management practice was generally more uniform and less radical than that practised by the NZ Forest Service.

In 1961, Spurr developed yield tables for two NZFP management regimes, thinned and unthinned. These yield tables formed the basis for yield planning and harvesting operations for the next 10 years. Clutter and Allison (1974) developed a general yield prediction procedure for NZFP that could be used to estimate growth and yield for both thinned and unthinned stands in its Central North Island forests. Essentially the system is a stand-level simulator that generates detail at a diameter class level. This growth model was revised by Woollons and Hayward (1985) and again in 1995 by Woollons (pers. comm.). In addition, models have been developed by Woollons for the Carter Holt Harvey Forests estate in Auckland and Nelson. Work is underway on a Canterbury model. The general methodology for all these models follows the Clutter approach. However, fixed diameter classes are no longer used. Rather an input tree list is projected through time.

(b) Economic stand models

The need for a comprehensive computer-based model to enable the economic and financial analysis of silvicultural regimes led to the setting up of a second NZ Forest Service research/management project team – the Radiata Pine Task Force (1979-82). There was concern at the proliferation of different silvicultural regimes throughout New Zealand and the Task Force was established "to provide a better basis for determining and rationalising silvicultural regimes" (Sutton, 1984a).

Prior to the Radiata Pine Task Force, the financial evaluation of silvicultural options had been largely done manually. For example, Fenton (1972) led a team at FRI in the late 1960s and early 1970s which evaluated a range of silvicultural options for a notional 25,000/ha forest using a detailed budget analysis approach. While computer routines were used for financial analysis, there was no integration with growth models. This work demonstrated that it is "impossible to maximise both volume and value production, and managers concerned with clear objectives must make a choice of the appropriate trade-off" (Kirkland, 1985).

The Radiata Pine Task Force used as its base the yield prediction system and stand volume generator of the Mensuration Project Team. It developed a system to predict both the quantity and quality of stand yield which was linked with a residual valuation procedure in the economic stand silvicultural model, SILMOD. Major contributions of the Radiata Pine Task Force were:

- the EARLY growth model previously discussed. This predicts the diameter over studs (DOS) for each pruning lift and hence pruned log quality. It allows the scheduling of pruning and thinning operations. For example, pruning can be scheduled to achieve a target DOS;
- log quality predictors. These estimate the major log quality variables affecting potential log value. The factors are either predicted or estimated from direct measurement and include: for all logs, the degree of sweep (deviation from straightness); for unpruned logs, branch size (Inglis and Cleland, 1982), wood density (Cown and McConchie, 1982) and internode length; and for pruned logs, defect core size (Park, 1982) and resin pocket incidence (Park and Parker, 1982);
- the harvesting production and cost estimator program, HARPCE (Blundell *et al.*, 1985);
- a sawing residual log valuation model which predicted sawlog values from timber grade out-turns, timber prices and processing costs (Whiteside, 1982). It had long been recognised that forest managers must look beyond the forest gate when making silvicultural decisions.

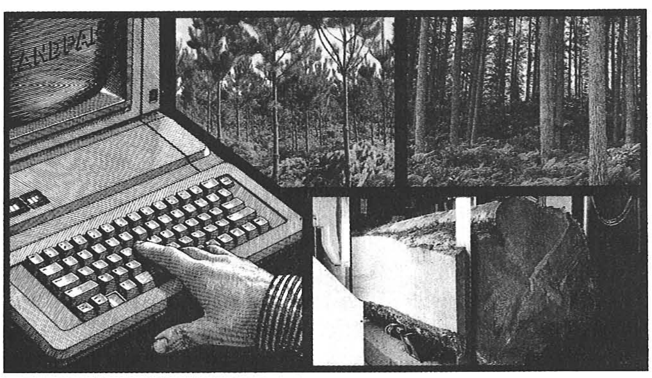
The Conversion Planning Project Team (1983-86) was subsequently set up in order to incorporate and extend previous work with the objective of developing "a conversion planning model linking the output of the forest and the various processing options to market requirements for a full range of forest products" (Kininmonth, 1984). Amongst its achievements, the Conversion Planning Project Team developed:

- a standard set of log grades for resource description (Whiteside and Manley, 1987);
- a log-grade predictor (LOGRAD) which rearranges the log mix predicted by PROD into the standard log grades (Whiteside *et al.*, 1987);
- log yield models that predict the physical yield of manufactured products, as well as the residual log values (revenues less processing costs) of logs with defined characteristics utilised in different manufacturing processes (e.g. sawing – Whiteside and McGregor, 1987).

The fourth special project team set up at FRI was the Agroforestry Project Team (1983-86) which had the objective of "providing mechanisms for evaluating combinations of forestry and agriculture" (Knowles, 1988). The agroforestry model (AGRO –Cox *et al.*, 1988) models the effect of trees on established pasture. It estimates the shading effect of the tree canopy (Percival and Knowles, 1988) and the effect of pruning and thinning debris or slash (Paton, 1988) on understorey pasture growth. The livestock carrying capacity and net revenue for each year is then predicted.

A major outcome of the four NZ Forest Service/FRI task forces and subsequent research has been the STANDPAK Stand Prediction Model (Whiteside, 1990). Conversion of STANDPAK from VAX mainframe to PC has been a major step in giving industry access to the modelling system. It has essentially become the repository for the latest research findings. Over the last 20 years, there has been a rapid increase in the available information base on the growth and utilisation of radiata pine. This data has come from such diverse sources as the establishment and remeasurement of silvicultural trials and other permanent plots, the assessment of tree quality and the sawing of samples of logs. With this expanding database has come an improved knowledge about the physical and financial behaviour of the forest estate.

Hence STANDPAK is serving an important extension role by making research results and data available to managers. The model integrates wide-ranging research findings in a readily-usable and applied format.



Stand models have progressed from growth models to economic stand models such as the STANDPAK system which simulates the growth, silvicultural management, harvesting and sawing of stands.

Recent trends and new developments

(i) Initial growth

The EARLY growth model commences at age four, after the stand establishment phase. Research effort is now focussing on initial stand growth from planting time to about age four.

Mason (1992) developed the model INITIAL to predict the growth of tree diameter and height for stands established in the Central North Island, taking into account cultivation, weed control and fertiliser treatments. There are plans to implement this model within the STANDPAK system.

(ii) Genetic gain

Tree breeding has modified, and is continuing to modify, tree growth rate and quality. In addition, the forest grower at any point in time has a range of different families/clones potentially available for deployment. In order to evaluate options, there is a need to be able to quantify the future log out-turn by size and quality resulting from different seedlots grown under different silvicultural regimes on different sites.

As a first stage, provisional growth model multipliers for top height and basal area have been estimated and implemented in most of the state-space regional growth models (Carson *et al.* in prep). The multipliers relate to the GF rating of the seedlot but are common to the whole country. These multipliers have been estimated from the limited database currently available and will be reviewed as data become available from an extensive series of genetic gain trials established by the NZFRI/Industry Stand Growth Modelling Cooperative.

Work is now underway to develop genetic gain modifiers for log quality characteristics.

(iii) Wood properties

An Enhancement of Radiata Pine Product Values Programme was initiated at FRI in 1993 to better quantify the impacts of log and wood properties on the value of end products.

The long-term targets are to:

- be able to estimate tree size, tree quality and key wood and fibre quality features for all families/clones in the breeding population (grown on any site under any silviculture);
- be able to predict the quantity and quality of products from processing logs from any part of a tree of known size and log/wood quality;
- understand the impact of log size and log/wood quality on the cost of processing logs;
- understand the markets and price differentials for end products.

This programme builds on previous research and concentrates on log and wood properties of individual families and clones. It has relevance to the forest manager in a number of areas including the development of economic weights for breeding and allowing the forest manager to produce a target tree through manipulation of genetics, site and silviculture.

(iv) Carbon sequestration

Plantation forests have the potential through the sequestration of carbon from the atmosphere to produce a net reduction of carbon emissions in New Zealand. A number of estimates have been made of the impact of plantation forestry in New Zealand on carbon sequestration. For example, Maclaren and Wakelin (1991) estimated the amount of carbon stored in plantations and forest products in 1990 and the amount of carbon that would be sequestered under different new land planting scenarios.

A "CARBON" module is being developed for STANDPAK to estimate the carbon sequestration by a stand over a wide range of sites and silvicultural practices. This module will incorporate wood density and biomass functions to enable the prediction of the carbon stored in a stand from stem volume production.

(v) Other species

Research is continuing to develop functions for other species for incorporation in STANDPAK to provide managers with a tool to evaluate a range of species. Work is well advanced for Douglas fir (Knowles *et al.* 1995) while a research plan for Cypresses is being developed.

5. Forest estate models

Up until the late 1960s, cutting plans were prepared manually. In the late 1960s, a series of computer-based forest estate simulation models were developed at NZFP, culminating in a system called FPS76 (Allison *et al.*, 1979). FPS76 was a computer application of manual forest simulation methods. An underlying concept was that of the croptype. A croptype is an aggregation of forest stands which may differ in age but which are regarded as uniform with respect to future management and yield prediction. For forest planning purposes stands were aggregated into croptypes with each croptype consisting of an age-class distribution of the areas of stands with a common yield table. The croptype was adopted as a compromise to link stands and forests (Allison *et al.*, 1979).

FPS76 was widely used as a yield regulation tool by the NZ Forest Service and other forestry organisations as well as NZFP. It suffered from some of the limitations of the manual method on which it was based, e.g. only one category of volume was considered and non-wood resources could not be included in the simulation.

Subsequently, a new series of Resource Maturity and General Management Simulators has been developed by NZFP. The first of these models, RMS80, has been updated through a number of versions into RMS2020. They have incorporated as optional features the forest measures developed by Allison (1978). For example, the Equivalent Normal Forest (ENF) concept is used to provide a standard of measurement against which a forest can be compared. The ENF is a forest mass measure. It measures "a quantity of forest in terms of a standardised relationship between ... rotational maturity and the annual yield that would maintain it" (Allison. 1985a). The Normal Exchange Value (NEV) is a related money measure used to provide a standard comparison for forest value (Allison. 1985b).

At the time of the Mensuration Project Team, the FPS76 simulator was being used by the NZ Forest Service in Rotorua to prepare long-term cutting plans. An optimisation model, CPLAN, was developed as the Project Team's long-term forest estate planning model (Shirley, 1979). This linear programming model required the user to specify a number of management alternatives for each cutting unit. CPLAN then selected the management strategy that optimised the specified objective function. It enabled resource flows other than wood volume to be included in the analysis.

CPLAN had limited use for forest planning. A limitation was the time required to produce resource flow estimates for each management alternative and to manually code this data. A change in the mainframe computer used by the NZ Forest Service also created a handicap in the continued implementation of CPLAN.

Garcia (1981) developed the Interactive Forest Simulator (IFS), a computer program to simulate forest plantation management using the same croptype concept used in FPS76 and the subsequent RMS simulators. An important feature of IFS is its interactive nature – the current status of the forest is displayed to the user who can explore a number of cutting options for that period before selecting one option and advancing it to the next period. IFS quickly became widely used by NZ Forest Service planning staff because it was easy to use and was made widely available on microcomputers through the efforts of the NZ Forest Service Resources Inventory Group.

Garcia (1984) subsequently developed the linear-programming-based estate modelling system FOLPI (Forestry Oriented Linear Programming Interpreter) to be compatible with the IFS simulator, reflecting the viewpoint that simulation and linear programming (LP) are complementary rather than competitive methods. This system has been widely used and has evolved in response to experience gained (Manley *et al.*, 1991).

Tasman Forestry Ltd has developed its own estate modelling system, RegRAM (McGuigan, 1992), a regional harvest scheduling and resource allocation model that uses optimisation and simulation techniques. The system succeeds LOGRAM (McGuigan, 1983), a single-period LP-based log allocation model.

Recent trends and new developments

(i) Model detail

For long-term planning purposes, an estate has generally been aggregated into croptypes to reduce the planning problem to a tractable size. Recent (and ongoing) hardware and software developments have allowed a greater level of detail to be modelled. For example, in the 1960s the Kinleith estate of NZFP was aggregated into two croptypes; by 1970 there were six croptypes; and by 1980 there were 12. During the late 1980s, 30 to 40 croptypes were used. Currently about 2000 croptypes are used (B. Rawley, pers. comm.).

One reason for the increase in model detail has been the increase in computer power. For example, a national FOLPI model of the NZ Forest Service estate which took 30 CPU hours (38 hours elapsed) to solve on a Micro Vax II in 1987 can be solved today on a 90 MHz Pentium in only seven minutes. Another reason has been the development of database languages which allow the management of large datasets. With estate models involving over a thousand croptypes, the need for good database management systems to provide area information and generate yield tables is paramount.

Forest estate models are used to develop management and investment strategies for the total estate. Advances in estate modelling systems, computer power and database languages now allow models with stand-level detail rather than aggregate croptypes.

(ii) Variable resolution modelling

The focus of early FOLPI work has been on long-term strategic and tactical planning over a time horizon of 60 to 90 years. It includes yield regulation, management strategy evaluation, processing plant scenario evaluation, investment analysis and forest valuation.

In 1991, a short-term version of FOLPI capable of scheduling the harvest of 2000 stands over five periods was developed. This version has been used for harvest scheduling (Gleason and Bailey, 1992).

The two versions of FOLPI were developed in a planning environment where decisionmakers are faced with two conditional problems (among others):

- What is the best long-term management strategy for the company subject to meeting short-term operational constraints?
- What is the best short-term operational plan subject to the company's long-term management strategy?

The classical hierarchical approach is to solve each of these problems separately with models of different resolution linked by decomposition or heuristic techniques.

Under a variable resolution approach, both problems are incorporated within a single model with the selective aggregation of stands into croptypes depending on stand age. This involves retaining older stands as unique croptypes with the aggregation of younger stands into successively more aggregate croptypes. Manley (1994) provides an example of the applica-

TABLE 1: Number of croptypes produced by a variable resolution croptype strategy, for example of 100,000 ha estate

Stand age relative to minimum clearfell age	No. of stands	No. of croptypes
Within 5 years	1529	1529
5-15 years	~ 2500	105
Over 15 years	~ 5000	1
		1635

tion of a variable resolution approach to a 100,000 ha estate containing 9000 stands. The croptyping strategy summarised in Table 1 was used.

The motivation for the approach comes from work by Te Morenga *et al.* (in prep.), which indicates that variable resolution models provide accurate detail in the short term while also incorporating long-term consequences.

(iii) Processing plant demand

A trend in estate modelling has been towards greater consideration of the current and future demand of log products by the wood-using industry. Whereas the simulators essentially stop at the forest gate, the LP-based systems allow the explicit modelling of the allocation of logs from forests to markets. Demand by log grade can be specified for individual processing plants and a unique price assigned to logs of each grade from a particular forest which are allocated to a particular plant. Detailed future processing scenarios can be developed and evaluated or future demand can be incorporated in a more general fashion through the specification of downward-sloping demand curves to allow for log price elasticity effects.

The trend towards incorporating greater processing plant detail into estate models is continuing. For example, a recent development in FOLPI has been to allow the flow of residues (e.g. chips) from solidwood plants to residue-using plants to be explicitly modelled. This means that the demand from residue-using plants can be met either by supplying logs or residues.

(iv) Short-term harvest planning

The evolution of LP packages which are integrated with spreadsheets has seen the development of customised models by forest planners for determining such issues as the stands to harvest and the cross-cutting strategies to be implemented by quarter for the next four to six quarters. (J. Shirley, pers. comm.)

The trend to using estate models for planning shorter and shorter time horizons has reached the stage where there is interest in modelling weekly log production and allocation. Here the issue is:

Given the volume available in stands and dumps, the logging capacity, the location of current logging and the next period's market demand for individual log products at each destination:

- which stands should be harvested?
- which cutting strategy should be assigned to each stand?
- what volumes of each log product type should be transported from each stand and dump to each market?

Currently, companies use manual methods and spreadsheets to match crew production and stocks with demand schedules. Clearly there is an opportunity to use analytical information tools in this area. A prototype model has been developed at FRI while methodology has been proposed by Ogweno (1994) in a study at the University of Canterbury.

(v) Spatial detail

There has been very little spatial detail incorporated within estate models. Certainly with highly-aggregated croptypes there has been limited ability to do so. In some models, constraints have been imposed to restrict the percentage of the area in a catchment that is clearfelled in any year or rolling period.

As stand-level detail is increasingly maintained in estate models, there is a need to be able to identify and model the interaction between stands, e.g. stands which it makes sense economically or environmentally to harvest simultaneously or to harvest in different periods. The restrictions placed in parts of the Pacific Northwest of North America on harvesting adjacent stands until 'green-up' has occurred is an example of this.

The incorporation of adjacency-type constraints into estate models imposes solution difficulties and changes relatively easy-to-solve LP formulations into mixed-integer LP formulations with exponentially increasing solution time. Research is currently being carried out to develop efficient solution strategies for solving FOLPI models incorporating adjacency constraints.

(vi) Specialist estate model for agroforestry.

In 1991, FOLPI was used in an estate level exercise to evaluate the impact of afforestation on a Taranaki farm in terms of profitability, wood flow, livestock numbers, cash flow and labour requirements (Knowles *et al.*, 1991). While FOLPI was able to model this land-use change exercise, it was apparent that many of the resource flows were multiples of other resources and easily generated in a spreadsheet environment. There was a clear opportunity for a specialist model for evaluating forestry on farms. Consequently the Agroforestry Estate Model (AEM – Knowles, 1994) was developed.

The development of AEM highlights the diversity of forest managers operating within the forestry sector and illustrates that different information tools are appropriate, depending on the scale and complexity of the estate and the issues faced.

(vii) Uncertainty

Typically, there has been limited consideration of uncertainty in estate models. Often modelling of uncertainty has been restricted to scenario analysis or sensitivity analysis. An example of this is the analysis by Manley and Wakelin (1989) of the effect of windthrow on forest value.

However, there are techniques for allowing uncertainty to be modelled on a routine basis within forest estate models. Manley and Wakelin (in press) report on a comparison of different decision-making criteria using an example of eight silvicultural regimes being evaluated under eight different price lists. An approach involving the development of an estate level trade-off curve between a measure of return (average forest value) and a measure of risk (minimum forest value) showed promise.

DISCUSSION

Where have we come from?

The development of information tools has assisted forest managers in a range of ways, including providing better information and allowing comprehensive analysis using that information. For example, stand and forest estate models allow a wide range of management alternatives to be explored. Silvicultural evaluation and cutting plan formulation obviously predate the development of computer-based model systems. However, with the evolution towards computer-based planning models has come the ability to quickly evaluate many alternatives and has allowed management to focus on the 'What if?' questions rather than mechanical calculation.

Whiteside and Sutton (1983) discuss some of the difficulties associated with the manually-based silvicultural evaluations carried out in the 1960s and early 1970s. These included "limits to the number of silvicultural and processing options that could be tested – a result of both the absence of information and projection methods and the time involved". They give as an example one economic model evaluation that took several staff over six months to complete.

A further limitation according to Whiteside and Sutton (1983) was "the inability to predict all the effects of a silvicultural treatment on tree quality". Sutton (1984b) observes that "no aspect of silviculture can be considered in isolation". The need to consider forest management as an interactive system in which all activities from forest establishment through harvesting and processing interact led to a computer-based modelling approach.

Elliott (1979b) discusses the tedious and time-consuming nature of the manual preparation of cutting plans. He gives the example of one week's calculation being required for a single regional strategy and quotes a resource forester who "likened the process to building a brick wall without mortar. Each time the wall is finished, someone kicks away the bottom brick and the whole process has to be repeated". Elliott states that in the 1960s there was not "the means to evaluate a wide range of alternative management practice".

The development of computer-based information has meant that a wider range of management alternatives can be evaluated. Further, by allowing quick response to management's 'what if' questions, planning models have broadened horizons by facilitating an understanding of the forest resource and alternative ways of managing and utilising it.

Where are we going?

Although the diverse range of information tools that are now, or are becoming, available makes it difficult to generalise, some common themes are evident:

(i) Increasing computer power

The power to cost ratio of computers will continue to increase dramatically in the future. Consequently information tools will allow the forest manager to carry out more complex and detailed analyses. For example, forest estate models will be both more detailed (e.g. less aggregation of stands into croptypes) and more comprehensive (e.g. forests and processing plants in a wider region modelled).

(ii) Greater integration of information tools

The FRI modelling philosophy has been to develop modular systems rather than a single 'one-model-fits-all' approach. This reflects the view that different tools are appropriate for different applications and that different organisations want to configure modules uniquely in their own planning systems. Nevertheless, there is an increasing emphasis on streamlining the interfaces between modules. This has led to the development of a framework for four different decision-support systems (DSSs) linking databases and predictive models for site management, forest management, wood properties and wood processing (G. West, pers. comm.).

There is also an increasing interest in formally incorporating qualitative knowledge and ideas into the decision-making process. Mason (1995) provides a conceptual model for a decision-support system for planning forest establishment operations which incorporates knowledge-based programming as well as quantitative modelling techniques.

(iii) More coherent planning

There will be greater emphasis placed on the coherency of different planning exercises within organisations. This will be facilitated by advances in DBMS and GIS which will facilitate the use of a common database. The recent development of MARVL Version 3 as an integrated harvest inventory system is a good example of this trend.

(iv) Greater vertical integration

The trend for inventory, stand modelling and forest estate modelling systems to increasingly consider the log and wood quality requirements of industry, as well as log quantity, will continue. For example, there will be an increasing requirement for forest managers to precisely assess mature stands in terms of log and wood quality. Information tools will be developed to allow this and to provide the information needed to match the resource with market demand. Related to this will be the development of advanced systems for operational log-making and allocation.

(v) New sites

The current expansion in the forestry estate is significant, not just because of the dominance of non-corporates responsible for the bulk of new land planting, but also for the sites being planted. A diverse range of sites, many of them ex-farm sites, are being planted throughout New Zealand. A limited database exists for the growth of radiata pine on these sites. Information tools need to be calibrated/developed to allow the forest manager to predict tree growth and quality for these sites.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the input received from Rod Brownlie, John Firth, Andy Gordon, Leith Knowles, Merlin McKenzie, Christian Pilaar, Brian Rawley, Jim Shirley, Graham West and Richard Woollons in the preparation of this paper.

REFERENCES

Allison, B.J. 1978. Some Aspects of Forest Planning. NZ Forest Products Ltd. 219 p.

Allison, B.J. 1985a. A quantity of forest. NZ Journal of Forestry. 30(2): 251-266.

Allison, B.J. 1985b. Forests as money. NZ Journal of Forestry. 30(2): 267-277.

Allison, B.J. and A.J.P. Barnes 1964. Clerical functions in a forest working plan. NZ Journal of Forestry 9(2): 190-222.

Allison, B.J.; G. Farquahar, W. Kane, K. Newell, and W. Sewell. 1979. NZ Forest Products Limited Forest Information System Review 1978. In Elliott, D.A. (Comp.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 48-76.

Beekhuis, J. 1966. Prediction of Yield and Increment in *Pinus radiata* Stands in New Zealand. New Zealand Forest Service, Forest Research Institute Technical Paper No. 49.

Blundell, W.M.; D.C. Evison, and S.E. Reutebuch. 1985. Harvesting production and cost estimation program (HARPCE). New Zealand Forest Service, FRI Bulletin No. 102.

Carson, S.D.; O. Garcia, J. Skinner and M.L. Kimberley (in prep.). Gain in improved radiata pine expressed as growth rate multipliers.

Clutter, J.L. and B.J. Allison. 1974. A Growth and Yield Model for *Pinus radiata* in New Zealand. In J. Fries (Ed.). Growth Models for Tree and Stand Simulation. Royal Coll. For., Stockholm, Research Notes 30. 136-160.

Cown, D.J. and D.L. McConchie. 1982. Wood density prediction for radiata pine logs. New Zealand Forest Service, FRI Bulletin No. 9.

Cox, O.; M. McGregor and P. Maclaren. 1988. Agroforestry components of the radiata pine stand model. In Maclaren, P. (Ed.) Proceedings of the Agroforestry Symposium, Rotorua. Ministry of Forestry. FRI Bulletin No. 139: 175-181.

Deadman, M.W. and C.J. Goulding. 1979. A method for the assessment of recoverable volume by log types. NZ Journal of Forestry Science 9(2): 225-239.

Eggleston, N. 1992. Satellite navigation in forestry. Forest Research Institute. What's New in Forest Research 222.

Elliott, D.A. 1979a. A mensuration planning system for exotic forest plantations. In Elliott, D.A. (Comp.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 87-119.

Elliott, D.A. 1979b. Plantation mensuration practice in Australia and New Zealand. In Elliott, D.A. (Comp.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 17-39.

Elliott, D.A. and C. Goulding. 1976. The Kaingaroa growth model for radiata pine and its implications for maximum volume production (abstract). NZ Journal of Forestry Science 6(2): 187.

Fenton, R.T. 1972. Senior author of two special economic issues of the NZ Journal of Forestry Science, Vol. 2 (1 and 3).

Fenton, R.T. and W.R.J. Sutton. 1968. Silvicultural proposals for radiata pine on high-quality sites. NZ Journal of Forestry Science 13(2): 220-228.

Garcia, O. 1979. Modelling Stand Development with Stochastic Differential Equations. In Elliott, D.A. (Ed.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 315-333.

Garcia, O. 1981. IFS, an interactive forest simulator for long-range plan-

ning. NZ Journal of Forestry Science 11:8-22.
Garcia, O. 1984. FOLPI, a forestry-oriented linear programming interpreter. In Nagumo, H. *et al.* (Ed.) Proceedings IUFRO Symposium on Forest Management Planning and Managerial Economics. University of Tokyo: 293-305.
Garcia, O. 1988. Experience with an Advanced Growth Modelling Methodology. In Ek, A.R.; S.E. Shiffley and Burke, T.E. (Eds.), Forest Growth Modelling and Prediction. USDA Forest Service, General Technical Report NC-120. 668-675.
Gleason, A. and C. Bailey. 1992. The market and harvest planning of the Kinleith Forest. In Whyte, A.G.D. (Ed.). Proceedings of IUFRO S3.03.01 Conference "Integrated Decision-making in planning and control of forest operations". University of Canterbury: 69-75.
Gordon, A.D. 1991 Portable field computers in New Zealand forest management. Australian Forestry 54(4): 219-225.
Gordon, A.D. and M.E. Lawrence (1995). Forest Inventory. Section 5.2 *in* Hammond, D. (Ed.) NZIF Forestry Handbook.
Gordon, A.D.; M.E. Lawrence and D. Pont. 1995. Assessing The Potential Log-Yield of Stands Prior to Harvesting. Proceedings 1995 Institute of Foresters of Australia Conference.
Goulding, C.J. 1994. Development of growth models for *Pinus radiata* in New Zealand - experience with management and process models. Forest Ecology and Management. Vol. 69: 331-343.
Goulding, C.J. and J.W. Shirley. 1979. A method to predict the yield of log assortments for long-term planning. In Elliott, D.A. (Comp.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 301-314.
Hosking, G. 1994. Airborne video for resource monitoring - a new technology takes off. Forest Research Institute. What's New in Forest Research 233.
Inglis, C.S. and M.R. Cleland. 1982. Predicting final branch size in thinned radiata pine stands. New Zealand Forest Service, FRI Bulletin No. 3.
Kininmonth, J.A. 1984. The FRI Conversion Planning Project Team. In Kininmonth, J.A. and G.D. Young (Comp.) Forest Products Research Needs for New-crop Radiata Pine. Proceedings of the 1982 New Zealand Forest Products Research Conference. New Zealand Forest Service, FRI Bulletin No. 86: 33-40.
Kirkland, A. 1985. Data needs and recent developments in resource management and planning. Prepared for the Twelfth Commonwealth Forestry Conference, Victoria.
Knowles, R.L. 1988. Work of the Agroforestry Project Team - an outline. In Maclaren, P. (Ed.) Proceedings of the Agroforestry Symposium, Rotorua. Ministry of Forestry, FRI Bulletin No. 139: 113-120.
Knowles, L. 1994. New Zealand Experience with Silvopastoral Models at the Stand and Estate Levels. Proc. Third North American Agroforestry Conference, Ames, Iowa, 16-18 August 1993.
Knowles, R.L.; B.R. Manley and J. Thomson. 1991. FRI modelling systems help evaluate profitability of agroforestry. Ministry of Forestry, Forest Research Institute. What's New in Forest Research No. 207.
Knowles, R.L.; I.P. McInnes and J.T. Miller (1995). Silviculture of Douglas fir. *In* Section 4:9.3 Hammond, D. (Ed.) NZIF Forestry Handbook.
Lees, H.M.N. 1967. Standard method for inventory and growth measurement of exotic forests. New Zealand Forest Service, Wellington.
Lewis, E.R. 1954. Yield of unthinned *Pinus radiata* in New Zealand. New Zealand Forest Service, FRI. For. Res. Notes 1(10).
McGuigan, B.N. 1983. A log resource allocation model to assist forest industry managers in process selection and location, wood allocation and transportation. Presentation to 37th Appita Annual Conference, Mt Gambier, Australia.
McGuigan, B.N. 1991. RegRAM1 - A flexible forest harvest scheduling and industrial processing global optimisation model. NZ Forestry 40(2): 17-20.
Maclaren, J.P. and S.J. Wakelin. 1991. Forestry and forest products as a carbon sink in New Zealand. Ministry of Forestry FRI Bulletin No. 162.
Manley, B.R. 1994. New Zealand experience in linking short-term and long-term forest planning. In Paredes, G.L. (Ed.). Proceedings of the International Symposium on Systems Analysis and Management Decisions in Forestry, Valdivia, Chile: 315-335.
Manley, B.R.; S. Papps, J. Threadgill and S. Wakelin. 1991. "Application of FOLPI: A Linear Programming Estate Modelling System for Forest Management". Ministry of Forestry, FRI Bulletin No. 164.
Manley, B.R. and S.J. Wakelin. 1989. Modelling the effect of windthrow at the estate level. In Somerville, A. (Comp.). Workshop on wind damage in New Zealand exotic forests. Ministry of Forestry, FRI Bulletin No. 146.
Manley, B.R. and S.R. Wakelin (in press). Incorporating future log price uncertainty into forest estate modelling. Proceedings of "The 1994 Symposium on Systems Analysis in Forest Resources". Monterey.
Mason, E.G. 1992. Decision-support systems for establishing radiata pine plantations in the Central North Island of New Zealand. Ph.D. Thesis, University of Canterbury.
Mason, E.G. 1995. A computerised decision-support system for planning forest establishment operations. In Gaskin, R.E. and J.A. Zabkiewicz, Popular summaries from second international conference on forest vegetation management. Forest Research Institute Bulletin No. 192: 277-279.
Ogweno, D.C.O. 1994. Integrated optimisation of operational and tactical planning of log production. Ph.D. Thesis, University of Canterbury.
Park, J.C. 1982. Occlusion and the defect core in pruned radiata pine. New Zealand Forest Service, FRI Bulletin No. 2.
Park, J.C. and C.E. Parker. 1982. Predicting value losses due to resin pockets in timber from radiata pine. New Zealand Forest Service. FRI Bulletin No. 6.
Park, J.C. and C.S. Leman. 1983. A sawing study method for evaluating timber from pruned logs. New Zealand Forest Service. FRI Bulletin No. 47.
Paton, V.J. 1988. Predicting the maximum area of pasture covered by radiata pine thinning and pruning. In Maclaren, P. (Ed.) Proceedings of the Agroforestry Symposium, Rotorua. Ministry of Forestry, FRI Bulletin No. 139: 130-144.
Percival, N.S. and R.L. Knowles. 1988. Relationship between radiata pine and understorey pasture production. In Maclaren, P. (Ed.) Proceedings of the Agroforestry Symposium, Rotorua. Ministry of Forestry, FRI Bulletin No. 139.
Shirley, J.W. 1979. Forest modelling: New Zealand Forest Service experience. In Elliott, D.A. (Comp.) Mensuration for Management Planning of Exotic Forest Plantations. New Zealand Forest Service, FRI Symposium No. 20: 391-400.
Shirley, J.W. 1983. Yield control systems for exotic state forests. NZ Journal of Forestry. 28(3): 356-371.
Somerville, A.R. 1985. A field procedure for the cross-sectional analysis of a pruned radiata pine log. New Zealand Forest Service. FRI Bulletin No. 101.
Sutton, W.R.J. 1984a: Radiata Pine Task Force - objectives, achievements, and implications. In Kininmonth, J.A. and G.D. Young (Comp.) Forest Products Research Needs for New-crop Radiata Pine. Proceedings of the 1982 New Zealand Forest Products Research Conference. New Zealand Forest Service, FRI Bulletin No. 86: 21-30.
Sutton, W.R.J. 1984b. New Zealand Experience with Radiata Pine. The H.R. MacMillan Lectureship in Forestry, Vancouver, B.C., Canada, February 1984. New Zealand Forest Service Reprint 1675.
Te Morenga, L.; B. Manley and S. Wakelin (in prep.). An examination of croptyping in forest estate modelling.
Tennent, R.B. 1988. The Stand Master: Data base for plantations. FRI Software Series No. 1.
Tennent, R.B. 1992. "The Forest Master, a Forest Management System". FRI Software Series No. 11.
Todoroki, C.L. 1990. AUTOSAW system for sawing simulation. NZ Journal of Forestry Science 30(3): 332-48.
West, G.G.; R.L. Knowles and A.R. Koehler. 1982. Model to predict the effects of pruning and early thinning on the growth of radiata pine. New Zealand Forest Service, FRI Bulletin No. 5.
West, G.G.; N.J. Eggleston and J. McLanachan. 1987. Further developments and validation of the EARLY growth model. Ministry of Forestry, FRI Bulletin No. 129.
Whiteside, I.D. 1982. Predicting radiata pine gross sawlog values and timber grades from log variables. New Zealand Forest Service, FRI Bulletin No. 4.
Whiteside, I.D. 1990. STANDPAK modelling system for radiata pine. Pp. 106-111. *In:* James, R.N.; Tarlton, G.L. (Ed.). "New Approaches to Spacing and Thinning in Plantation Forestry". Proceedings of

IUFRO Symposium. Ministry of Forestry, FRI Bulletin No. 151.
Whiteside, I.D. and M.J. McGregor. 1987. Radiata pine sawlog evaluation using the sawing log-yield model. *In* Kininmonth, J.A. (Comp.) Proceedings of Conversion Planning Conference. Ministry of Forestry, FRI Bulletin No. 128: 126-146.
Whiteside, I.D.; M.J. McGregor and B.R. Manley. 1987. Prediction of radiata pine log grades. In Kininmonth, J.A. (Comp) Proceedings of Conversion Planning Conference. Ministry of Forestry, FRI Bulletin No. 128: 55-69.
Whiteside, I.D. and B.R. Manley. 1987. Radiata pine resource description by log grade specifications. *In* Proceedings of Conversion Planning Conference. Ministry of Forestry, FRI Bulletin No. 128: 27-38.
Whiteside, I.D. and W.R.J. Sutton. 1983. A silvicultural stand model: Implications for radiata pine management. NZ Journal of Forestry 38(3): 300-313.
Woollons, R.C. and W.J. Hayward. 1985. Revision of a Growth and Yield Model for Radiata Pine in New Zealand. Forest Ecology and Management 11: 191-202.

Erratum – Peter Hall article

In the Peter Hall article, "Mechanical Site Preparation Using Excavators", in our August 1995 issue, two illustrations with their captions, figures 2 (Excavator with a spot ripper-mounder) and 4 (Prototype ROTREE mounder working in radiata cutover) got transposed during editing. The captions should be swapped. Our apologies to Mr Hall, and readers.

INSTITUTE NEWS

President's comments on Sustainability, the Principles of Plantation Management and Ethics

The topic of sustainability which has been addressed in recent Institute working groups, and in liaison with other organisations, is of course part of our forester ethic in maintaining good husbandry standards of forest management.

The principles of plantation management also aim at including this with other aspects of management such as biodiversity, indigenous forest protection, and social and human relationships. Some of the membership find difficulty with a number of the stiff doctrinaire elements in this dialogue, which appear to derive from either a misunderstanding or mistrust of our profession's commitment to the stewardship of land and its vegetative cover. This is a carry over from past battles of the 1978-87 era when Government agencies were judged by environmental groups to be untrustworthy in respect of exercising judgement. Thus stiff definitive quarantines around Governmental agency aims were seen to be required to ensure delivery of outputs that satisfied part of an electorate perceived by politicians to be represented by the vocal elements in this group.

The 1987-88 solutions are now increasingly seen to be inadequate. There is a need for all land managers to have a sense of responsibility for a wide range of stewardship functions considered by most practitioners to be essentially driven by the exercise of judgement. For the Institute, the latest round of meetings of local sections, convened by Vice-president John Galbraith, is aimed at giving our membership Council's view on the professional quality of membership, the demands of an increasingly technical working environment and the opportunity through CPD to enhance and improve decision-making capability close to the "tree roots". This will remove the need for supervision from a distance, but only if quality of performance can be expected. By enhancing quality of judgement in operational circumstances and eventually removing some of the suspicion that front-line decisions will be environmentally or economically flawed, we can expect the public perception of professional trustworthiness to be enhanced, as well as a reduction in corporate surveillance.

Peter Olsen

This will soon place a burden on the individual through insistence on both technical and ethical standards. We are aware of US foresters' insistence that the code of ethics must place great weight on the land ethic. This is, of course, the message that our Resource Management Act attempts to convey; that all land-based activity will sustain the land's capacity to continue to provide benefits and economic returns for future generations.

Understanding this concept, and adopting it in our revised code of ethics, will ensure that the dedicated forestry professional will meet society's requirement that we discharge land stewardship responsibilities without the need for complex "outcome" definitions. However, until we reach this standard, suspicion that the professional does not "know best" will persist and we will continue to have restrictive procedures of land-use consent aimed at forestry. The fact that other rural land users may not yet feel this pressure is merely a facet of resource management authorities' response to the interaction between political and statutory pressures. All land managers will eventually be required to meet this ethical standard.

As a profession we should be seen as pro-active.

P.F. Olsen

Forestry Corporation of New Zealand

At the AGM in Taupo I was reminded by Priestley Thomson that in the last journal article on this subject I had noted that I may need to follow up on the topic following resolution of the arbitration issue.

On June 20, 1995 I wrote to the