

New Zealand School of Forestry
University of Canterbury, Christchurch, New Zealand



Research 2003–2006

Paper No. 32

ISSN: 1174-0256

Contents

Introduction	1
Staff Directory	2
Postgraduate Opportunities	4
Staff Research	5
Theses Abstracts and List of Dissertations	45
Publications 2003-2006	95
Contact Details	106

Introduction

The aim of this report is to advertise the research capability of the School of Forestry to our clients. Our clients are our current and future students, the wider university, the forest research community, potential research collaborators and the forestry sector as a whole. This report covers research activity since 2003. The report is part of a series published every two to three years.

Undergraduate students often do not realise that their lecturers are not only involved in research but they are driven by research and that research is that part of the job that gives them most career satisfaction. Lecturers have the responsibility to ensure that the most recent research informs their lectures and that students are aware of this.

Postgraduate research students are the very core of a successful university department. This research report should provide potential postgraduate students with the information that they need to decide whether or not the School of Forestry at the University of Canterbury can cater for their research aspirations and the individual staff they should contact. The report contains the abstracts of recent postgraduate theses. The list of references is also a good indicator of the nature of research that the School is involved in.

We hope that the report will also be effective in encouraging research collaboration nationally and internationally. The School relies heavily on others in the forestry sector to be partners in our research and to advise us on research relevance.

Please contact any of our staff directly if you wish to learn more about what they are doing. Our website is www.forestry.ac.nz. General inquiries can be made to jeanette.allen@canterbury.ac.nz. If you are outside of New Zealand and interested in postgraduate study and scholarship opportunities you should also look at the international students section on the University website at www.canterbury.ac.nz.

Roger Sands
Professor and Head

Staff directory

Dr Luis Apiolaza, BForSc(Hons), For.Eng, PhD

A tree breeder and quantitative geneticist with industry-oriented research experience in Australia, Chile and New Zealand. Research interests include geographic patterns of genetic variability for forest trees, development of economic breeding objectives, simulation and optimisation of breeding strategies, large scale genetic evaluation and genetics of wood properties.

Dr Kelvin Chapman, ME(Chem), PhD

A consultant in the wood processing area with research interests in medium density fibreboard production and processes with special interests in resin injection in the blowline and in hot pressing.

Dr Hamish Cochrane, BSc, MSc(Hons), DipTchg, PhD

Educated at Canterbury in Environmental Science, research interests include biosecurity, invasive species in production and natural forests, and the use of information technology in forest management.

Dr Robert Donnelly, BSc, MF, PhD

An international forest industry consultant who works part-time at the School. Research background in marketing, pulp and paper manufacturing and optimisation models.

Assoc Prof Rob Douglas, BASc(CE), PhD

A geotechnical (soils) engineer with interests in geotechnical engineering as it applies to forest operations and in the heavy trucking used in forest operations.

Dr Helge Dzierzon, DipL-Forstw (MForSc cf), Dr.forest (PhD)

A growth and yield modeller, currently working as a Post-Doctoral Fellow at the School, with special interests in hybrid and functional structural modeling.

Assoc Prof Bruce Manley, BForSc(Hons), BBS (Accounting), PhD

A graduate of the School who spent 20 years at the Forest Research Institute in Rotorua as a scientist and science manager working on the development of forestry decision-support systems and using these systems as a consultant to the industry. Research interests include forest management planning, forest estate modeling and forest valuation.

Assoc Prof Euan Mason, BSc(For), PhD

Trained as a forester in the USA, worked as a forester and then as a scientist in New Zealand's plantations for 13 years, and then spent one year as a researcher at Lincoln University before joining the School.

Mr Kurt Niquidet, BSF, MA

Trained and worked as a forester before developing an interest in economics. Main research interests include cost-benefit analysis, economic development, regional log and timber markets, applied econometric analysis

Assoc Prof David Norton, BSc(Hons), PhD

A plant ecologist with research interests in conservation biology and management, ecological restoration, and sustainable land management.

Mr Ron O'Reilly, BScF, MForSc

Worked as a forester in Canada, with the Forest Service in New Zealand, and as a forest harvesting scientist at Forest Research, Rotorua before joining the School. Research interests are in logging productivity, wood flow and control, forestry labour, harvesting systems and planning.

Prof Roger Sands, BScFor(Hons), PhD

Educated at Australian National University and former Director of University Studies at the Creswick School of Forestry at Melbourne University. Research interests include tree physiology, soil science, silviculture, agroforestry, site productivity and forest management.

Prof John Walker, MA, PhD

A physical scientist before lecturing in forest products, has research programmes in the general area of wood processing, particularly mechanical properties, drying and preservation.

Dr Richard Woollons, BSc, PhD

An Adjunct Associate Professor with the School, research interests in mensuration, experimental design and analysis, plantation growth and yield modelling and applied statistics.

Postgraduate opportunities

The School of Forestry and its collaborators offer a range of postgraduate programmes. More detail can be found on our web site: www.forestry.ac.nz or by contacting the School Administrator, Jeanette Allen at jeanette.allen@canterbury.ac.nz. Abstracts of postgraduate theses and reports can be found on page 45 onwards.

Graduate Diploma in Forestry. This one-year degree is suitable for providing exposure to forestry for graduates with degrees other than forestry. Applicants with a degree from any university will be considered.

Postgraduate Diploma in Forestry. This one-year degree is suitable for retraining those who already have a forestry degree or associated qualification from the past; for providing some exposure to forestry for graduates with degrees other than forestry. It also provides a platform for entry to the second part of the Master of Forestry Science for those who are otherwise ineligible.

Master of Forestry Science. Suitable for people with a four-year honours degree in Forestry, or any four-year degree in appropriate subjects with acceptable grades. The MForSc has three pathways available to candidates: by examination and report; by examination and thesis (both of these taking a minimum of two years); or by thesis (a minimum of 12 months) – candidates must have an honours degree to be considered for this pathway.

Doctor of Philosophy. A research degree of three years duration, candidates need a good honours degree or Masters degree to enrol. The research must be original and make a significant contribution to knowledge within the broad spectrum of forestry. Under some circumstances, candidates enrolled in an MForSc may transfer to a PhD if progress has been very good and the nature of the research is suitable.

A list of courses offered by the School, and a brief description of their content, can be found on the web at the address above.

Master of Science (Environmental Science in Forestry). A candidate eligible to enrol in the MSc programme can opt to undertake an MSc(ENVR) in Forestry. The degree requires five papers plus a thesis, with a minimum period of study of two years.

Staff research

Dr Luis Apiolaza

My main research objective is to create better trees – through the use of genetic, statistical and economic techniques – in such a way that they maximise profit of the firm. More specifically, I am currently interested in the development of genetic material that is profitable in shorter rotations. Superior trees together with more intensive silviculture will require less area, permitting the conservation of larger areas of land.

This objective implies:

- Understanding the economic conditions under which short rotations are feasible and financially appealing. These conditions are expressed as improvement objectives.
- Finding selection criteria that can be used to perform very early selection of trees.
- Understanding the patterns of natural genetic variation for characteristics of economic interest.
- Designing breeding strategies – and necessary support infrastructure – to maximise economic worth of trees.

Formal definition of improvement objectives

The direction of tree improvement is determined by the list of traits subject to improvement and their respective economic weights. This is often called a breeding objective. Until now, most breeding objectives have been defined through the use of so-called bioeconomic models or a hedonic approach. Unfortunately, the former may violate assumptions for formal economics while the latter may ignore the intrinsic value of characteristics not yet recognised by the market. We are working with Ph.D. student Rosa Maria Alzamora on the use of alternative economic approaches that both comply with economic assumptions and that recognise the value of attributes that may not have market value yet.

In addition, with Simon Whittcock we worked in the incorporation of non-traditional traits in breeding programs, including coppicing for eucalypts and revenues from carbon sequestration. An interesting result for Australian conditions is that breeding programs have to deliver at least 15% of gain (for a combination of volume and basic density) to justify replanting over coppicing.

Genetic variation of wood quality traits

Tree breeding is based on the optimal exploitation of natural variation and on the inheritance of traits from parents to progeny. For many years, tree breeding was primarily focused on growth rate and stem form, to the detriment of wood quality. One of my current interests is to find ways of characterising – as early as possible – and using naturally occurring variation. This includes the design of sampling schemes for using techniques like near infrared analysis (NIR), Silviscan and acoustic velocity for early selection of superior trees.

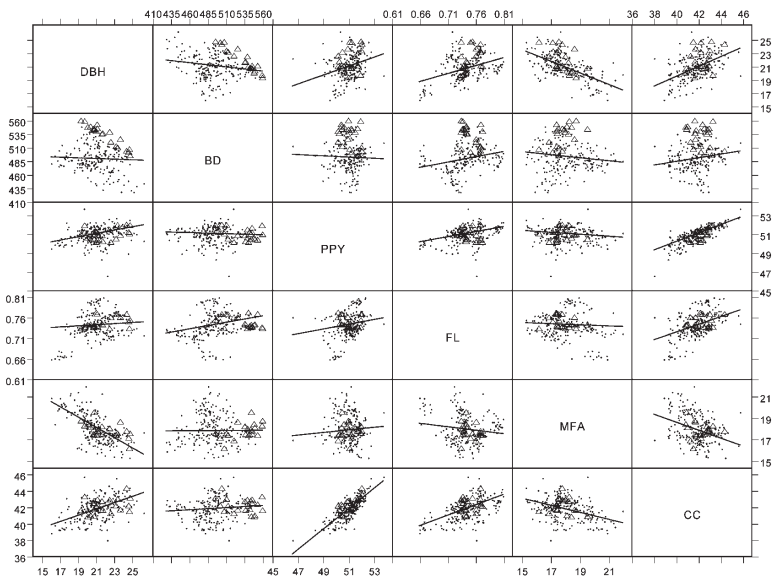


Figure 1: Scatterplot matrix of breeding values for stem diameter (DBH), basic density (BD), NIR predicted pulp yield (PPY), fibre length (FL), microfibril angle (MFA) and cellulose content (CC) for *Eucalyptus globulus* (Apiolaza et al. 2005).

This work has had effect on the choice of natural populations for starting or enriching breeding programs of eucalypts. I expect that it will have an even bigger impact on the radiata pine breeding program in New Zealand. Here the emphasis will be on finding tools for the rapid, low-cost and very early screening of genetic material with reasonable quality young wood.

Simulation and design of breeding strategies

Traditional tree breeding strategies tend to be monolithic and inflexible, making them very susceptible to disruption. Further, they tend to be very conservative, which increases implementation cost and reduces rate of gain per year. In this area I am particularly interested in the optimisation of selection and mate allocation, both as a way of maximising genetic gain and of managing breeding populations. My intention is to find operationally simpler (although theoretically more complex) options for breeding and population management. I am implementing solutions to this problem using a combination of AMPL (A mathematical programming language) and Python (a scripting language).

With Satish Kumar (ENSIS) we are also developing a flexible simulator of breeding strategies for the NZ Radiata Pine Breeding Company. The objective is to simulate the current strategy to highlight bottlenecks and propose improvements.

Miscellaneous

In addition to work focused on tree breeding, I also collaborate with colleagues and students on quantitative work, mostly related to statistical modeling and application of quantitative genetics to other organisms. As an example, with David Sinn (PhD in Aquaculture) we studied the genetic control of squid personality traits, using a combination of principal components and linear mixed models. Another example is the work with Michael MacDonal, where we studied the effect of logging on the abundance and diversity of bird populations using generalised linear mixed models.

Dr Hamish Cochrane

Introduction

My research is focused mainly on biosecurity and in particular animal pest management. I am interested in integrating spatial technologies so that better quality data can be utilised for decision making in biosecurity. I also have a broader interest in forest security and health and safety.

Habitat selection and use

Currently I am involved in a project based in the South Island High Country that is looking at farm management. The particular aspect that I am involved in is habitat selection of merino sheep. The project is being run in conjunction with Associate Professor David Norton and is supported by the College of Engineering, University of Canterbury; the MAF Sustainable Farming Fund, with additional support from the High Country Section of Federated Farmers, the High Country Accord, and Merino Inc.



Figure 1. GPS locations for sheep on Otematata Station, North Otago showing avoidance of specific landscape features.

The data collected to date are being used to assess habitat selection of merino sheep within large (circa 5 000 ha) high country blocks. The aim is to identify specific habitat features that either attract sheep or alternatively act to channel movement towards particular vegetation types. Data collection utilises GPS collars allowing significant blocks of data (circa 8 000 locations per animal) to be collected and analysed. Early results have helped to answer fundamental questions such as daily range and have also suggested that landscape features do act to channel movement and habitat selection.

Data collection is continuing and in future will focus not only on habitat selection in large blocks but will also look at habitat selection by ewes in terms of lambing success.

My interest in habitat selection has led to a range of dissertation and postgraduate research projects. Previous work on GPS-collared deer has been supported by one honours dissertation that looked at movement and habitat utilisation of red deer (*Cervus elaphus scoticus*) in the Canterbury high country, a Masters report that looked at integration of GPS, GIS and remote sensing to facilitate explicit red deer-resource interactions in the Canterbury high country of New Zealand, and a Masters thesis that has looked at temporal variation and interrelationship of movement and resource selection of red deer with respect to climate. The current sheep project will involve a PhD level student beginning in 2007.



Figure 2. Attaching GPS collars to sheep. Cartoon reprinted with permission of Chris Slane/The New Zealand Farmers Weekly

Biosecurity

I have a continuing research and teaching interest in this area. My own research focus within this broad area is on habitat selection by pest animals. I also have a student who has looked at microsite establishment for wilding conifers, an excellent international student who looked at a comparison of biosecurity and biosafety systems within the Philippines and New Zealand, a student who has just finished looking at the potential for weed spread between New Zealand and Antarctica, a current Masters student who is looking at the invasion characteristics of *Didymosphenia geminata* and a PhD student who is researching cost models for different importation pathways of products associated with forestry or posing a risk to forestry.

Security

I have an ongoing interest in terms of criminal activity within forests. To date this has focused primarily on aspects of drug cultivation and has used GIS to model areas which are higher risk within plantations in terms of drug cultivation. The aim is to provide forest managers with another tool from a health and safety perspective that allows risk mapping of forest estates. The work is ongoing with successively larger data sets being incorporated. In 2005 an honours dissertation was completed on factors influencing the location of cannabis crops cultivated within the central North Island, and has provided a starting risk model for the work. I am also interested in the incidence and types of deliberate criminal acts that occur within the broader primary industry. This interest has led to the publication of a co-authored article on the topic and an ongoing data collection process to further characterise the nature and extent of this phenomenon.

Dr Robert Donnelly

Research interests and expertise are in product-market development projects and studies for sustainable hardwood and softwood wood products. Specialist in plantation-based eucalyptus with earlier Global Review published in (2003) – co-authors Donnelly, Flynn and Shields, DANA – Rotorua, *Global Review for Eucalyptus Solid Wood Products*, 300 pages. I am also involved with sustainable management and marketing of New Zealand indigenous beech products (principally silver and red beech).

The University of Canterbury Schools of Forestry & Biological Sciences have been involved for the past 7 years in participatory FRST funded research supported by the Office of the Maori Trustee and SILNA landowners. The SILNA Community of Landowners was established by Parliament in 20 October 1906 under the South Island Landless Natives Act that granted 57 538 ha to South Island Maori families and individuals who are legally represented by the Office of the Maori Trustee. Some 20 000 ha of the SILNA land is indigenous forest under sustainable management, some 11 000 ha currently is under the Forest Stewardship Council Certification System, and the balance has potential for sustainable management under NZ regulations/FSC.

The prior research for SILNA forest owners involved a series of FRST projects entitled “Sustainability on Maori-owned forests in Southland”. These pioneering studies during 1996–2003 initiated a research-driven process to orient Maori forest owners to sustainable management and to indicate the importance of achieving viable economic returns from sustainably-managed forests. Sustainable forestry research has been underway and on-going in selected Southland operations. The completed research, and results under review, indicated a higher level of costs were required to maintain sustainability, in turn highlighting the requirements for extra marketing inputs outside the FRST terms of reference. MAF and NZ TRADE & ENTERPRISE have supported this research. The major project achievements are included in FRST annual reports. Donnelly served as the project leader for the economic part of this research 2000-2004.

In 2004, the final year of the FRST projects, included the development of an industry web-site and a seminar to disseminate the results of the biological and economic research both current and prior undertakings. The results of the seminar were summarized in a Forestry Journal article, and in addition, a second article summarised the results of the silver beech marketing report prepared by Steven Olson, PhD.

Currently, the SOF under the Research Office is the principal consultant for the SFF Beech project described in the terms of reference and outlined below. The principal consultant and project leader is Robert Donnelly, Visiting Lecturer Markets and International Trade as described in the summary outlined below.

The beech project co-sponsors are The Office of the Maori Trustee and the Indigenous Forest Section (IFS) of the Farm Foresters Association. In addition, the industry is providing input and support.

Currently, the beech species that predominate in the principal beech working circles of (1) Central Westland /Tasman and (2) Southland plus the (3) Central and Eastern North Island working circles are lesser-known hardwoods which are undervalued and under-utilised. The government moratorium on logging native podocarp forests helped open market opportunities, but native beech is losing ground to imported overseas hardwood products. Prior research has indicated that the wood quality for the primary beech species is equivalent to high-quality temperate hardwoods used for furniture, flooring and other quality joinery, as toys and handles. Successful market applications in domestic markets should help calibrate this high-quality hardwood, which is essential both economically and ecologically, since sustainability requires internationally competitive product prices. There also should be expanding international market opportunities for quality manufactured sustainable hardwood products, as temperate supplies diminish. To this end, it is essential for the industry to invest in state-of-the-art marketing activities. Today, the manufacturing industry is small, fragmented, and requires external assistance to “boot-strap” product-market definition activities. In addition, this product-market definition data provides the information-base for timber growers in IFS and represented by the Office of the Maori Trustee, including SILNA.

Opportunity

The research has to date provided management guidelines for indigenous beech forest landowners and the manufacturing industry including clients with information on the best economic return possible from these forests and forest products. It has been an innovative approach that starts with economic viability and then balances biological sustainability within existing supply-demand constraints. It will improve land-owner and government decision-making regarding sustainable beech forestry. With this research funding and stakeholder community input, we intend to provide concrete recommendations for improved decision making across the entire industry sector with three specific results:

1. Furthering the economic return from New Zealand beech management and processing through identifying the main domestic product/ market value propositions for the primary beech species (market survey/definition component), with a follow-on evaluation for exports (year 2) and a final year monitoring review (year 3).
2. Evaluating the resource, initially by estimating volumes and product classes potentially available across the 3 working circles (using IFU data base), with a more detailed GIS-based evaluation component to follow, as the market survey/ definition work gets underway (resource evaluation component).
3. Furthering the understanding of the biological systems related to the economics, and sustainability of managing beech forests is a secondary lower-priority task and only a concluding reporting task at the end of the project to evaluate the economic impacts (components 1 & 2) on beech management guidelines (biological management component).

For the forest landowner community, increased demand for sustainable operations will provide business opportunities in both forestry and downstream processing/ marketing. Sustainable management of the IFS and Maori/ SILNA lands, with landowner empowerment, will enable long-term asset management and capture long-term economic benefits from forest ownership. It will also demonstrate social responsibility and provide broad ecological benefits. Increased product demand, at acceptable returns, will encourage indigenous forest landowners and manufacturers in New Zealand to support a viable and self-supporting industry.

Assoc Prof Rob Douglas

Engineering in Forest Operations

For the seven years I've been at Canterbury, I've been pursuing research on the application of geotechnical and transportation engineering to problems in forest operations. I detail four examples in what follows.

Effect of harvesting equipment on soils

Prof. Sands, Post-Doctoral fellow Dr. Matt Wood, and I embarked on a study of the effect of harvesting equipment on forest floor soils, in 2001. I provided the geotechnical (soils) engineering expertise in this major, multi-year study, funded by Rayonier Inc. The project was designed to examine the effects of the season of operation (relatively wet or relatively dry), type of harvesting equipment, and level of traffic (numbers of passes) on a forest floor soil. It was later extended to observe the effects of these variables on subsequent seedling growth.

Tests were carried out in two seasons using two rubber tyred skidders (Figure 1) and a tracked forwarder, and a range of numbers of passes of the equipment. Soil density and moisture content were measured or inferred via a wide variety of field and laboratory methods. For the first time we are aware of, a handful of geotechnical



Figure 2. The soil at the site was trafficked by two rubber tyred skidders and one forwarder.
Photo: Matt Wood

engineering techniques were brought to bear on what is normally considered a soil science problem.

Usually, trafficking of soils is assumed to result in soil compaction. In our study, that was not the case. The soil was *disturbed* (displaced) and in extreme cases rutted severely, but it was *not* compacted. In both seasons, the soil moisture content was wet of what geotechnical engineers call the optimum water content for compaction, and as a result, was not compacted. This finding has significance to Rayonier, for when decisions are made on the timing of harvests and the selection of equipment, a few perceived constraints are lifted.

The project was extended to enable a study of the effects of the treatments on seedling growth. Surprisingly, in some cases seedling growth was *enhanced* by machine traffic, due to a suppression of weed competition. I leave it to others to go into greater depth on that finding elsewhere in this document.

For more on the work, see:

- Sands, R., Haramburu, E., Wood, M., and Douglas, R.A. Effect of harvesting traffic and ripping on growth of radiata pine in the Taringatura Forest in New Zealand. Submitted to the *NZ Journal of Forest Research*, April, 2006. Under review.
- Wood, M.J., Douglas, R.A., and Sands, R. (2006). The Taringatura Study: the effects of harvest machine traffic and tillage on a forest soil in New Zealand. *International Journal of Forest Engineering* 17 (1) 53-66.
- Wood, M.J., Douglas, R.A., and Sands, R. (2004). A comparison of three methods for measuring the density of a forest soil in New Zealand. *International Journal of Forest Engineering* 15 (1) 71-80.
- Wood, M.J., Douglas, R.A., and Sands, R. (2004). The effects of harvesting traffic and tillage on the mechanical properties of a forest soil in New Zealand – final report to Rayonier, N.Z. 83 pp.
- Douglas, R.A. (2003). Forest floor compaction study, Taringatura Forest, New Zealand. *Proc. of the Second Forest International Engineering Conference*, Vaxjo, Sweden. Uppsala, Sweden: SkogForsk. 4 pp.
- Douglas, R.A. (2003). Developing a comprehensive protocol for the study of forest floor compaction. *Proc. of the Second International Forest Engineering Conference*, Vaxjo, Sweden. Uppsala, Sweden: SkogForsk. 4 pp.

Wood, M.J., Sands, R., and Douglas, R.A. (2002). Forest soil compaction and long-term site productivity in New Zealand – an update. *Water in the Soil-Plant-Atmosphere System (WISPAS)*, No. 83, November, 2002.

Wood, M.J., Sands, R., and Douglas, R.A. (2001). Forest soil compaction and long-term site productivity – further trials in New Zealand. *Water in the Soil-Plant-Atmosphere System (WISPAS)*, No. 80, November, 2001.

Road Network Analysis

From about 2004, the rates charged by Southland District Council became quite controversial. A plan to charge varying rates, depending on the perceived use and damage to council roads, was floated as a response to historical under-spending and ballooning use and accelerated damage by heavy vehicles. Industrial forestry was one of six sectors identified, and a four-fold increase in the portion of rates associated with Council road usage by the forestry sector proposed.

Questionable assumptions in the underlying modeling of road use by logging trucks were identified. We developed a regional scale network analysis, including every single road in the Council's network (2900 links), to test this modeling. The work was a combination of formal network analysis and geographic information system (GIS) techniques. It became the subject of an MForSc thesis project implemented by candidate Les Dowdle.

Les modelled four scenarios, the four combinations that result when either the network links are restricted to those currently in use, or unrestricted use of any road segment in the network is permitted, crossed with the cases where either the sources of wood and the mills are paired as they are under contracts now, or they are left to be freely combined. Good agreement between traffic flows as they are observed now with the flows resulting from the [restricted haul roads H fixed sources and mills] model was obtained, giving us confidence in the model. Subsequent modeling showed that significant reductions in transport costs could be derived if source – mill contracts were reassigned.

In general, the work showed that while the basic modeling carried out by the Council was essentially in agreement with Les' modeling, a "perceived damage factor" used by the Council to arrive at its final rates structure was unsupportable.

Les has parlayed his thesis work into a position doing similar work all over New Zealand with GHD Consultants, based in Christchurch.

For more on the work, see:

- Dowdle, L.R., and Douglas, R.A. (2007). Regional network analysis of log truck transportation on public roads in New Zealand using geographic information systems. *TRB 9th International Low Volume Roads Conference*, Austin, Texas, June 24-27, 2007. In press.
- Dowdle, L. (2006). Network analysis of log truck transportation on Southland's public roads using GIS. Unpublished MForSc thesis.: NZ School of Forestry, University of Canterbury Christchurch, N.Z.
- Douglas, R.A. (2003). Regional network analysis of primary industrial truck traffic on public roads in New Zealand using GIS. *Transportation Research Record* 1819 (1) 104-108.
- Douglas, R.A. (2003). Large scale network analysis of the impacts of logging truck traffic on public roads on New Zealand's South Island. *Proc. of the Second International Forest Engineering Conference*, Vaxjo, Sweden. Uppsala, Sweden: SkogForsk. 4 pp.

Low Volume Road Maintenance Management

Forestry access roads represent considerable assets, both in terms of their construction cost and maintenance costs. While public road authorities have long used formal systems for the management of the maintenance of their road networks, formal systems are only gradually coming into use in the industrial forestry sector.

The Forest Engineering Research Institute of Canada (FERIC) has developed concepts they had initially devised in the early 1990s to the point where a commercially viable system – Optigrade – is now available. The system creates road grading schedules based on road roughness measurement. An accelerometer mounted on a haul truck axle measures road roughness at 100 Hz, and a truck-mounted GPS unit records the locations of the roughness measurements. Software analyses the roughness data, and prepares the grading schedule. With grading maintenance targeted at only those segments of the road in *need* of grading indicated by road roughness, as much as a third of the cost of grading maintenance can be saved.

Through a contract to represent FERIC in Australasia, I have been conducting research on the use of Optigrade in New Zealand. In an ironic twist, it became clear that Optigrade could be further developed for use back in the public sector, on New Zealand's huge network of "low volume roads" (LVR) managed by district councils. To move from the single, linear haul roads used in forestry to the grid networks managed

by district councils created GIS-based challenges. To mount the accelerometer on the suspension of a council road maintenance manager's ute instead of the steering axle of a heavy haul truck posed technical problems, because the response of the ute suspension was entirely different and sensitive to speed. In addition, moving to the use of utes called for a complete revision of the test protocol.

The work was carried out under contracts with Carter Holt Harvey, Fulton Hogan, and Sicon Ltd, and reported in various national and international publications.

For more on the work, see:

Pidwerbesky, B., and Douglas, R.A. (2007). An asset management strategy for unsealed low volume roads in New Zealand. *TRB 9th International Low Volume Roads Conference*, Austin, Texas, June 24-27, 2007. In press.

Douglas, R.A., Mitchell, S., and Pidwerbesky, B. (2004). Adaptation of a grading management system for unsealed public road networks in New Zealand. *Proceedings 6th Conf. on Unbound Aggregates in Roads (UNBAR 6)*, University of Nottingham, July 6-8 2004. pp. 157-165.

Provencher, Y., Mercier, S., and Douglas, R.A. (2004). Améliorer l'impact des interventions d'entretien par l'emploi de techniques d'auscultation des chaussées économique. *Proc. 39^{iem} Congrès Annuel de l'AQTR*, 4 au 6 avril 2004, Québec, Canada. Montréal: Association Québécoise du Transport et des Routes.

Mercier, M., Brown, M., Provencher, Y., and Douglas, R.A. (2003). Improving road quality and user satisfaction while lowering road maintenance costs by using Optigrade. *Proceedings, 21st Australian Road Research Board (ARRB) Conference*, Cairns, Queensland, May 18-23, 2003. (papers are presented on CD)

Tyre/road surface contact stress

Great benefits have been derived from the use of very low inflation pressures in the tyres of heavily loaded vehicles running on low standard roads. The military has long used the technique, and systems to deliberately deflate the tyres of a haul truck on the fly, called *central tyre inflation* systems (CTI), began to creep into industrial forestry in the late 1980s. The technique is now used widely on unsealed haul roads. There is new evidence, however, that its use on *sealed* roads can be harmful. It may be that the severe squirming of the tread face that occurs under low inflation pressure can literally pluck stone chips out of the pavement's bituminous matrix, leading to a phenomenon called ravelling.

Stemming from an interest in CTI itself, my focus shifted to the contact stresses that exist between tyre tread faces and the road surfaces upon which they roll. As a first step, it was desirable to develop an apparatus to measure those contact stresses. At the time, there were two such units in existence, one of them built by colleagues at the University of Ulster, in Northern Ireland. Working with their small unit, I have designed and built a larger prototype (Figure 2). Twenty five steel pins each mounted with six semi-conductor strain gauges monitor contact stresses in each of the three coordinate axes. The data is recorded at 100 Hz on a high speed analogue-to-digital data recorder.

A grant has been approved by Land Transport New Zealand to develop the apparatus further, and to use it to collect input data for numerical models of pavement response and performance as affected by the inflation pressure of the tyres. The experimental work will be conducted in collaboration with David Alabaster, Manager of Transit NZ's CAPTIF full scale pavement test facility. Numerical modeling will be done by Dr. Bruce Steven, Post Doctoral Fellow at the University of California at Davis (a former Research Associate at Canterbury), Dr. Sabine Werkmeister, Post Doctoral Fellow at Canterbury, and Dr. Greg Arnold, a private consultant and former research manager at Transit NZ.

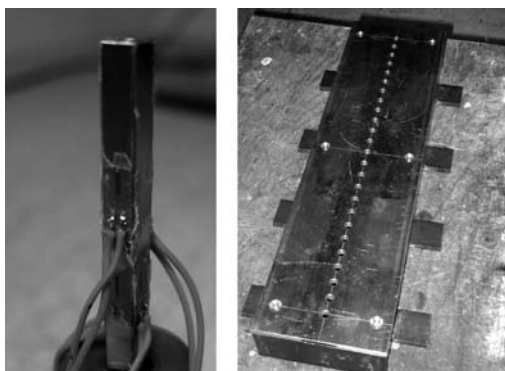


Figure 3. Strain gauged pin, and apparatus box. Pin is 5mm square, box is 660mm long. Box will be mounted in the test pavement, sitting flush with the pavement surface. Tyres will roll perpendicularly across the row of instrumented pins protruding 1 mm through the holes in the top plate.

Photos: R.A. Douglas

For more on the work, see:

- Douglas, R.A., Woodward, W.D.H., and Rogers, R.J. (2003). Contact pressures and energies beneath soft tires: modeling the effects of CTI-equipped heavy truck traffic on road surfaces. *Transportation Research Record* 1819 (2) 221-227.
- Douglas, R.A. (2003). Contact energies beneath soft tyres, the effects on road surfaces of CTI-equipped logging truck traffic. *Proc. of the Second International Forest Engineering Conference*, Vaxjo, Sweden. Uppsala, Sweden: SkogForsk. 8 pp.
- Douglas, R.A., Woodward, W.D.H., and Woodside, A.R. (2001). Road contact normal and shear stresses under tyres with low inflation pressure. *Proceedings, 20th Australian Road Research Board (ARRB) Conference*, Melbourne, March 19-21, 2001. (papers are presented on CD)
- Douglas, R.A. (2001). The impact of traffic loadings on low volume roads. Invited Keynote Paper Presentation, *2nd Low Volume Roads Workshop*, Rotorua, March 16, 2001.
- Douglas, R.A., Woodward, W.D.H., and Woodside, A.R. (2000). Road contact stresses under tires with low inflation pressure. *Canadian Journal of Civil Engineering* 27 (6) 1248-1258.

The future

Recently I accepted a position at Golder Associates, Whitby, Ontario, Canada. There I will continue research on the engineering of low volume roads. I hope my replacement here at Canterbury will continue with an interest in forest access roads – certainly there is ample need for such research to support New Zealand's forest industry. I look forward to perhaps meeting the incumbent at the next international conference on low volume roads, sponsored by the US Transportation Research Board's Low Volume Roads Committee, to be held in Austin, Texas, June 24 to 27, 2007.

Dr Helge Dzierzon

I am a growth and yield modeller with research interest in functional and process models. I am also interested in functional structural plant models.

I am working on the project “Developing a National Model to Predict the Growth and Quality of Radiata Pine Plantations in New Zealand” within a post-doctoral fellowship granted by the University of Canterbury. The major aim of this project is to introduce site sensitivity to classical growth and yield models by using the general model approach of hybrid modeling.

Mensurational growth and yield models have been used widely and successfully for many years. However, changing environmental conditions, the extension of forest plantations during the past 20 years, and advances in simple physiological modeling have stimulated interest in deriving models that are more responsive to site and climate.

Thus, the major question addressed during this work was whether or not it is possible to create site-sensitive models on a national scale and how much process information we might use without losing too much precision. To reach that goal, we investigated differences between a stratified and a hybrid modeling approach on national scale for basal area and mean top height at a stand level.

On the whole, modeling radiata pine growth on a national scale seems possible even though the application of such a model on regional scale is problematic. Nevertheless, as altitude and hence climatic conditions were much more variable in the region with the worse performance, the introduction of more sophisticated site models seems to be leading to an appropriate and usable model.

Assoc Prof Bruce Manley

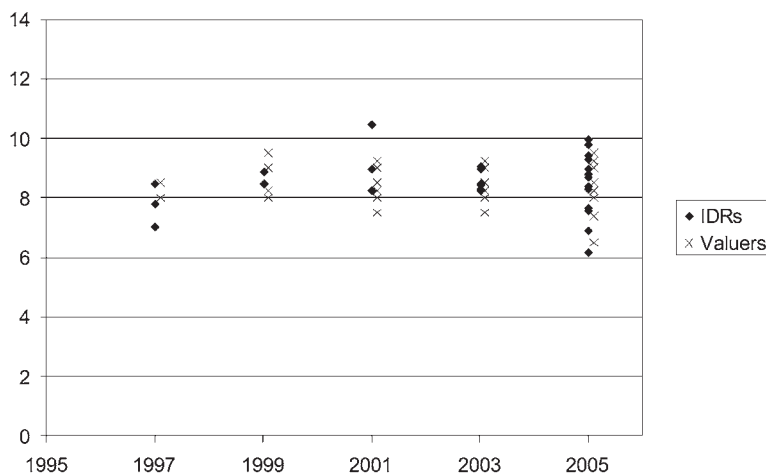
My current research falls under the categories

- Forest valuation
- Forest management planning
- Carbon and bioenergy modeling
- Log and wood quality & linkage to products and markets

Forest valuation

The Forest Valuation Standards developed by the New Zealand Institute of Forestry provide a framework for the valuation of plantation forests in New Zealand. The standard method involves the use of the expectation value approach (i.e. discounted cashflow analysis) in conjunction with available transaction evidence.

Recent surveys (Manley 2003, 2005) have documented the discount rates used by forest valuers to estimate the market value of a forest. Implied discount rates (IDRs) have remained at the same general level since 1997. Although IDRs reported in 1997 are low relative to those reported in 1999, 2001 and 2003 they were limited in number and fall within the range of IDRs reported in 2005.



IDRs (applied to post-tax cashflows) for transactions reported in each discount rate surveys. Also shown are the discount rates used by forest valuers.

The Forest Valuation Standards can be regarded as work-in-progress. There are still important research issues to be studied. One question is whether the option pricing approach is a better method of forest valuation than discounting future cashflows. When discounted cashflow analysis is used to value a forest, average log prices are typically assumed. This ignores the option that a forest grower has to delay harvesting when log prices are low and to increase production when log prices are high.

Andres Susaeta recently completed his Masters thesis “Comparative analysis of the discounted cashflow approach and option pricing theory for forest valuation: a Chilean case study.” This study sought to explain factors that cause the value estimated under the two different approaches to differ. As expected, it was found that as log price volatility increases the option value of the forest increases relative to the value calculated by discounting cashflows. It was also found that the difference between the two approaches increases as log prices fall or harvesting costs increase; i.e. as stumpages decrease there is an increasing value associated with the option of deferring harvest.

Plantations have value beyond the financial value associated with wood production. In her PhD studies “Environmental and social valuation of plantation forest ecosystems in New Zealand”, Rosa Rivas Palma is undertaking research to enable the total economic valuation of forests in New Zealand by including their social and environmental values, thereby aiding forest management, policy development and reporting.

The work is based on a survey in the Hawkes Bay region in November 2005. A sample was drawn from the electoral rolls that included the territorial authorities from this region. There were 395 surveys completed. The survey data is now being analysed using choice modeling methodology. The standard Multinomial Logit Model has been fitted to the data, allowing the estimation of part-worths (marginal utility estimates) for each of the attributes used (environmental characteristics describing soil and water quality).

Forest management planning

The focus here has been on the incorporation of non-traditional factors into forest management planning.

Teguh Rehardja completed his PhD “Informed preferences in forest-based land use planning in Indonesia”. Important considerations in this research were the wide range of stakeholders in forestry in Indonesia and the need to include non-wood factors such as biodiversity, erosion control and employment, as well as forest outputs such as wood volumes and cashflows.

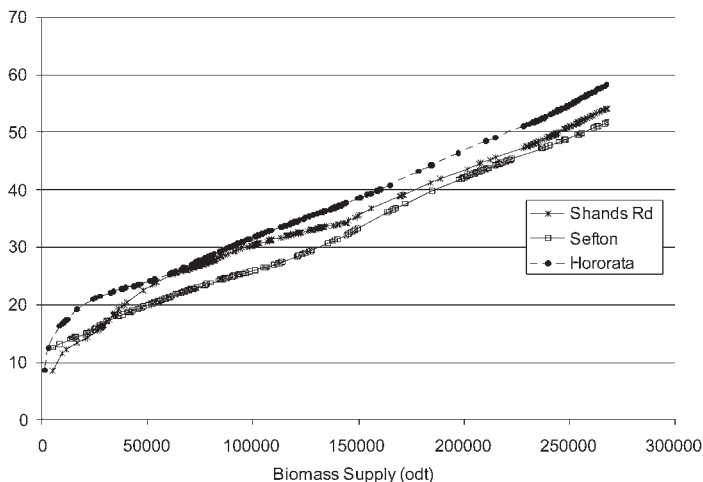
A preliminary interview survey of opinions suggested eight scenarios with varying emphasis on economic, ecological and social aspects. The Q method was subsequently used to analyse respondents preferences (a) on the scenarios based on graphs showing the consequences of each; and (b) on verbal statements about different aspects of land use planning.

Kadim Martana used a hybrid method between the Analytic Hierarchy Process and SWOT analysis in “Assessing decision-makers’ perceived preferences to plantation establishment in Indonesia”. The approach allows the development of plans that reflect the relative importance of different factors for forests that have multiple uses (and multiple decision-makers).

Carbon and bioenergy modeling

Isabel Loza-Balbuena is nearing completion of her PhD studies on “The impact of climate change policies on the greenhouse gas balance of the New Zealand forest industry”. The project includes the development of a model of the New Zealand plantation forestry sector that spans both the plantation estate and the wood processing industry. The goal is to develop a framework that can be used to evaluate policy options including land use change, wood processing scenarios and bioenergy options.

Kimberly Robertson has completed her Masters thesis “Estimating regional supply and delivered cost of forest and wood processing biomass available for processing”. An initial model was developed for Canterbury and then tested for Nelson. Potential sources of biomass are chiplogs, forest landing residues, cutover residues, sawdust, bark and chips.



Cumulative average delivered cost of biomass at three different Canterbury sites for different levels of supply.

Log and wood quality & linkage to products and markets

A large amount of data has been collected as part of the Wood Quality Initiative. I am managing a WQI project that is converting this data into usable algorithms to predict tree acoustic velocity and density.

Kenneth Tsang completed a Masters thesis “The changing Chinese wood products consumer: Opportunities and challenges for the NZ forestry sector”. An element of this project was a survey of Chinese industrial wood consumers to determine the factors that influence them in adopting a new product. Price was rated as the most important factor followed closely by environmental issues. Other important factors were services, wood properties, availability and product quality.

Monica Heberling Giudice did her Masters thesis on “Strategic marketing for Uruguayan *Eucalyptus* solidwood products”. In this the scale of the Uruguayan resource and its wood properties were quantified. Market opportunities for *Eucalyptus grandis* were identified. Furniture and flooring were suggested as value-adding products that would allow a shift from commodity markets to niche markets.

Assoc Prof Euan Mason

Dr Mason's principal research interests lie in silviculture, growth and yield modeling, and hybrid physiological and mensurational models.

Impacts of silviculture on wood properties

New Zealand's silviculturalists have tended to trade volume production for desirable large-scale log geometry, by intensively pruning just a few trees per hectare and then retaining very low stand densities so that pruning investments in each tree will pay. Models developed for evaluating silvicultural practices have largely overlooked wood properties such as stiffness and stability during drying that are crucial when wood is used in structural applications. Dr Mason has a research programme aimed ultimately at representing these other, small scale, wood properties into silvicultural decision tools. Stand density is clearly a key to improving structural wood grades, but his research is directed towards understanding mechanisms that contribute to effects of silvicultural treatments and genotype on modulus of elasticity, mediated through microfibril angle, density, and other properties of tracheids.

Hybrid models

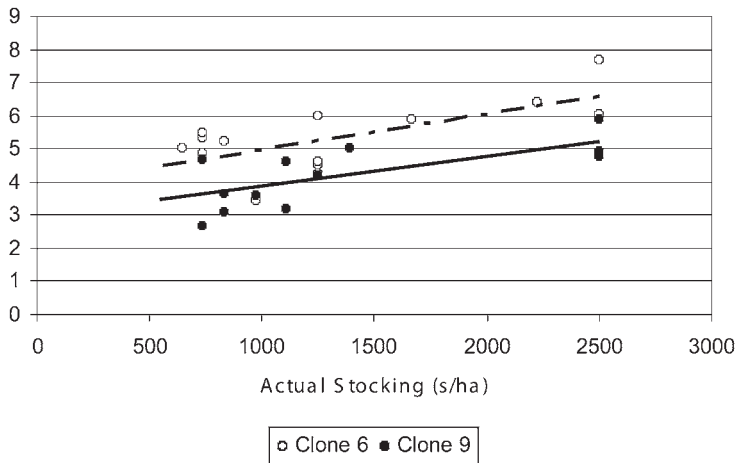
Hybrid models are likely to be useful for managers in future because:

- They can potentially represent rotation-length impacts of regeneration practices
- With Geographic Information Systems (GIS) we can know more about each site and stand, and so managers will want models that are sensitive to the extra information
- Such models can encapsulate reasons for variation in growth pattern from site to site, thus there will be less need for regional models
- Variation in weather from year to year can be represented in such models, and so updating inventory information to arrive a current yields can be more precise
- Representing effects of variation in monthly climate offers monthly predictions of growth for scheduled operations such as pruning
- Climate change may affect growth patterns, and these models can use the most recent patterns for growth projection while utilizing all historical data
- Carbon storage is explicit in some models, and so estimating carbon sequestration by forests can be made easier.
- Effects of silvicultural practices on wood properties may be more effectively represented in hybrid models than in conventional mensurational models.

Dr Mason and his students are engaged in developing a new kind of hybrid model that retains important features of mensurational models such as consistency and path invariance while also being sensitive to monthly changes in weather. This a coherent blend of mensuration and physiology, unlike many other approaches that involve running mensurational and physiological models in parallel.

Field experiments

Dr Mason maintains seven field experiments in the Canterbury region that provide a platform for his and his students' research programmes. In addition, he has a network of experiments in other regions that were established in the years following 1978 and which provide some long-term monitoring of impacts of silvicultural practices.



Relationship between tree level stiffness and actual stocking for two clones representing the extremes in stiffness. Linear equations are shown for both clone 6 (dotted line) and clone 9 (solid line) at Dalethorpe. Research was conducted by one of Dr Mason's previous students, Jean-Pierre Lasserre.

Current postgraduate students

Stuart Anderson (MForSc candidate)

Stuart is developing fire danger rating systems for scrub weeds in New Zealand. He is studying ignition and also applying a water balance model to characterise the risk of ignition of plants such as gorse given a fuel loading and previous weather conditions. This work is being jointly supervised by other academics with skills in fire research.

Horacio Bown (PhD candidate)

Horacio's research will contribute to the development of a "nutrient modifier" for hybrid models that quantifies the impacts of site fertility on light use and carbon allocation in trees. He is studying the effects of level and form on nitrogen on growth and allocation, the impacts of N supply on retranslocation, and also how these factors vary with genotype. In addition he is modeling the impacts of foliar nutrition on photosynthetic response to internal leaf carbon dioxide levels.

Rajesh Sharma (PhD candidate)

Rajesh is investigating alternative deployment strategies for clonal forestry in one of Dr Mason's experiments at Dalethorpe, Canterbury. Clones have been deployed as pure clonal blocks and also as intimate mixtures in the experiment. Questions addressed by the research include:

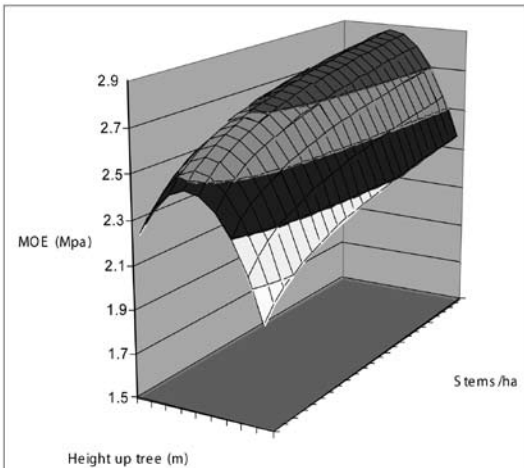
- Does deployment strategy affect stand dynamics?
- How soon can desirable clones be distinguished from undesirable ones?
- How should clonal forests be modelled?
- Are there risks associated with clonal deployment?
- Can growth of "superior" individuals be adequately quantified in a breeding programme using individual tree plots?

Gofred Sialumba (PhD candidate)

Gofred's research involves studies of the impacts of water deficits and fertility on wood properties of radiata pine in an experiment in Canterbury that was established by Dr Peter Clinton, of ENSIS Ltd. There is some evidence that wood deficits may affect stiffness in profoundly different ways from the effects expected, given the tendency for water stressed trees to be more slender. Slenderness and stiffness have been well correlated in previous studies.

Matt Waghorn (MForSc candidate)

Matt is studying the impacts of spacing and tree breed on wood stiffness distribution in stems of radiata pine. He is using a Nelder spacing experiment that includes several different breeds and also compares aged cuttings with seedlings.



Impact of Stems/ha and height up a tree on modulus of elasticity, from research conducted by Matt Waghorn, one of Dr Mason's MForSc candidates.

Mr Kurt Niquidet

Having recently moved to New Zealand from Canada, the focus of my research to date has been on recent forest policy changes in the province of British Columbia. This research has been conducted in collaboration with the Forest Economics and Policy Analysis (FEPA) research unit at the University of British Columbia, whose support I am most grateful for. The following summarises this work, and outlines the beginnings of my new research ventures in New Zealand.

Policy Change in British Columbia

Forest Policy in British Columbia has undergone significant change in the new millennium. Traditionally, the provincial government, who also happens to be the owner of approximately 95% of the forestland, has looked unfavourably upon markets in the allocation of forest resources, preferring to adopt a centralised, command and control governance system over resource use. Timber harvesting rights were granted through a tenure system to private companies based on regional employment and manufacturing conditions, stumpage fees were administered by complex pricing formula, annual harvest levels were regulated, and utilisation standards were imposed without regard to the corresponding economics. Naturally, this system had its critics; government officials began categorising their own forest policies as “soviet style” and lumber producers in the United States, who were consistently losing market share to British Columbian producers, saw the system as a subsidy, warranting countervailing action.

Facing declining investment and employment in the forest sector and the imposition of a punitive 27 percent duty on shipments to its largest marketplace, the government decided it was time for a change. These changes were formalized in the government’s Forestry Revitalization Plan; the major components of the plan are summarized below:

- The elimination of processing and employment conditions in the award and operation of timber tenures
- The auction of 20% of the annual harvest, with the auction results to form the basis of a new administered stumpage system.
- Harvesting and utilisation levels will be made more flexible, corresponding to market conditions.

As an economist I sought to study the effects of the Forestry Revitalisation Plan through transactions in the markets for timber, labour and capital. Given the call for the expanded use of timber auctions, I began by studying the influence regional competition levels had on the bids for standing timber.

A hedonic stumpage model was created that controlled for timber species, quality and location thus allowing the influence of the number of bidders to be revealed. As one might expect, regions with few bidders, all else being equal, generated lower bids, a phenomenon known as bid shading. This bid shading however was limited by transportation costs to adjacent, more competitive regions. These results highlighted the need for a reservation price policy at a regional level and the benefits of increased log exports on the competition levels in the stumpage market.

This model was then expanded to investigate the influence of various socio-economic conditions on bidding behaviour. Of particular interest was how bids differed when timber was awarded according to a combination of revenue, manufacturing and employment criteria. The results showed that, in these situations, bidders were able to use employment and capital investment as a claim against resource rents. This ultimately resulted in a loss of revenue for the provincial government and likely caused the over employment of labour and capital in the forest sector. It was therefore concluded that the recent elimination of these multi-criteria auctions greatly enhanced economic efficiency, but generated significant distributional impacts. In particular, the provincial government stands to gain by collecting more revenue, but forest sector employees and some capital owners are likely to be negatively impacted by the policy reforms.

Lastly, I analysed the returns of publicly traded securities during and after the announcement of the Forestry Revitalisation Plan. The results indicated that at the time of the policy announcement, the market generally did not anticipate that the policy reforms would boost the profitability of the British Columbian forest sector. Moreover, since the plan, the returns of the stocks studied tended to be more sensitive to overall market movements. This suggests that over the longer term these firms will be viewed with more risk by market investors and consequently their cost of raising new capital will increase. Since many of these policies were designed to solve the softwood lumber dispute with the United States, I suggest that the lack of impacts at the time of the announcement may be a reflection of the market's feelings towards the ability of the policy change to influence the dispute. Furthermore, the increased risk associated with these firms might be due to the new policy environment which requires companies to source greater supplies from spot markets, rather than long term supply contracts with the provincial government.

New Zealand

I have the following research interests, all of which I hope to apply to research topics while in New Zealand.

- Regional lumber, log and stumpage markets
- Cost-Benefit analysis of forest sector regulation
- Industrial organization in the forest sector
- Global forest products trade
- The roll of forestry in economic development and poverty alleviation

As a start, I am supervising a Masters student, Glen O'Kelly. Glen is investigating the variables which influence a firm's decision to vertically integrate along the forest sector supply chain. Of particular interest is the degree to which these factors vary across the world's major timber producing regions and how this variation might be explained by local geography, market structures and institutions. We hope to take these results and apply them to the New Zealand forest sector, highlighting the pros and cons of domestic institutions and the organisational structure of the New Zealand forest industry.

In the short to medium term, I will also begin work on evaluating the informational efficiency of the New Zealand log market. This will start with an assessment of the historic time series of log prices; from this assessment I hope to comment on the price formation process and how knowledge of this process may be incorporated into decisions over harvest timing and log storage. This work will hopefully lead into other log market topics such as investigating mechanisms which improve market signals for wood quality.

Looking forward to meeting the new challenges ahead.

Assoc Prof David Norton

Introduction

My research and that of my students is focused on the integration of biodiversity and economic values within primary production systems, especially high country pastoral farms. The overarching objectives of this research are to:

- Better understand the resilience of high country ecosystems, and especially native biodiversity in them, to external influences such as climate change and intensification.
- Work with the farming community to implement farm management practices that help sustain the full range of values that occur in high country ecosystems (especially economic and biodiversity conservation values).

These notes provide a brief summary of some of our current research projects.

Farm management planning

Our main current project is evaluating the role of whole-property management plans as the basis for ensuring long-term sustainable management of different values (economic, biodiversity, etc) within a high country pastoral farming property. This research has involved assessments of biodiversity and economic values on two study properties (Glenmore and Otematata Stations) and the development of a generic farm management plan template that high country farmers can use to develop their own plans. This research is funded by a grant from the MAF Sustainable Farming Fund, with additional support from the High Country Section of Federated Farmers, the High Country Accord, and Merino Inc.

The farm management plan approach being used aims to integrate all aspects of farm management within a single plan. The management plan is based on a general statement (vision) about how the farming family would like to see the property at some point in the future (e.g., when they pass the property on to the next generation), while five-year goals are used to summarise specific targets that need to be met to achieve this vision. Goals relate to all aspects of the property including stock and pasture management, biodiversity conservation and recreational opportunities. Other sections of the management plan include: (1) The legislative, market, environmental and social context of the property; (2) Constraints to achieving management goals (e.g., weather conditions, soils, animal pests, district plan rules); (3) Tools for achieving the goals (this includes sections on stock and pasture management, plant and animal pest management, ecological management and public access); (4) Management units

within property; (5) Monitoring outcomes across all goal areas; and (6) Management plan implementation.

The farm management plan will be of considerable value for farmers as it will formalise best management practice for a range of activities, support RMA consent applications and provide a framework for eco-accreditation schemes, thus adding value to the property. More information on this project is available at www.highcountryaccord.co.nz/biodiversity.

Photo-monitoring

As part of our research on whole property management planning we have been developing an approach to land cover monitoring. We have recently published guidelines for undertaking photo-monitoring on high country and hill country farms. Photo-monitoring involves repeat photos of the same scene from the same place over a period of time. If undertaken properly, photo-monitoring can be used to (i) assess the response of vegetation to a land management activity such as fertiliser addition



School of Forestry technician Lachlan Kirk establishing photopoint monitoring site, Otematata Station

or change in stocking rate/type, and (2) document long-term changes in land cover on the property. It is a very simple and cost effective method to monitor changes in land cover, especially on large properties. Copies of the guidelines are available at www.highcountryaccord.co.nz/biodiversity.

Influence of pastoral management on plant biodiversity in a depleted short tussock grassland



School of Forestry students Maria Bosman and Tammy McMahon assist Peter Espie undertake biodiversity survey in short tussock grassland on Glenmore Station.

This study which was a collaborative project with Peter Espie and high country farmers Will and Jim Murray investigated the effects of different management inputs (fertiliser and seed) and grazing patterns on plant biodiversity in short tussock grassland with a strong *Hieracium pilosella* component. Cover abundance of vascular and non-vascular plants and environmental variables were measured in 32 10x10 m plots located in five blocks with different management treatments. Ordination of the floristic data separated the block with the highest management inputs from other blocks. Several adventive species were significantly more abundant in this block, while several native species were either absent or uncommon, but were significantly more abundant in other study blocks. *H. pilosella* was significantly more abundant in blocks with lower

management inputs. Diversity was significantly higher in the block with the highest management inputs. The native tussock *Poa colensoi* had significantly greater cover abundance while *Festuca novae-zelandiae* tussocks were significantly taller in this block. Our results suggest that high management inputs reduce the abundance of *H. pilosella* and diversity of native species, but increase the abundance of other adventive species and the cover and vigour of native tussocks. Our results highlight an interesting management conundrum for short tussock grasslands. No-input management is likely to result in a decline in native biodiversity, as well as production values, as *H. pilosella* mats deplete soil nutrients and restrict regeneration of native species. However, input of fertiliser and adventive seeds to enhance production values, although resulting in an increase in the vigour and abundance of some native species (mainly tussocks) and a reduction in *H. pilosella* abundance, will also result in a decline in overall native species richness. This research is being published in the third issue of New Zealand Journal of Ecology 2006 (www.nzes.org.nz).

Prof Roger Sands

Taringatura Harvesting Trial, Southland

Collaborators were Dr Matthew Wood, Dr Robert Douglas, and a French student, Edouard Harambaru. This trial looked at the impact of the number of passes of a range of harvesting machines on soil properties and on the subsequent growth of radiata pine established on the disturbed soils. Dr Matthew Wood was the lead investigator in this trial. Matthew spent two years at the School financed by a University of Canterbury Post-doctoral Fellowship. Matthew now works for the Tasmanian Forest Commission.

The results of this trial were unexpected and somewhat controversial. The harvesting machinery disturbed but did not compact the soils unduly because they were too wet. Increased intensity of trafficking reduced the rate of radiata pine in unripped soil but increased it in ripped soil. This interaction was explained by the better weed control in the ripped and trafficked areas. Details are provided in the attached references.

Landscape Ecology in the Nelson Region

The lead investigator in this trial was Keiko Nagashima and collaborators, besides myself, were Dr Graham Whyte, Dr Ted Bilek and Professor Nobukazu Nakagoshi. In this study discriminant analysis was used to study past and current land use patterns to predict future land use. It was predicted that plantations would become a more dominant land use and that district plans should recognise this by introducing measures for the conservation and rehabilitation of lowland vegetation to protect biodiversity

Biuret Effects on the Growth of Douglas fir

The lead investigator in this trial was Dr Jianming Xue and collaborators, beside myself, were Dr Peter Clinton and Dr Tim Payn, both from ENSIS. This research showed that biuret could act as a plant growth regulator and both stimulate or inhibit growth depending on concentration. It also showed that biuret could prime native nitrogen mineralisation in soil.

I recently completed a book, *Forestry in a Global Context*, which is a text book directed at first year university students but also relevant to anybody who wants a general overview of forestry, historically and globally.

My recent postgraduate students have been doing a range of things. Graham Coker has nearly completed his Masters degree which is looking at the potential of using leaf area index as a measure of site quality. Avinash Shrivastava is looking at the economic and social implications of the change from public to private control of plantation forest in New Zealand.

Prof John Walker

Research in wood processing involves one-to-one collaboration amongst academics across departments in the University. Such research welcomes postgraduates from a wide diversity of disciplines. For interdisciplinary studies, the Wood Technology Research Centre provides an umbrella organization: it coordinates occasional postgraduate meetings and formal workshops to showcase university research to industry. The School of Forestry is an active participant in the Wood Technology Research Centre.

Within the School, the last few years' research has been on wood quality of plantation forests, with increasing emphasis on the need for shorter rotations for pine and on opportunities for alternative species (cypresses, Douglas fir and eucalypts). The pragmatic case for such trends is set out in *Pine in perspective*.

(<http://www.fore.canterbury.ac.nz/docs/research/pineinperspective.pdf>)

It may be helpful to refer to recent publications and work-in-progress to understand the nature of current research interests:

Entwistle KM & Walker JCF. (2005). *The Hemicelluloses Workshop*. Wood Technology Research Centre, University of Canterbury.

Walker JCF. (2006). *Primary Wood Processing: principles and practice* (2nd edition). Springer, Dordrecht, The Netherlands.

Apiolaza, LA, Entwistle KM and Walker JCF. (2007) (in prep.). *Compromised wood: understanding the physiological and biomechanical responses of young trees to environmental pressures*. Wood Technology Research Centre, University of Canterbury.

Looking for Good Wood

Trees are amongst the most variable of all living organisms. When trees of the same age and from the same stand are felled and the logs are sorted into stacks according to diameter, length and visible features, eg size and distribution of branches along the stem, there will be an enormous range in the intrinsic (invisible) properties for those logs within a particular stack. For example the stiffness of visually "identical" logs varies by a factor of three.

The long-term profitability of the solid wood processing industry depends on having tools to identify the variations in intrinsic quality of logs. With radiata pine, achieving adequate property values for the three "essential requirements" – stiffness, straightness and stability – is surprisingly difficult! Values are most problematic in the

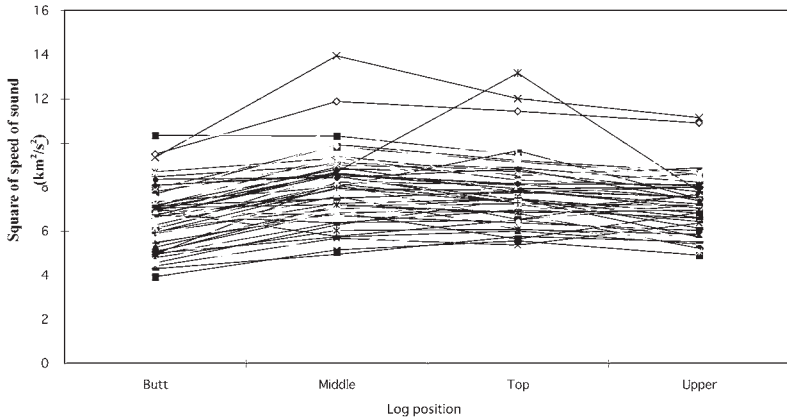
corewood zone, which is the 10 or so growth rings adjacent to the pith. In a 25 year-old tree 50% of the merchantable stem volume is corewood.

At the fundamental level, the stiffness is determined largely by the microfibril angle, the angle at which the cellulose molecules coil round the tracheid cell walls. By analogy, just as a lazy spring can be stretched easily while fencing wire is very stiff and inextensible, so the stiffness of wood increases five-fold as the microfibril angle decreases from 40° (a lazy spring) to 10° (approximating to a taut fencing wire). Studies of the effects of microfibril angle on wood quality are supported by the x-ray diffractometry team in the Department of Chemistry (Professor Ward Robinson and Dr Jan Wikaira). While it is not possible to take the diffractometer to logs on the skid site, this facility allows us to benchmark other research tools with fundamental wood characteristics like microfibril angle. An alternative field-robust technology is needed for field studies and this is provided by low frequency acoustics (or by near infra-red).

Acoustics permits the measurement of wood stiffness in logs and standing trees through the use of the equation $MOE_{dynamic} = rV^2$, where r is the density and V is the velocity of sound. This equation separates the contributions of density, which largely reflect quantity (mass) of wood in the tree, from that of wood quality on which the velocity of sound depends (cell diameter and wall thickness, the relative proportions of the various cell wall layers, the microfibril angle in the S_2 layer, chemical composition etc.).

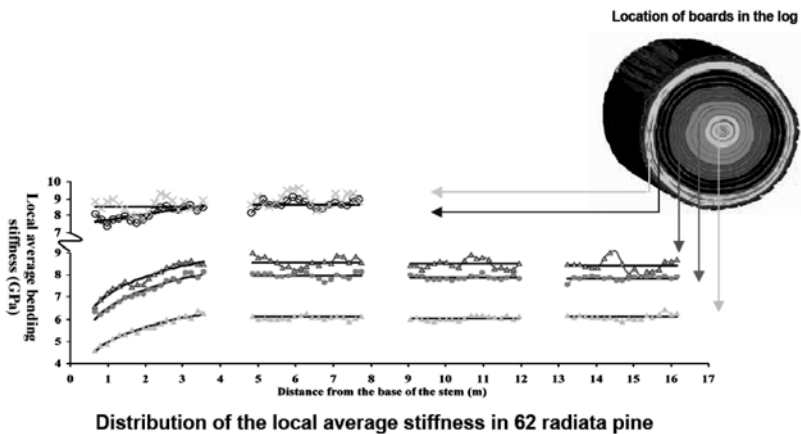
Dr Ping Xu validated such technology in her PhD study of 27 yr-old trees from an unpruned stand on the Mamaku Plateau. Trees were cut to give four logs and the acoustic velocity was measured along every log. The plot of the (velocity of sound)² for all logs from every tree accurately reflects the intrinsic stiffness of the logs. There are two striking features: there is little difference in log stiffness between the butt and upper logs, and the range of values amongst each log type is huge. This justifies the earlier statement that log stiffness can vary by a factor of three.

Knowing the grade out-turn from the knotty corewood of fast-grown radiata pine is vital for sawmills to operate more profitably. Currently the millers do not know which logs in a batch of logs can be sawn profitably into structural lumber and which should be sawn for dunnage. Dr Ping Xu delineated the extent of the problem, by examining wood properties within logs. By machine stress grading the boards and “reassembling the logs” she displayed the stiffness gradients within a log (from the

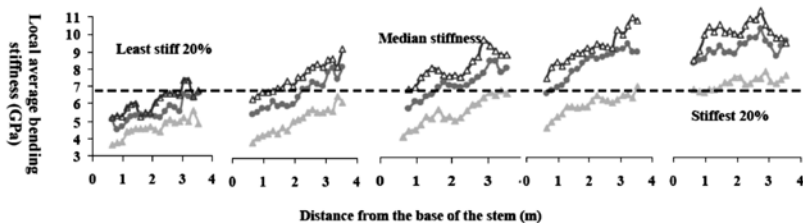


pith to the cambium). The diagram below emphasises the very poor stiffness of the wood surrounding the pith.

The most interesting new observation is that the bottom of the butt log has particularly poor properties: yet sawmillers traditionally consider the butt log to be the best part of the tree.



This data is of the average properties of all logs. One needs to consider the properties of individual trees to develop more detailed strategies for segregating logs using acoustics. Consider the proposition that 90% of all the problems in manufacturing good product can be attributed to 10% of the logs being milled. The unidentified poorest logs will be processed at a loss as identification of poor quality is perceived only subsequently. Boards will be dried, only to warp unacceptably; lumber will be dressed with a rough, woolly or chipped surface; structural lumber will be graded only to find that it fails to meet specifications. This low quality tail in a population is a feature of all processing whether machining screws, mixing concrete, or casting metal. The reason why it is so important to the timber industry is that trees are amongst the most variable of all living organisms. The range of strength in a batch of steel is insignificant compared to the range of property values found in lumber. Dr Ping Xu subsequently segregated the logs into five stiffness classes to demonstrate the distinctive outcomes. The poorest butt logs fail to meet minimum stiffness standards while the stiffest produced boards of adequate structural grade even when containing pith.



Butt logs when sorted into five equal-sized groups ranked in increasing order of stiffness.

Xu, P. & Walker, J.C.F. (2004). Stiffness gradients in radiata pine trees. *Wood Science & Technology* 38 (1) 1-9

Influence of wind and stocking

Arturo Bascuñán (MForSc, Chile) has explored the effects of wind on tree form and wood quality across three relatively narrow stands of *Pinus radiata*, aged 11, 17 and 25 years, on the Canterbury Plains, New Zealand. The experiment assumed that the

major influence on stand edges would be the strong north-westerly winds that blow periodically. He observed that the negative effect of wind extended into the stand the equivalent of one tree height, regardless of the age of the stand, with the poorest trees being on the stand edge: outerwood dynamic modulus of elasticity (E_d) and tree height increased with distance from the stand edge, while taper reduced. Trees at the stand edge, or in the buffer zone equivalent to one tree height, may be of marginal value for structural timber: trees on the edge were some 12% less stiff than interior trees. Curiously even larger edge effects were observed at the downwind side of these stands that we were unable to explain.

Arturo Bascuñán, Moore JR & Walker JCF. Variations in the dynamic modulus of elasticity with proximity to the stand edge in radiata pine stands on the Canterbury Plains, New Zealand. *NZ Journal Forestry* (submitted)

Parallel studies on pine by Mark Grabianowski (MForSc, Germany), by Jean Pierre Lasserre (MForSc, Chile) working with Assoc. Prof. Euan Mason) and on eucalypt by Mandeep Gill (PhD, India) and Eddie Warren (BForSc) both working with Dr Luis Apiolaza have noted that wood stiffness of young trees decreases, sometimes very markedly, as the initial stocking of stands decreases. In some instances low stockings can result in stiffnesses that are only 60-70% of the stiffness of heavily stocked and unthinned stands.

Grabianowski M, Manley BM & Walker JCF. (2004). Impact of stocking and exposure on outerwood acoustic properties of *Pinus radiata* in Eyrewell Forest. *NZ Journal of Forestry* 49 (2) 13-17.

Lasserre, J-P, Mason EG & Watt MS. (2005). Effects of genotype and spacing on *Pinus radiata* corewood stiffness in an 11 year-old experiments. *Forest Ecology & Management* 205 375-383.

The implications are serious. First in order to achieve fast growth and short rotations, foresters have opted for low initial stockings, both of which aggravate the corewood problem. Secondly, many small forest owners plant woodlots and shelterbelts, both of which will have much greater edge areas compared to larger forested blocks of the major forest companies. Edge trees and trees in the margin will be less stiff.

These studies demonstrate the importance of breeding for stiffness in young pine, and also the parallel interest in new forest initiatives centred on alternative species, especially fast-growing and intrinsically stiffer hardwood species such as eucalypts.

Acoustic tools

Dr Michael Hayes (Electrical and Electronic Engineering) developed the acoustic tool TreeTap for forest studies. This is one of a number of acoustic tools - Fakopp, Hitman (Director), WoodSpec – that, alongside other technologies, have proved useful in quickly characterising standing trees, logs and lumber. Such technologies are transforming understanding of wood quality.

A resonating member has nodes and antinodes at various points along its length depending on which overtone is being examined. A knot at a node is “invisible” and the resonance frequency and the overall acoustic velocity will not take its presence into account: by comparing the frequencies for the various overtones there is the prospect of inferring the presence of knots (Helge Hansen, MForSc in progress, Germany)

Moisture content and heartwood formation

Julian Moreno (PhD, Mexico) is currently working at Tumut with Forests New South Wales, Australia, investigating the occurrence of dry sapwood in their pine stands. Studies include measurement of mechanical and physical properties and consider effects of tree age, climate and site.

Influence of the hemicelluloses

Something like 25-30% of woody biomass are hemicelluloses, and something like 50% of the swollen cell wall consists of hydrated hemicelluloses. This is an extraordinarily large investment by the tree. Currently, new research is being developed concerning the biomechanical role of these hemicelluloses – in absorbing and dissipating wind energy and in reaction wood processes.

Alternative species

In New Zealand too large a proportion of its forests are radiata pine, chosen originally because it was fast growing, could be bred to have good form and was relatively disease resistant. It's physical and mechanical properties – like those of most pines – make it a commodity timber.

Owners of small forests, woodlots and shelterbelts – who together account for around half of current new planting – have shown increasing interest in alternative species (cypresses, Douglas fir and eucalypt). Research programmes to support such interest are currently being developed.

Theses abstracts and list of dissertations

The abstracts presented here are from a wide range of output from undergraduate and postgraduate students of the School. These outputs vary considerably in scope, length and quality.

Doctor of Philosophy

The PhD is an original piece of research that is examined to the highest contemporary international standard. The research generally takes three or more years and usually there will be publications in refereed journals arising directly from the thesis.

Master of Forestry Science

There are two types of Masters degree. In the first the major output is the thesis which is a research project of at least one and sometimes up to two years' duration. The thesis is expected to be of a high standard but the scope is often broader, and the extent of analysis and research less than that of the PhD. The second is by papers and report. Because of the requirements for coursework, the report is a smaller piece of work than the thesis and usually takes from a few months up to one year to produce.

Undergraduate Dissertations

All Faculties in the University of Canterbury give recognition to their top academic students by awarding their degree with Honours. In the School of Forestry these students are identified at the completion of their third year of study and an invitation to honours is extended. If accepted, the students are required to complete a dissertation in addition to the regular 4th Year component of study towards the degree. The dissertation is an opportunity for students to gain experience in research methods and analysis. Students are able to select a topic of their own choice, but with a degree of supervision by an appropriate member of staff.

Topics vary widely and are frequently determined by the nature, location and conditions of summer employment and availability of time and appropriate research material. A project outline is generally approved by the supervisor, and some guidance given, though much is left to the student's initiative. The dissertations are not refereed or modified by editorial comments, and thus represent individual student effort. Consequently, they vary widely in quality, length and comprehensiveness and account should be taken of this.

All theses, reports and dissertations are available at the Engineering Library at the University of Canterbury. It is possible to borrow copies through any recognised Library through the interloan service. If you wish to obtain a personal copy (a cost is involved and time delays can be experienced while the authors permission is sought for a copy to be made) requests should be sent to:

eng@libr.canterbury.ac.nz

In this publication we have included abstracts of all postgraduate theses and reports and listed the author and title of all dissertations examined for the period late 2002 to early 2006 inclusive.

Doctor of Philosophy

DENHOLM, Patricia M (2003)

Biodiversity, Biosolids and Bioindicators in *Pinus radiata* D. Don Planted Forests

The global issue of biodiversity was addressed at a local level in this thesis, which examined the effects of a biosolids application programme on the diversity of soil and litter arthropods in *Pinus radiata* D. Don planted forests in mid Canterbury, New Zealand. A taxonomic inventory of selected sites not only added to the sparse records of entomological data for similar habitats across New Zealand, but also enabled the development of a predictive model for comparison and validation in forward research. Evidence was sought for biosolids-mediated effects in the field on (i) the functional diversity of the arthropod assemblage, (ii) Shannon-Wiener diversity (H') and (iii) an ecologically relevant, invertebrate bioindicator. This novel bioindicator, the larval crane fly *Leptotarsus* spp. (Diptera: Tipulidae) was further used in a laboratory manipulation in an attempt to quantify the ecological relationship between the genus and soil physical properties. It was then subject to chronic toxicology tests to explore the histological effects of dietary uptake of Cu and Zn. Damage to the gut tissues and a differential effect on the architecture of the fat bodies was shown by histochemistry and light micrography. This evidence providing support for the “scope for growth” hypothesis, which suggests the allocation of energy to detoxification may impact on an organism’s energy reserves, thus affecting growth and development. The larval crane fly *Leptotarsus* spp. Is recommended as a pliable and responsive organism for chronic metal toxicity testing.

No support was found for the general hypothesis of a biosolid-mediated effect on arthropod functional diversity at the community level or on the diversity (H') of species. However, there was unequivocal evidence of a significant negative effect on the abundance of the larval crane fly *Leptotarsus* spp. in the field where dewatered biosolids are applied at rates beyond 400 kg N/ha. It was predicted that crane fly species with a brachypterous female would most likely be affected in forests receiving biosolids applications above 400 kt N/ha. The four crane fly species identified from the study sites were the sole representatives of the myceto/geophagic functional group. Although biosolids applications are likely to constrain both the local diversity and abundance of crane flies, the species redundancy hypothesis predicts ecological processes are unlikely to be affected. Laboratory manipulations failed to show linkage between crane fly larval abundance and their contribution to the generation of porous space in the soil, although these larvae are expected to mediate other soil-related processes, such as the redistribution of fungal inoculants.

Arthropod diversity under *P. radiata* is dominated by generalist species. Greater than 50% of the arthropods trapped were indigenous. The sampled forests clearly provide a refuge within the agricultural mosaic and contribute to the retention of local biodiversity. The trophic structure of the arthropod assemblage was dominated by predatory species. A positive relationship between species diversity (H') and the stage of development of a stand was best described by a logarithmic curve, indicating diversity (H') increased most rapidly during the first (approx.) 10 years of forest establishment. The suites of indicator species identified as significantly indicative of the *P. radiata* habitat are expected to simplify future assessment at the long-term monitoring sites by offering an investigative tool for the non-specialist.

This thesis provides information on the community structure of a highly modified habitat which is of interest to both entomologists and forest managers. As well as giving information on seasonal abundances in relation to trapping methodologies, it provides baseline data and predictive models useful for comparing long-term effects and suggests appropriate bioindicator species as tools for straightforward and cost-effective monitoring in the future. In practice, the main results demonstrated that although biosolids-mediated effects in the *Pinus* habitat were effectively quantified at the level of genus, forest managers can have a high level of confidence that a significant biosolids-mediated effect on invertebrate biodiversity at the community level is unlikely, at least in the short term, at advised rates of application.

GRUNER, Ingrid G (2003)

Comparative Ecology and Conservation of Rare Native Broom, *Carmichaelia* (Fabaceae), South Island, New Zealand

Using a comparative approach, the presented study explores the ecology of ten species of native New Zealand broom, *Carmichaelia*, and their vulnerability to competition and herbivory, with the aim of gaining a better understanding of the significance of introduced species as a threat to rare indigenous plants in New Zealand. In particular, the study focuses on the relationship between characteristics of the *Carmichaelia* species and their vulnerability, as well as on other factors influencing the significance of introduced species as a threat.

To gain better understanding of the ecology of the *Carmichaelia* species, their current habitats and associated plant communities were investigated using quantitative-descriptive methods in the field. The effect of competition with introduced plants was

studied in two glasshouse experiments, differentiating above ground competition for light from below ground competition for nutrients and water. The experiments focused on the early life-stage of seedling establishment of the *Carmichaelia* species. The impact of herbivory by introduced mammals was studied in four field-based exclosure trials, focusing on the effects on survival and reproductive activity of adult *Carmichaelia* plants.

The results showed that the effects of competition and herbivory vary between the different species. Furthermore, they provided a set of species characteristics that can be used as indicators to predict the vulnerability of *Carmichaelia* to the impact of introduced species. These indicators provide a useful tool for threatened species management, as they allow the identification of the most vulnerable species as well as the most significant threat to each species. Furthermore, the indicators can be used to group species, combining those with similar vulnerability profiles, and therefore, likely similar management needs.

However, the example of the *Carmichaelia* species also illustrated that the use of indicators for the vulnerability of threatened species is limited and needs to be combined with case-by-case studies to verify the actual significance of threats for each population of concern. The vulnerability profiles derived from species' characteristics can be used to guide such site-specific studies, ensuring they focus on the most relevant threat factors. This combination of the understanding of general patterns in the vulnerability of species with targeted species and site-specific studies will lead to increased efficiency in the conservation management of threatened plant species.

WATT, Michael S (2003)

Modeling the Influence of Weed Competition on Growth of Juvenile *Pinus radiata* at a Dryland Site

The reduction in growth of commercially grown conifers by weeds over the juvenile phase is an important management issue. This thesis investigates the mechanisms of interaction between juvenile *Pinus radiata* and the woody weed broom (*Cytisus scoparius* L.) at a dryland site, and uses this information to develop process-based models of tree growth, sensitive to competition from weeds. All the results presented in this thesis were taken from an experiment established on a drought prone site, located on the Canterbury Plains, New Zealand. Within the experiment

a comprehensive and detailed set of measurements were taken from trees growing weed-free and with broom competition, from the beginning of the second year to the end of the third year after planting.

The presence of broom severely retarded the growth of trees over the two year measurement period. Treatment differences in basal area, which became significant one month after measurements started, increased from six-fold at the end of the first year to 12-fold after two years. At the end of the second year, trees growing without broom were two-fold taller, and had a crown diameter four-fold greater than trees in plot with broom. Above-ground biomass was the most sensitive indicator of competition. Compared to trees in weed-free plots, above-ground biomass of trees in plots with broom was reduced by 25-fold after two years.

During the first year, the strong link between predawn needle water potential, ψ_e , and fractional biomass growth for trees in plots with broom ($r^2=0.91$) suggests growth losses in this treatment were almost entirely attributable to seasonal water deficit. Although ψ_e was also strongly related to fractional biomass growth, f_b , over the second year ($r^2=0.71$), values of f_b across a comparable range of ψ_e , were on average 15% lower than during the first year. Inclusion of a simple shading index explained this difference, suggesting broom restricted tree growth during the second year through competition for both light and water.

Nitrogen fixation by broom, and the extent of fixed nitrogen transfer to *Pinus radiata* was assessed from measurements of the natural abundance of the ^{15}N isotope, $\delta^{15}\text{N}$. Values of $\delta^{15}\text{N}$ were highest in *Pinus radiata* growing without broom, intermediate in *Pinus radiata* growing with broom, and lowest in field grown broom. Broom was an effective fixer, deriving 81% of nitrogen in above-ground tissues from the atmosphere, which was equivalent to $111 \text{ kg N ha}^{-1} \text{ yr}^{-1}$. The intermediate values of $\delta^{15}\text{N}$ found for trees growing with broom suggest that there was some transfer of fixed nitrogen from the broom to the *Pinus radiata*. However as soil uptake by the broom ($29 \text{ kg N ha}^{-1} \text{ yr}^{-1}$) considerably exceeded estimated rates of nitrogen transfer ($2 \text{ kg N ha}^{-1} \text{ yr}^{-1}$) growth of trees was not enhanced by this recycling of fixed nitrogen.

Compared with *Pinus radiata* in weed-free plots, trees growing with broom allocated dry matter preferentially to stems (+8%) at the expense of foliage (-4%), roots (-2%) and branches (-2%). These findings on allocation confirm derivations based on pipe model theory and indicate that the root to shoot ratio in juvenile *Pinus radiata* remains relatively stable even under severe water deficit.

A water balance model was developed to partition water loss and explain treatment differences in tree basal area growth, over the first year. In both treatments, modelled root-zone water storage (W) corresponded closely to measured values over the course of the year. Total annual evaporation in the treatment with broom was 25% higher than that for the treatment without broom. This higher rate was primarily due to wet canopy evaporation from the broom and, to a lesser extent, from increased rates of total transpiration within this treatment. The integral of root-zone water deficit was strongly related to fractional basal area growth of trees in plots with broom. These findings highlight the importance of root-zone water storage in regulating productivity on dryland sites and indicate that water balance modeling provides a useful approach for predicting the influence of weed competition on tree growth.

A generally applicable model of juvenile tree growth was developed and tested at this dryland site. This model predicts tree growth by reducing growth from an empirically determined optimum rate (weed-free) using a seasonally estimated competition modifier, which accounts for the degree of weed competition for both water and light. Test results showed good correspondence between measured and predicted tree diameter growth in treatments with and without broom, over the two year period. As this model was developed using process-based modifiers for water and light it is applicable to sites covering a wide range of climatic and edaphic conditions.

XUE, Jianming (2003)

Effects of Biuret Addition on Soil Nitrogen Transformations and Douglas Fir Seedling Growth

This project was carried out to evaluate the feasibility of using of biuret as a plant growth and/or soil microbial activity regulator at low concentrations, and as a slow-release N fertiliser at high concentrations.

Biuret stimulated Douglas fir seedling growth at low concentrations, but inhibited it at high concentrations. The stimulation of biuret on seedling growth in sand and solution culture was associated with increased net photosynthetic rate and nutrient uptake and when grown in the soil it was also related to the improvement of soil N availability and therefore the uptake of N by seedlings. Provenance 93 (relatively fast growing) was more responsive to lower concentrations of biuret, but more sensitive to the toxicity of biuret at high concentrations than provenance 98 (relatively slow growing). Yellow-tip (chlorosis) in needles was a typical symptom of biuret toxicity.

Applied nitrogen had a much greater effect on Douglas fir seedling growth than biuret. Provenance 93 grew faster at lower N supply due to its greater ability to absorb more nutrients and further to distribute more into the shoot.

Biuret at lower concentrations had a positive real priming effect on net mineralisation of native soil N in both soils. The causes for the positive priming effects were related to the stimulation of microbial growth and activity at an early stage of the incubation and/or the death of microbes at a later stage, which was biuret-concentration-dependent. Biuret additions increased gross rates of soil N mineralisation and nitrification and affected the turnover rates of mineral N pools. The biuret-¹⁵N tracing technique further confirmed that biuret addition stimulated the mineralization of native soil N by increasing the turnover rate constant (k value). The potential of biuret as a slow-release N source at high concentrations (especially in the Burnham soil) was related to the slow mineralisation, nitrification and more immobilisation of biuret-N, which reduced the potential of N losses by volatilisation and denitrification.

CHAUHAN, Shakti S (2004)

Selecting and/or Processing Wood According to its Processing Characteristics

In this study, three issues associated with the segregation of wood according to their processing characteristics have been addressed. In the first part of the study, the influence of inhomogeneity on the acoustic velocity measured by a resonance based acoustic tool "WoodSpec" and a transit-time based tool "Fakopp-2D" was investigated. Four laminated panels with varying degree of inhomogeneity were prepared and acoustic velocities were measured by both tools. The acoustic velocity measured by the Fakopp-2D tool was always higher than that measured by the WoodSpec tool. The difference in the two velocities was found to differ with the magnitude of inhomogeneity in the panel. It was demonstrated that the velocity measured by the resonance frequency obeys the Law of Mixtures and is controlled by the volume-weighted average stiffness of wood. In contrast the velocity measured by the Fakopp-2D tool was influenced by the amount of energy propagating at the dilatational speed. The progression of the wave-front in panels was investigated using Fakopp-2D tool by picking up the arrival time of the signal at off-axis probes. The wave-front profile was found to be determined by the stress-wave speed (stiffness) at different angles from the axis symmetry. In logs, the transit-time velocity was found to be sensitive to the localised stiffness of the wood lying in between the measurement

probes within the propagation path. A strong correlation was observed between the velocities measured by WoodSpec and the Fakopp-2D tool in young radiata pine and eucalyptus logs; however the acoustic velocity by Fakopp-2D was higher than the WoodSpec velocity. The results imply that Fakopp-2D would be used to rank young trees according to their stiffness.

In the second part of the study, two trials were conducted to test the hypothesis that acoustics can be used to segregate pulp logs into categories which will require different amounts of energy during mechanical pulping and will produce pulps with different strengths. *Pinus radiata* logs of varying age, length, SED, LED, taper, and volume were measured for acoustic velocity, segregated into four different velocity groups and chipped separately. It was shown that acoustics could segregate logs into groups that perform very differently in terms of pulp and paper properties when refined to a given freeness or at a certain energy input. At a given target freeness there was a 20% difference in energy requirement between the lowest and highest velocity logs. Similarly there was a 17% difference in tensile strength between the lowest and highest velocity logs for a given specific energy.

In the third part of the study, investigation were made to explore the potential of acoustic velocity in ranking young *Eucalyptus nitens* trees according to growth stress level. Longitudinal growth strain was measured in 155 selected trees at the breast height and acoustic velocity was measured in the same trees using the Fakopp tool. Measurements in the first 34 trees showed some relationship between growth strain and acoustic velocity which eventually vanished as the measurements were progressively extended to all 155 trees. The results indicated the dangers of drawing possible inferences on the basis of small sample sizes.

With the disappointment over the use of acoustics to predict growth stress, consideration was given to other experimental approaches. The authenticity of a pairing test (bending on sawing) was established in indicating the growth strain level in trees. A mathematical model was suggested to predict the magnitude of bending on sawing the log based on growth strain level and log geometry. The relationships between longitudinal growth strain and certain key wood properties were also investigated. Green density, green moisture content, basic density, radial shrinkage, outerwood and corewood densities, volumetric shrinkage and dynamic MoE at 12% mc and length-weighted fibre length were determined. Amongst all the studied wood properties, only shrinkage-related properties were found to have some association

with the mean growth strain in trees. The mean growth strain was moderately but significantly related to the volumetric shrinkage of the outerwood while the corewood shrinkage was not related. However, the volumetric shrinkage differential (difference between outerwood and corewood shrinkage) was strongly related to the growth strain ($r=0.70$) suggesting that the growth stress gradient might be related to the shrinkage property variations within the stem. Fisher's LSD test indicated statistically significant lower volumetric shrinkage, lower outerwood MoE and less collapse in the wood from trees with the lowest growth strains as compared to those from the highest growth strains. The results suggest that *Eucalyptus nitens* trees with low strains could exhibit a lower degree of the drying defects like collapse and internal checking during processing.

The large variation in wood quality characteristics in plantation grown timbers makes some screening for wood quality necessary for the effective management of wood resources and for the allocation of logs according to "Fitness for Purpose" to capture greater value of forest product value chain.

HSU, Ching Yi (2004)

Radiata Pine Wood Anatomy Structure and Biophysical Properties

Several important characteristics such as density, acoustic velocity, modulus of elasticity and tracheid dimensions are examined in stemwood, branchwood and rootwood in young (age 3 and 7) *Pinus radiata*. Stemwood air-dry density decreases little from ground level to the top of the tree falling gradually from 415 kg/m³ to 405 kg/m³. Branchwood air-dry density is higher than stemwood density. The branchwood density is approximately 480 kg/m³ close to the stem and then decreases sharply to ca. 410 kg/m³ near the branch tips. Rootwood density at 12% moisture content is similar to stemwood density ranging between 420 and 405 kg/m³ but changes little along tap roots (405 kg/m³).

In stemwood, the air-dry modulus of elasticity increases from ground level (ca. 2.5-3.5 GPa) to approximately 4 metres (ca. 5.5-6.5 GPa) and then decreases thereafter to 7 metres (ca. 2.5-3.5 GPa). The air-dry MOE of branchwood decreases linearly with tree height up the stem from approximately 4.5 GPa at 1 metre to 3 GPa at 6 metres. Roots are the least stiff part of the tree. The air-dry MOE value decreases along roots from the stem-root junction (ca. 1.9 GPa) to the root tip area (0.5 GPa) in latera roots, and from 1.4 GPa to 0.4 GPa in tap roots.

In stemwood and rootwood the tracheid dimensions change with distance from ground level in both directions with significant different patterns. For stemwood, the tracheid length decreases with height up the stem. The mean tracheid length is approximately 1.70 mm at breast height whereas it is 1.55 mm and 1.40 mm at 2.4 metres and 4.6 metres respectively. Rootwood tracheids are much longer (nearly double) than stemwood tracheids. The tracheid length increases with increasing distances from the stem-root junction. The mean tracheid length adjacent to the stem-root junction area is approximately 2.2 mm whereas for the middle and root tip areas it is 2.6 mm and 3.3 mm respectively.

Compression wood is a common feature of stem and branchwood. However, this atypical tissue is absent in roots except in some restricted instances where compression wood extends a short distance from the stem down into the root.

Branchwood in green condition can be used to predict volume-weighted stemwood qualities at 12% moisture content when specific conditions are applied (select a straight portion of first branch segment from the largest diameter branch at breast height, $R^2=0.64$). However, this approach has little practical appeal as equally good or better correlations can be obtained using Fakopp on standing trees ($R^2=0.75$). Therefore future work should focus solely on the use of time of flight instruments such as Fakopp on stemwood.

VAN EYNDHOVEN, Erik (2004)

Resource Selection by the Brushtail Possum (*Trichosurus vulpecula* Kerr) in a Mixed Red-Silver Beech (*Nothofagus fusca* – *N. menziesii*) Forest, North Westland, New Zealand: a multi-scale, GIS-based approach

Resource selection by the brushtail possum (*Trichosurus vulpecula*) was studied in a beech (*Nothofagus*) forest in order to elucidate possum ecology in an extensive forest type lacking extensive possum research. The study was conducted in the Upper Grey Valley, north Westland, on a post-glacial terrace dominated by *Nothofagus fusca* and *Nothofagus menziesii* and dissected by a gravel road.

Five principal research questions were posed for the study of possums within the site. These were:

- What are the movement parameters of the resident possum population?
- What are the patterns of vegetation heterogeneity?

- What constitutes possum diet?
- What are the relationships between possum diet and vegetation heterogeneity?
- What are the relationships between possum movements and vegetation heterogeneity?

Twelve possums were radio-collared and radio-tracked over a year. Home ranges calculated with the kernel method averaged 8.1 ± 1.0 ha (mean \pm s.e.), which is large compared to possum home ranges observed in other continuously forested sites. Range lengths were similarly large (456 ± 42 m). Bi-monthly variation was only displayed with significantly smaller home ranges in winter when compared to autumn.

Despite the fact that the study site was generally dominated by *N. fusca* and *N. menziesii*, considerable heterogeneity existed with respect to the possum palatable species within the site. Many palatable species such as *Aristotelia serrata*, *Fuchsia excorticata*, *Muehlenbeckia australis* and *Trifolium repens* occurred predominately along the roadside, whilst *Weinmannia racemosa* occurred predominately on steep areas within the forest TWINSpan classification of the forest identified three vegetation communities. These were open sites, including the road and swamp areas, steep areas, including the hill and escarpments, and terrace areas.

Resource selection by possums within the site was investigated with diet preference analysis, habitat selection analysis and modeling of use of space versus resource variables. Diet preference was analysed by comparing the level of consumption of food types with their level of availability within the site at multiple scales. The top five ranked preferred food types, calculated overall were, in decreasing rank, *Fuchsia excorticata* foliage, *Carpodetus serratus* fruit, *Rubus cissoides* foliage, *Muehlenbeckia australis* foliage and *Pseudopanax colensoi* fruit.

Habitat selection analysis indicated that although overall selection was not occurring, possums exhibited a degree of preference towards the terrace community. Modeling of resource variables against use of space indicated that although there was latent variability between individual possums, there was a trend for greater use of areas with high abundance of preferred species. Modeling of pooled possum use of space on an annual scale indicated that use was positively correlated with species richness and negatively correlated with *N. fusca*, *Quintinia acutifolia*, and *Coprosma rotundifolia* abundance, which are all unpreferred species. Annual home ranges of possums were found to be negatively correlated with forage quality as defined by preferred species.

A model of possum resource selection within the site was postulated to the effect that possums choose their home range location randomly, with respect to vegetation heterogeneity, and then modify the size of their home range to suit nutritional needs rather than modifying range location.

The ranging behaviours and resource selection of possums observed in this study have implications for the management of possums in similar forest types. Efficiency of control and monitoring operations may be increased by using a spacing regime derived from possum home ranges. Inferences obtained from habitat selection analysis indicate that stratification of control and monitoring operations is not warranted in similar forest types. The development of extensive models with predictive capabilities for the distribution of possums within the environment has the ability to become a useful tool for possum managers. Further research of potential benefit could include investigation into resource quality and availability, the effect of home range size on residual trap catch (RTC) indices, improving diet assessment techniques and assessing possum preference for non-foliar food types.

MITCHELL, Robin A (2005)

A Comparison of Three Natural Succession Chronosequence Case Studies from the South Island, New Zealand to Select Predictable Indices for Evaluating Restoration Success

Evaluating the success of ecological restoration interventions in establishing self-sustaining development towards distant goals within project timescales is problematic. Trajectory analysis is a promising evaluation strategy to this end yet it has received little research attention and is uncommonly used. This thesis aims to identify indices predictable enough to be suitable for trajectory analysis, focusing plant assemblage structure. The primary objectives were to: a) accurately infer plant assemblage development gradients of primary successions in three different ecosystems of the South Island, New Zealand by means of sampling well aged chronosequences; and b) establish which indices had sufficiently strong and consistent response trajectories to all three inferred vegetation development gradients to be considered predictable. The vascular plant assemblages of at least five development stages in each of the three sites were sampled intensively using multiple fixed area plots. Ordination and stepwise regression established that age was highly correlated with the main floristic gradient and environmental variables

were unimportant in explaining floristic variation. Data for index calculation consisted of plant species cover abundance and leaf area estimates as well as soil chemical properties. Development stage age estimates enabled index response trajectories to be constructed from stage mean values. Regression models were fitted to observed index trajectories for each site to test response strength and predictability. Comparisons of regression statistics and trajectories among the three sites for each index showed that the majority of indices had predictable responses to all sites; these were: soil pH and organic carbon; importance score; Simpson's species diversity; distance from the lognormal model of species relative abundance distribution; growth form diversity; taxonomic distinctness; and DCA axis one. Together, these indices are suggested to be able to evaluate if development trajectories indicate progress towards three restoration goals via intermediate objectives. These goals are: 1) a persistent plant assemblage; 2) a plant assemblage with specific structural attributes; and 3) a well functioning ecosystem. For trajectory analysis to effectively evaluate restoration success with these goals it is recommended that recovery gradients are long, monitoring periods are at least three decades and multiple indices are used that convey complementary information.

RAHARDJA, Teguh (2005)

Informed Preferences in Forest-Based Land Use Planning in Indonesia: a methodological case study

Indonesia is large and rich in natural resources. Its forest extends over 60 per cent of the country's land and contains many other natural resources. There are many stakeholders, often with conflicting interests. The demands placed on the forest have resulted in declining quantity and quality of the forest lands. People have recognised the need for reviewing and improving the forest-based land use plan, and, in so doing, promoting the participatory approach rather than the traditionally centralistic one. This has been attempted, but there were difficulties in the participatory evaluation of land use options' impacts. Therefore, this study aims to develop a method to help forestry-based land use planning take into account stakeholders' preferences after considering land use scenario consequences.

Based on the situation in Indonesia and existing options, this study adopted the mixed rational-participatory approach. The rational side was attempted by FOLPI simulation of land use scenarios. An interview survey of opinions suggested eight

scenarios of varying emphases on the economic, ecological and social aspects, which were simulated in FOLPI with area and resource data of each land use. The results were graphs of land use changes and their economic, ecological and social impacts.

The participatory aspect was promoted by Q methodology applications. Q was used to analyse respondents' sorts of a set of statements about different aspects of land use planning, and revealed the typology and preferences of stakeholders with regard to land use planning. Using verbal statements in such exercises discovered the typology and normative preferences, while using the FOLPI application graphs as the statements disclosed the positive preferences. In tandem, they provide useful information as inputs to stakeholder deliberations towards a new, rational, and acceptable land use scenario.

This study, therefore, recommends a method to help forest-based land use planning stakeholders. The method includes FOLPI simulation of the broad-scoped land use scenarios, and Q applications both the conventional verbal way and the innovative graphical way.

Master of Forestry Science Theses

ARMSTRONG, Kiri A (2002)

Is *Nothofagus menziesii* (Hook. f.) Oerst. (Silver Beech) an Advance-Growth Regenerator?

In New Zealand, current knowledge of indigenous forest regeneration is inadequate to determine what harvesting system or systems are appropriate for achieving the long-term goal of sustainable forest management. The single-tree/small-gap selection harvesting system favours advance-growth regenerators, or gap-phase regenerators from seed and is currently under trial for the management of a *Nothofagus menziesii* forest in Southland, New Zealand. The hypothesis that *Nothofagus menziesii* is an advance-growth regenerator at this locality was tested by examining the characteristics of the seedling population. A previously existing set of quadrats (1 x 1 m samples) were re-measured throughout 2001, forming a dataset with seedling numbers and heights at various points in time. Biotic and abiotic variables were also measured. The characteristics of the static and changing seedling population were examined using spatial autocorrelation, and factors that influence the seedling population were identified using path analysis.

Recent measures of change indicate that the current size and structure of the advance-growth seedling population will be maintained. These characteristics alone do not provide sufficient evidence to suggest that *Nothofagus menziesii* at Beaumont Bush is not an advance-growth regenerator. However, there are significant areas that lack an advance-growth seedling pool and recent recruitment patterns indicate that this is also unlikely to change assuming that current environmental conditions remain the same. This spatial inadequacy suggests that *Nothofagus menziesii* at Beaumont Bush is not an advance-growth regenerator. However, results of comparison between the seedling population dynamics in gaps compared with under the canopy are consistent with advance-growth regeneration theory, suggesting that where there are seedlings, *Nothofagus menziesii* at Beaumont Bush is an advance-growth regenerator.

Moss was the preferred site for seedling establishment, and although the mechanism by which moss improves seedling recruitment was not identified, moisture is potentially crucial. The major finding was that the highly heterogeneous spatial distribution of the seedling population is primarily influenced by the abundance of the fern *Blechnum discolor*, which negatively influences seedling recruitment by promoting litter and inhibiting moss. *Nothofagus menziesii* appears to adopt different regeneration strategies depending on various factors, including the distribution and abundance of *Blechnum discolor*.

CATTANEO, Mariana (2002)

Effects of Microsite Characteristics, Competition and Grazing on *Pinus contorta* Dougl. and *Pseudotsuga menziesii* (Mirb.) Franco Seedling Establishment

In New Zealand, the spread of exotic conifers can affect conservation and land use production values, and is of concern to both managers of conservation land and the general public. This study had three principal objectives: 1) determine the microsite preferences of *Pinus contorta* and *Pseudotsuga menziesii* in an open shrubland; 2) quantify the effect of grass competition on the seed germination and early seedling growth of *P. contorta* and *Ps. menziesii* in the glasshouse; and 3) evaluate the effect of sheep grazing on density and growth of wilding conifers in unimproved short tussock grassland. The first objective involved the comparison of seedling and available (unoccupied) microsites on the basis of the following variables: establishment substrate; vascular cover; and proximity and height of neighbouring plants. Litter cover had a significant negative effect on the establishment of neighbouring plants. Litter cover had a significant negative effect on the establishment of *P. contorta* seedlings; while there was no significant difference between the rest of the substrates. For *Ps. menziesii*, lichen and bryophytes were unfavourable substrates, litter favoured seedling establishment, while there was no significant difference between the rest of the substrates. Herbs were a favourable vegetation substrate for *P. contorta* and mat-like woody plants for *Ps. menziesii*, while shrubs suppressed the establishment of both species, but less so for *Ps. menziesii*. Vascular cover (> 5 cm tall) reduced the establishment of both species. *Ps. menziesii* showed a marked benefit from shelter provided by shrubs, but this was much less evident for *P. contorta*. The competition trials indicated that grass competition significantly reduced the seed germination and early seedling growth of both species. In both stages, *Ps. menziesii* performed better than *P. contorta* in the presence of grass. The third objective provided evidence that sheep grazing at a stocking rate of less than 0.5 stock units/ha is effective in reducing the density and growth of wilding conifers. The study showed that, although existing vegetation structure and composition influenced the establishment of *P. contorta* and *Ps. menziesii*, unmanaged open shrublands pose few effective barriers to conifer invasion. The management of the vegetation structure could assist in controlling conifer invasions by maintaining a dense and closed-canopy vegetation cover where shade and competition will limit the establishment of seedlings. Sheep grazing is an effective option to reduce the incidence of wilding spread.

DE ZWART, Eykolina J (2002)

Possum Resource Selection in a Fragmented Landscape, Cass, New Zealand

This study presents the results of an investigation to determine the resources utilised by possums in a spatially heterogeneous landscape in the Canterbury high country. The study area comprised a mosaic of forest, scrub, shrubland, grassland and swamp at the University of Canterbury field station at Cass, inland Canterbury.

The vegetation communities at Cass were originally divided into seven different categories based on species composition. These areas are referred to as the swamp, grassland, shrubland, scrub 1, scrub 2, native forest, and exotic forest. Communities were classified using two multivariate techniques; TWINSpan and Detrended correspondence analysis. A vegetation map of Cass was produced using ground survey and aerial maps, and displayed the extent and coverage of vegetation communities. These vegetation communities reflect the influence of burning and farming. The study area comprises c. 195 ha.

The overall possum density was low, with approximately one possum per hectare. This result may be due to resources that possums need for survival, being deficient in the area.

Possum movements were investigated by radio-collaring six female possums and six male possums at Cass. These possums were radio-tracked six times during a period of ten months, with each radio-tracking session undertaken for a period of three consecutive nights. The data collected were used to derive individual home ranges using Minimum Convex Polygon and Kernel home range estimates. There was no statistically significant difference between female and male home ranges at Cass. No seasonal difference in possum home range was detected, although other possum home range studies have found seasonal differences. There were too few den site location areas to enable accurate information concerning seasonal variation of den sites. Possums had relatively large home ranges, which probably result from a low possum density in the areas, as well as spatial heterogeneity of key resources. Nine possums showed some degree of home range overlap, but there did not appear to be any difference between females and males with respect to this. Sixty percent of the possums studied exhibited bimodal home ranging behaviour. Bimodal behaviour almost certainly results from the spatial heterogeneity of key resources, with possums having to travel long distances in order to use all the resources.

Possum diet was assessed using a point sampling technique, which identified all ingested stomach material greater than 3 mm, at four times through 2001. There was no statistical difference between female and male diet, or between juvenile and adult diet. Thirty-eight different food items were consumed by possums over the study period, with four dominant food items that comprised of 50% of their diet (*Aristotelia fruticosa*, fungi, *Podocarpus nivalis*, and *Blechnum penna-marina*).

Due to the spatial heterogeneity of vegetation communities at the Cass study area, possums utilised the different habitats non-randomly, preferring the scrub and forest communities.

Possum management is not currently needed at Cass, although in the future, if possum density increases then management options should be reassessed in order to minimise possum impact.

HUSTEDT, Sina (2002)

The Ecology and Conservation of a Threatened Shrub: *Hebe armstrongii* (Scrophulariaceae), Canterbury, New Zealand

This study presents the results of the investigations into the ecology of the threatened shrub species (Scrophulariaceae) *Hebe armstrongii*, Mt White, Canterbury, New Zealand.

There are four populations of *Hebe armstrongii* located in the study area (Nigger Valley) comprising of 1730 plants. All four populations had similar population structure in terms of height and canopy spread classes and regeneration. Throughout these four populations there was an observed absence of juveniles, indicating a lack of regeneration although plants were found to be flowering and setting seed.

Herbivory, which has previously been the documented limiting factor in the regeneration of this species, appeared to have no effect on regeneration in the present study. There were no significant differences in population structure or health between open and enclosed areas.

There are four vegetation communities identified within the study area, two predominately grassland communities and two grassland-shrubland communities. *Hebe armstrongii* was associated with two vegetation communities; a community dominated by *Halocarpus bidwillii* and to a lesser extent a community dominated by *Ozothamnus leptophylla* and *Agrostis capillaris*. These communities were distributed

on Big Flora and Little Flora terraces and on the island in the Mounds of Misery. Moss and *Leucopogon colensoi* were the species most frequently associated with *Hebe armstrongii*, while the shrub species *Halocarpus bidwillii* and *Ozomanthus leptophylla* to a lesser extent.

With the implementation of the management by research suggested by this study, the further decline and possible extinction of wild *Hebe armstrongii* populations may be avoided.

CHRISTENSEN, Brendon R (2003)

Validity of Biodiversity Monitoring Programmes: Boundary Stream Mainland Island Project, Department of Conservation

The recent move to *in situ* conservation management world-wide is supported by, and stems from the 1992 International Convention on Biological Diversity. The Department of Conservation – charged with the conservation of New Zealand’s natural resources – has directed efforts towards the restoration of natural processes as an avenue to halt local biodiversity decline. Ecosystem, habitat, and nature restoration programmes such as the Boundary Stream Mainland Island Project (BSMIP) represent the forefront of conservation management, combining intensive multi-species pest control, with broad-scale hierarchical monitoring programmes.

Monitoring programmes confer information that is intended to support decision-making and management by the reduction of uncertainty, or by increasing knowledge. The validity of monitoring programmes depends on three key parts; the guiding objectives, biological relevance, and statistical reliability. Seven major long-term monitoring programmes established at the BSMIP were evaluated according to the above criteria. All monitoring programmes had appropriate guiding objectives, and were biologically relevant (outcome and result monitoring were balanced respective to each other and to the restoration intervention and efforts at BSMIP). The statistical reliability of the programmes was appraised with the use of the computer programme MONITOR, which provided a calculated value for the statistical power of the monitoring programmes. All monitoring programmes except two (Lizard monitoring: which was initially designed as a short-term species survey, and Mustelid monitoring: which would be a good candidate for a double sampling methodology) had a robust design (evaluated using the actual initial data, and conservative criteria for the detection of population change). The monitoring programmes that did achieve

a level of statistical robustness, provided a statistical power of ≥ 0.8 ($\geq 80\%$) within appropriate timeframes for restoration of ecosystem processes (e.g. the timeframe for detection of a 10% change in the abundance, density, relative index, etc of the Result monitoring programmes: Rodents = three years, Possums = six years, and outcome monitoring programmes: Weta = five years, Ground Invertebrates = four years, Birds (species nos.) = four years, Vegetation (Species, and sapling nos.) = 15 years).

The guiding objectives for monitoring programmes must have clear, specific, measurable, and achievable goals, in order to identify appropriate variables, in both spatial and temporal scales. The biological relevance or “linkage” between monitored groups is important and must be at least outlined, for monitoring programmes to be able to identify potential cause and effect. Statistical reliability (the balance between statistical significance, statistical power, and the timeframe for a conclusive result to be determined) is important, as it is the key method of detecting change. Statistical power can improve the design and efficiency of monitoring programmes and clarify research results. Power analysis has become readily available for researchers and managers with the development of computer programmes specifically designed for this task.

GRABIANOWSKI, Mark (2003)

Measuring Acoustic Properties in Lumber and Trees

Acoustics provide methods for non-destructive evaluation of wood and, in particular, of the mechanical properties of wood, especially stiffness. A wide variety of acoustic tools are available. For this thesis the performance of Time of Flight (TOF) tools is the centre of interest, for they provide a way of assessing the properties of standing trees. The first chapter reviews previous research in wood quality and introduces the principles of acoustics in wood. In the second chapter a variety of tools are compared in initial tests on dry lumber to test their suitability for infield use and correspondence to static bending tests.

The objective of this study is threefold: to test for factors that could have an influence on the acoustic properties in trees, such as tree height, compression wood or stocking (Chapter 3), to test TOF tools for their suitability in the field to assess standing trees (Chapter 2, 4 and Appendices I to III); and to gain an insight into how the acoustic properties of outerwood relate to those of corewood and lumber (Chapter 4).

Standing trees of different ages and stockings are assessed with the Fakopp 2D (Chapter 3). Further studies are conducted in the laboratory with a variety of acoustic tools on lumber and logs (Chapter 2, 4 and Appendix I to III). Statistical analyses with t-Tests and regressions tests for correlations between acoustic velocity and other factors (Chapter 3). Further, statistical tests are used to test for correlations amongst those TOF tools and with the resonance tool WoodSpec (Chapter 2 and 4).

There are no correlations between the acoustic velocity of trees and stocking, tree height or diameter. There are possible correlations between acoustic velocity and tree age, knots and compression wood respectively but this requires further study (Chapter 3 and 4). Strong correlations are found between TreeTap and Fakopp 2D, which also show good correlations with WoodSpec (Chapter 2 and 4). Furthermore, correlations are found between the acoustic velocity of outerwood and corewood. Results of TOF tools on logs show good correlations to those gained on green and air-dry lumber (Chapter 4).

PHIPPS, Hilary L (2003)

Assessing the Success of Restoration Plantings at Cape Foulwind, New Zealand

Holcim (New Zealand) Ltd. Operate a quarry near Cape Foulwind, New Zealand. Quarrying operations have a dramatic effect on the environment. Consequently, the company has developed a restoration strategy that aims to mitigate the environmental and visual impacts of quarry operations. The objective of this study was to determine how successful the restoration plantings at Cape Foulwind have been to date. Achieving restoration success is dependent upon meeting the goals established for the restoration project. The specificity, appropriateness, and ease of measurement of these goals play a large part in determining the level to which restoration plantings can be deemed successful.

The six planted restoration study sites investigated (planted 3-22 years prior to this study) were compared with three forest remnant sites, acting as a reference. Determination of the level of restoration success involved investigation of both ecosystem structure and functional attributes. Vegetation composition, ground active invertebrates and various ecosystem attributes, including soil, litter depth and decomposition, and seed rain were investigated using numerous diversity indices and ordination techniques where appropriate.

The results of this study suggest that while complete success of these restoration plantings has not yet occurred, attributes necessary for initial success were present. Planted restoration sites were facilitating the entry of novel regenerating species. The current limiting factor to progression within the planted restoration study sites appears to be the lack of full canopy cover, and subsequent development of suitable microclimatic conditions. A large difference was apparent in composition and abundance of ground active invertebrate communities in planted restoration and remnant study sites. Of the environmental variables investigated, litter depth was found to be the key driver of invertebrate distribution over the nine study sites.

Holcim's restoration plantings at Cape Foulwind have successfully provided new habitat for native biodiversity, while facilitating development of ecosystem structure and functioning. Importantly, they are increasing the connectivity between the native forest remnants that are present, enhancing the aesthetic appeal of the quarry area.

PONT, David (2003)

A Model of Secondary Growth for Radiata Pine

A data set comprising detailed crown architecture and stem wood properties measurements obtained from a single tree was used to investigate the relationships between crown and stem growth, with the objective of developing a model of stem growth in terms of crown structure. Four hypotheses relating crown structure to stem growth, based on the theories of Pressler (in Assmann, 1970), Larson (1962b and 1969) and the pipe model (Shinozaki *et. al.* 1964) were tested.

Relationships obtained from analysis of crown architecture data were used to estimate past crown structure, in terms of foliage mass and average distance to foliage, at each age for the sample tree. The method of Duff and Nolan (1953 and 1957) was used to analyse ring area and basic density measurements taken from each annual ring at several positions along the stem. Analysis revealed three fundamental stem growth patterns, correlated with crown structure. The relationships identified between crown and stem growth were used to support the hypothesis that ring area is related to foliage mass, and to support the hypothesis that distance to foliage and foliage mass are related to basic density. Two hypotheses based on the pipe model, relating sapwood area to foliage mass, were found to apply within the crown only. Alternative hypotheses, including the length of the conductive path to foliage, accounted for changes in sapwood area within and below the crown.

The relationships established formed the basis of a model of secondary growth, comprising four equations, which estimates ring area increment and ring basic density at any point on the stem from foliage mass and average distance to foliage. The model is economical in structure and mathematical formulation and evaluation showed it predicts stem ring area and basic density consistent with well-known patterns. Definition of the model in terms of crown structure results in realistic responses to factors such as between-tree competition and thinning. The chosen modeling approach, linking crown and stem growth, is suitable for future development using data sets representing different site, silvicultural and genetic factors.

TABUKOVU, Maika (2003)

Marketing Study of Markets for Fijian Hardwood Species in New Zealand

This study investigates the potential for distributing Fijian hardwood species in New Zealand markets and how stakeholders would benefit from a marketing network providing a win-win situation. Fiji, a small nation with limited natural forest resources, needs to manufacture value-added wood products for export. This should result in increased financial return, creating employment opportunities, reducing the number and amount of native tree species being extracted and better natural forest management. Secondary data were collected about the Fiji Forest Industry (including timber exporters) and the New Zealand Forest Industry (including importers) to try to identify the five major Fijian hardwood species (Kauvala, Kaudamu, Dakua makadre, Dakua salusalu and Damanu) used in New Zealand. In conjunction with the interviews, primary data from survey questionnaires and a literature review, the following findings were obtained, analysed and discussed.

- i) **Fiji Forest Industry.** The present level of harvest from native forest is around 100 000 m³ per annum. If continued at that level, only 30 years of native forest logging remain. There are 45 native species being extracted at the present time without a proper marketing program in place for any of them individually. This puts a lot of pressure on native fauna and flora and has increased the chances of soil erosion, especially in a tropical country like Fiji, which receives heavy rainfall. Identifying the right markets and producing the right product when needed is important for the Fiji forest industry today and for the future. Fiji needs to make a serious effort to reduce the number of native tree species from being

extracted to sustain native forest ecosystems and for general environmental benefit. Sawmillers are being encouraged to increase the intake of exotic species like pine and mahogany. Ten major native species are well received in the export market, but more added value products from manufacturing finished products are needed. This would surely provide a large financial boost to the economy of Fiji. Sixty percent of the annual volume of native species extracted is from Vanua Levu, the second largest island. This arises because the only two plywood mills in the country are located on Vanua Levu. These two mills compete for the same species, namely Kouvula, Kaudamu, Dakua makadre, Dakua salusalu and Damanu, and produce the same products, namely veneer, plywood, blockboard and timber. Despite the presence of 23 other sawmills, these two plywood mills are also producing almost three quarters of the annual sawn outturn production. During the past five years Fiji has exported about 86 000 m³ a year, made up of the following product proportions: plywood (39%), sawn timber (32%), veneer (26%), blockboard (2%) and mouldings (0.4%). Increased demand for plywood and veneer from the two plywood mills has resulted in increased levels of harvest for native species and created more waste in timber yards. The Fiji wood products industry needs to do more remanufacturing mouldings and blockboard, as there are substantial market demands for these products. Mouldings are fetching the highest prices (averaging NZD2,000 to 15,000 per m³) particularly in the New Zealand market. Fiji exported only 1000 m³ of moulding in the past five years with the average value of FJD600 per m³. This clearly indicates the need for the Fiji Government to increase the volume of mouldings exported in the international markets especially New Zealand resulting in more job opportunities for the country. Also, producing high value products from prime species in Fiji will eventually reduce the environmental impact and increase the return to all stakeholders.

- ii) **Integration of Marketing Logistic Functions.** The nature of marketing is changing as competition among suppliers of tropical hardwoods into New Zealand is increasing. Companies have been forced to change their management techniques to capture and retain market share, while at the same time delivering the right product, at the right time, and at the right price for customers' satisfaction through tighter logistics and supply chain management. Fiji hardwood suppliers are having a big problem trying to fulfil customer demand. In part, this encourages New Zealand importers to source tropical hardwood products from

other countries. Providing an integrated logistics with a customer focus, and also reduced cycle time through partnership/alliance, sharing of information and creating value, should result in a competitive advantage for Fijian hardwoods in New Zealand markets. Forming a multi-national strategic alliance between suppliers and importers should be an advantage to small suppliers of these Fijian hardwoods in particular. Establishing a main distributing centre strategy in New Zealand is probably one of the best alternatives. The centre should be based in Auckland and market Fijian hardwood species throughout New Zealand, but at the same time there should be an office in Christchurch for markets in the South Island. The next step would be to have a full marketing study in Fiji looking at the industry and then working towards implementation of the market research findings on a wider scale.

- iii) **Certification and Country Image.** Forest certification (FSC) for Fiji timber products is perhaps another way forward for Fiji, since its native forest resource is diminishing at present and should be managed on sustainable basis. Identifying niche markets that earn as high a financial return as possible is of paramount importance. Certification may open up better niche market opportunities for these hardwoods as customers do not apparently worry about paying a high price as long as the product is certified. Certification might also provide a positive country image for Fiji in other product areas, if its forests are known to be being managed sustainably. New Zealand is an environmentally conscious country and certified products should boost the sale of Fijian products in New Zealand. Most New Zealand wood importers are willing to buy certified products for their public image and customer requirements. The numbers of customers buying only certified tropical hardwoods are growing, and these are the customers Fiji should target.
- iv) **New Zealand Target Markets.** There are exciting prospects in high value markets for Fijian hardwoods in New Zealand. Fiji should target markets interested in certified products (FSC) focusing on substitutes for high-value New Zealand rimu products, such as *Dakua salusalu* and *Kaudamu* used in mouldings, joinery, furniture, flooring and manufacturing. The Fiji firms are small but they can produce high-value products to serve the high end of the market. The Do-It-Yourself (DIY) market is also another option for distributing Fijian hardwoods. To meet the challenges, Fiji needs to foster an innovative industry that continues to work in cooperation with, and is supported by a more highly skilled workforce,

has improved manufacturing technology and quality controls, and effective market development programmes. Fijian hardwood products should be aiming at the high end of the DIY market where customers are willing to pay higher prices for product solutions. Fiji hardwood products should focus on a market niche strategy based on concentrating on a narrow buyer segment and out-competing rivals by offering niche members customized attributes that meet their tastes and requirements versus rival products. Five species are well received on the New Zealand market, but Dakua salusalu is in greatest demand because it is a substitute species for rimu. Apart from Kauri which is dominant in picture frames the other four species could produce more than 13 different high-value wood products made out of Fijian hardwoods that are wanted on the New Zealand market. Fiji's suppliers should realise that New Zealand is a high quality market and that they should produce quality products for customers that are willing to pay high prices.

- v) **Position Strategy.** Fijian hardwoods are stable, easy to work with and have beautiful colours (both sapwood and heartwood) that are similar to rimu, kauri, maple, red cedar and whitewood. There are 27 countries supplying tropical hardwoods into New Zealand. Fiji, therefore, should be actively in marketing their products there, using “push and pull strategies” with strategic partners to make them competitive in the market. Customers should be told these products are the best substitutes for products made up of New Zealand's native species and that they are readily available in any major timber-distributing centre, such as PlaceMakers, around the country. The species, if properly manufactured and applied, produce long-lasting, beautiful, natural wood colours that suit the taste of New Zealand customers and which are derived from forests under sustainable management.
- vi) **Marketing Mix Strategies (product, place, price and promotion).** Moulding products are producing the highest financial return to manufacturers and distributors, followed by flooring, furniture and picture frames. About 36 different moulding designs produced from Dakua salusalu and Dakua makadre indicate the sale potential of these species in New Zealand markets now that New Zealand's supply of native timber is rapidly dwindling. Auckland is the best distributing centre, because of its location and population growth. Transporting the products to other cities and regions can be easily achieved by a combination of road, rail, sea and air. It is important that the centre cooperates closely with the Fiji supplier

and has ample stock on hand to be able to supply any product at all times when needed by the customers. Major regions on which to concentrate marketing activities are Tauranga, Nelson and Tasman, where the population growth is greater. Because these Fijian hardwood species are substitutes for New Zealand native species, the pricing should be close to that of rimu or slightly less to be competitive. The present average price charged by Fiji's suppliers is NZD950/m³ (green sawn) and NZD1,500/m³ (kiln dried rough sawn). When processed and sold to distributors, the average wholesale price for finished products is NZD4,000/m³, which rises to NZD8,000/m³ (retailed price) when sold to final customers. The mark-up price is around 600 per cent. This value chain example demonstrates the potential for selling Fijian products when they are well presented in the marketplace. It also indicates that some of the margin appreciation might be shared with the producers and forest owners if properly organised distribution was developed. All the species already have popular New Zealand brand names, like Pacific Sap Rimu (*Dakua salusalu*), Pacific maple (*Kaudamu*), Pacific Kauri (*Dakua makadre*), Pacific Calyphyllum (*Damanu*), Pacific Whitewood Species (*Kauvula*). These Fijian hardwood species also have significant market opportunities in other neighbouring countries like Australia, where Fiji should also be actively marketing its wood products. Having identified the niche at the to-end of the market, the Fiji industry should be setting up a better marketing network and strategic alliances to create a better economic future for the industry and the country as a whole.

THEINHARDT, Nerida (2003)

Plant Restoration at an Open Cast Coal Mine, West Coast – New Zealand

This study assessed the success of planting trials testing different techniques for plant restoration at the high elevation Stockton open-case coal mine, South Island, New Zealand (owned by Solid Energy New Zealand Ltd). Mining over the past 100 years has resulted in a series of large overburden dumps that are devoid of vegetation. The extreme environmental factors (high altitude, high rainfall, fog, low temperatures, frost and acidic substrates) make plant restoration difficult. The final status of the land once mining has ceased is most likely to be public conservation land and the goal of restoration is, therefore, towards indigenous woody vegetation. However, there is little experimental data available on the best techniques for restoration in this

environment. This study took advantage of a number of trials established over the last ten years to quantify the performance of different treatments on plant establishment and growth (substrate type, landform and fertiliser), and of different planted species.

For those species with sufficient replication, the results highlighted the value of fertiliser addition together with substrate and landform in enhancing plant growth. Generally, at the Stockton mine site the addition of fertiliser had no significant effect on plant growth for species planted on soil. In contrast, there was a high response to fertiliser addition, for restoration planting established on quarry rock or sandstone (overburden material). The best growth occurred on sites with soil used as a growing medium and on hummocky landform.

Recommendations were made in order to provide guidelines for the establishment of future restoration trials. We recommend:

- Where there was insufficient soil to be used as growing medium, fertiliser addition together with sandstone or quarry rock, especially on hummocky sites, showed greater value in enhancing plant growth.
- Tall grassy herbs, toetoe and mountain flax were the best performing restoration species. Further it is recommended that the value of manuka and shrub tutu for restoration be investigated.

Finally, this study has shown the importance of ensuring that sufficient replication is included in restoration trial planning, to enable statistically precise conclusions to be drawn from the experimental treatments.

THOMPSON, Karl M (2003)

Market Access for New Zealand Silver Beech (*Nothofagus menziesii*) in Europe

This study investigates the potential of NZ silver beech (*Nothofagus menziesii*) in solid wood and veneer product forms to access European hardwood markets. The focus market segments being high-value applications such as furniture, joinery, flooring and other high value appearance grade finished wood products. The study also indicates the market potential of other promising NZ hardwoods such as red beech (*Nothofagus fusca*) and hard beech (*Nothofagus truncata*). Analysis and interpretation of field interviews from a sample of German, Flemish, Dutch, Italian, Spanish, Scandinavian and United Kingdom (UK) importers, agents, retailers, manufacturers,

industry experts and academics in conjunction with a review of secondary literature and personal observations have identified the following:

- i) **Forest Stewardship Council (FSC) certification:** FSC silver beech products provide a competitive advantage in terms of market access to specific specialized niche markets in Europe. Independent third-party certification is expected to be a market access requirement in the UK in two to three years. Exporters of FSC silver beech product can expect 5% premiums. Certified Wood Products (CWP) demand is growing as the global certified resource continues to expand. The CWP market segment continues to gain momentum in the UK, Netherlands, Germany, Belgium and Switzerland with re-export based markets now present in Spain and Italy. The cost effectiveness of the NZ industry pursuing FSC remains a debatable issue (dependent upon supply elasticity). However, it will be a key product attribute if NZ exporters wish to enter and retain key high-end European markets. Seventy-two percent of respondents recommended that NZ exporters pursue FSC certification as a beneficial means to market entry.
- ii) **Market Positioning:** Silver beech is confused with European beech (*Fagus sylvatica*), though not considered to be of the same quality. Most buyers based comparisons of the heartwood silver beech product samples against North American cherry (*Prunus serotina*), Russian birch (*Betula pendula*), East European and North American red alder (*Alnus rubra*), and Chilean lenga (*Nothofagus pumilio*). Silver beech rated higher than the common substitutes. As a temperate quality hardwood, silver beech without marketing and market development, fits the present day European Union (EU) demand for a pale-coloured, medium density, utility hardwood.
- iii) **Branding:** To avoid confusion with European beech and lower price impacts, silver beech products must be differentiated. This is more prevalent on the continent. The strong recommendation from this study is to change the name to a distinctive NZ brand name for a high quality hardwood, which has been tested for suitability in the destination markets.
- iv) **Starting Point:** Market entry recommended for silver beech is into the UK via an inventory holder/distributor. Timbmet is likely to be the best option, with certain reservations; they suggest starting at the soft maple (*Acer rubrum*) position (US\$800 per m³ CIF, 4/4 dressing/FAS grade). End-user demand must be assured via a six to nine month trial and test period with key joinery clients. This suggests

exporting at or above current domestic mill prices with premiums for speciality items (+200 mm widths, specific thicknesses for turning squares, and colour separation for sapwood).

Silver beech entry possibilities in the continental EU markets are in small niche high-end applications (fine furniture). On the continent remanufactured products (stairso and Swiss pear (*Pyrus communis*) substitute flooring are opportunities to upgrade low quality and for short lengths; with competitive pricing at US\$1000 per m³ CIF. The sliced veneer product was viewed as interesting by respondents if it was FSC-certified.

- v) **Product Development:** Trade show attendance is recommended on the continent, where NZ exporters can build a new image for silver beech based on higher quality specifications (colour grading, wide widths) to achieve premium northern temperate hardwood positioning in Europe. Availability of both high quality FSC and SFM resources should be emphasised. Supply availability of super high quality, colour-sorted silver beech is limited, therefore the lower grades need upgrading.

Research is needed for value-added product options and hence exporter's capabilities, particularly where FSC resources are involved and higher premiums are possible. Finished product designed to destination market fashion was suggested by an Italian eco retailer, for which they were interested. Further research is needed in the area of product extensions such as second rotation silver beech being positioned at the "white" soft/hard maple (*Acer saccharum*) level. A follow-on recommendation is to take a similar marketing approach as the North Americans with their temperate hardwoods, where all species promotion is done under the same organization, the American Hardwood Export Council (AHEC).

- vi) **Opportunities Identified:** Table 12, in section 7.5 summarises the key opportunity identified during field work for NZ exporters assessing the benefits of accessing EU markets.

TSANG, Kenneth KF (2003)

The Changing Chinese Wood Products Consumer: opportunities and challenges for the NZ forestry sector

The Chinese wood products market represents a significant opportunity for the New Zealand forestry sector, especially in the coniferous roundwood and sawn timber market. Despite the Sino-Russian agreement on wood products trade, which allows Russian suppliers have to only pay half of the normal value-added tax for their exports to China, New Zealand wood products still show competitiveness in the coniferous wood products market. However, lack of warehousing facilities and subsidiaries in China limit New Zealand's ability to access many small domestic industrial wood consumers. In addition, the exclusion of New Zealand pine from the current Chinese building and fire codes, prevents the use of New Zealand pine for wood framed residential housing. Moreover, the use of coniferous timber species is still not widely accepted in the domestic market in relation to the housing construction, interior decoration, and furniture sectors.

In order to promote New Zealand pine effectively, this study found that "*Price*" and "*Environmental Issues*" are the most important factors which will influence the Chinese industrial wood consumers to adopt a new wood-based product. Most respondents in this study indicate that the general managers and plant managers are final decision-makers in adopting a new wood product. Wood consumption behaviour of the industrial wood consumers varies by sector. Most respondents indicate that they are dependent on the domestic Chinese importers as their main sources of supply.

It had previously been found that the apparent consumption per capita of most wood-based panel products increase as the real GDP increases in an international market. This study does not have any statistical evidence to show whether the apparent consumption per capita of industrial roundwood and sawnwood increases with the Chinese real GDP. Furthermore, the apparent consumption of most wood products tends to be inelastic with respect to the adjusted average import and export prices. Other macroenvironmental drivers are likely to influence the demand of wood products in China.

BASCUNAN ALDUNATE, Arturo (2004)

The Influence of Wind on Radiata Pine Tree Shape and Wood Stiffness

This thesis explores the effects of wind on radiata pine (*Pinus radiata*) tree shape and wood stiffness, from the edge to the interior of a stand. The objective of the thesis is to detect, prior to felling, low stiffness trees or areas in a stand that due to wind will yield poor recovery of stiff lumber. The first three chapters review previous research. The first chapter focuses on the wood quality of radiata pine with special attention to stiffness, its causes and consequences. The second chapter introduces the principles of acoustic tools and how the forestry industry can use these to segregate raw material according to differences in wood quality. The third chapter describes the stress due to wind over a stand and how trees adapt internally and externally to wind.

The next three chapters describe studies that were conducted in four narrow shelterbelts of radiata pine aligned perpendicular to the north-west winds. The chosen stands comprised three different age classes and two wind environments. At each stand, 30 transects were placed across the stand. At each transect, 20 trees were selected from the windward to the leeward edge of the stand. The outerwood stiffness of 2260 standing trees was assessed with the TreeTap acoustic tool. Results showed that stiffness and tree height increases with distance from the stand edge, while taper is reduced. The negative effect of wind on wood stiffness extends into the stand for a distance equivalent to one average tree height from both stand edges regardless of the age or location of the stand. The poorest trees were those located at the edges of the stand. High differences in outerwood stiffness between both sides of the stem were found, which increased with tree age and tree lean. A relationship could not be found between tree spacing to neighbours and tree outerwood stiffness.

Knowledge of these low stiffness areas inside a stand will permit forest managers to develop different strategies to manage the variability in wood quality arising from wind. Future research might consider a sawmill study and further developing the methods utilized in this study in stands containing clonal trees.

HEBERLING GIUDICE, Monica (2004)

Strategic Marketing for Uruguayan Eucalyptus and Wood Products

Uruguay is a relatively small country by international standards both in land area and in population. In the late 1980s, the government of Uruguay decided to establish plantation forestry and to provide for new industry business development, with rural employment opportunities. An incentive programme was established to subsidise planting costs and a future commitment made to importing processing equipment with duty exemptions.

The planting programme has been successful. Today there are 616 000 hectares planted, of which 424 000 are *Eucalyptus* forests. But Uruguay has had no forestry culture. The issue is one of looking at future projections and anticipating future requirements for developing markets and marketing programmes, a missing ingredient in the current programmes.

This study addresses the situation in the Northern Department of Rivera. Here there has been highly intensive management implemented to *Eucalyptus grandis*. The questions concern availability and likely product-markets for a lesser-known hardwood species. The issues are how to access these markets and achieve value for new hardwood products. There is some experience developing with plantation *Eucalyptus* but only for the largest international marketer, Weyerhaeuser. This questions the need to review the market opportunities for landowners growing solidwood *Eucalyptus* to avoid a commodity approach selling into SE Asia.

The identified value-adding product opportunities include furniture and flooring. The species attributes are shown to meet product-market requirements in international markets. General hardwood trends are identified which support more hardwood production and sustainable products from plantations. Recommendations are offered for market positioning and branding Uruguayan *Eucalyptus* products. Two parallel New Zealand case studies are cited in support of the recommendations. The question is one of raising the sights to achieve market objectives early on and developing a national, industry and company approach to achieve these objectives. This requires both investment and commitment.

DOWDLE, Leslie R (2005)

Network Analysis of Log Truck Transportation on Southland's Public Roads using GIS

A network analysis of log truck transportation on public roads was conducted to develop a system to aid planners and policy makers concerned with road use by the forest sector in the Southland region of New Zealand. The availability of wood from planted production forests within Southland is forecast to double over the next 20 years. As most logs are transported to mill or port by truck the substantial increase of wood volume will impose unprecedented pressure on the public road network and industrial and governmental issues are arising over who should pay for increasing road costs. Targeted rating options for roads which could negatively impact on the economic strength of the regions' forest industry are being explored by the Southland District Council (SDC).

A system which identifies where the impacts imposed by log truck traffic are going to become severe is the first step to resolve these funding issues. The transportation Geographic Information System (GIS) software package TransCAD was used to determine log truck distribution patterns in Southland by viewing the forest transportation operation on public roads in the context of network models on a GIS platform. Improved knowledge of the distribution of log truck traffic in Southland should facilitate the development of improved funding mechanisms to upgrade, rehabilitate or maintain the public road network.

Forest resource transportation studies have found that possible changes in transportation flow patterns serve as a basis for improving the basic distribution cost structures for the forest industry. Large-scale savings could be realised by optimising Southland's pattern of wood supply on a regional basis. A new initiative which decreases distribution costs could create a competitive advantage for Southland's forest owners as a whole with the mutual benefit of increased efficiency of public road network use by log truck traffic.

LASSERRE, Jean Pierre (2005)

Influence of Initial Stand Spacing and Genotype on *Pinus radiata* Corewood Properties

The effect of silvicultural practices on wood quality is an important issue for the production forestry sector. The overall aims of this thesis are (i) to investigate the utility of acoustic instruments for measuring MOE, (ii) to assess the influence of bark and branch removal on whole stem MOE and (iii) to determine the effect of the initial spacing and genotype on the corewood properties of *Pinus radiata*. The results presented in this thesis were taken from two spatially separated genotype by spacing experiments located in Canterbury, New Zealand.

Both branch and bark removal significantly influenced whole stem MOE measured by resonance (MOE_{res}), increasing values by on average 8.3% and 5.4%, respectively. The influence of bark on MOE_{res} was relatively constant across the MOE range examined, ranging from 8.0% at low rates of MOE_{res} (2.6 GPa) to 8.6% at high values of MOE_{res} (5.5 GPa), with bark. In contrast, increases in MOE_{res} induced by branch removal ranged from 24% at low values of MOE_{res} (3.4 GPa) to 0% at high values of MOE_{res} (6.5 GPa), with branches.

There were strong positive linear relationships between outerwood MOE measured by time of flight (MOE_{tof}) and whole stem MOE measured by resonance (MOE_{res}), both when bark was present ($r^2 = 0.94$) and removed ($r^2 = 0.92$), from the whole stem. Although stand spacing and tree diameter did not significantly influence these equations the relationship between MOE_{tof} and MOE_{res} logs with bark attached was significantly influenced by clone. The percentage of stems correctly reallocated by time of flight back to whole log MOE classes (high, medium and low), was significant and high, averaging 80% across the three classes. These results highlight the utility of MOE_{tof} measurements on standing trees in predicting whole stem MOE_{res} , and also suggest that it is important to account for the effect of bark and branches when measuring whole stem MOE using acoustic methods.

In the second part of this thesis the influence of genotype and initial spacing on corewood was determined on standing trees over the lower stem (0.2 to 2.0 m) of 135 trees. These trees were from two adjacent sub-experiments of the same age which comprised 10 different clones installed at three initial spacings of 833, 1250 and 2500 stem ha^{-1} . Values of MOE_{tof} significantly varied between all spacing levels studied, with values of MOE_{tof} across clones ranging from 5.9 GPa at close spacing

(2 500 stems ha⁻¹). Although MOE significantly differed between clones ($P < 0.01$) the clonal influence on MOE_{tof} was lower than that of spacing, with values ranging by on average 1.3 GPa (cf. 1.8 GPa for spacing) between the two clones representing the MOE_{tof} extremes. No significant interaction ($P > 0.05$) was found between clone and spacing level. Tree diameter exhibited a significant ($P < 0.01$, $r^2 = 0.5$) negative correlation with MOE_{tof}. After the influence of diameter had been accounted for, spacing still had a significant ($P < 0.01$) positive influence on MOE_{tof}.

In the third part of this thesis two new genetic populations were measured and incorporated into the analysis explained in the second part. In total three contrasting genetic populations (GF1, GF27 and clonal) grown at two spacings (833 and 2500 stems ha⁻¹) were studied. MOE was significantly influenced by planting spacing and genetic population. Planting spacing had the largest influence on MOE_{tof}, with values in the closely spaced plots exceeding values in the wide spacing plots by on average 1.7 GPa or 34%. Gains in MOE_{tof} attributable to genetics averaged 0.8 GPa or 15%. MOE_{tof} was not significantly influenced by the interaction between planting spacing and genetic population. There was a significant ($P < 0.01$) negative relationship between tree diameter at breast height (dbh) and MOE_{tof} for the clones, GF27 and GF1, respectively. Although correction for variation in dbh reduced variation in MOE, residual variations in MOE_{tof} between planting spacings and genetic population were still significant after the effect of dbh had been removed.

The fourth part of this thesis investigated the influence of genotype and spacing across two spatially separated experiments in Canterbury. Planting spacing had a highly significant influence on MOE_{tof} with values in the close stand spacing plots exceeding values in the wide stand spacing plots by 37% (1.8 GPa) at site 1 and 31% (1.5 GPa) at site 2. Gains in MOE_{tof} attributable to genotype were highly significant and averaged 0.9 GPa or 18%, across sites. There was a highly significant interaction between genotype and site, which was due to rank changes in MOE_{tof} between sites for the two stiffest genotypes. Although significant, the interaction between genotype and stand spacing was relatively weak, compared to other effects.

Diameter at breast height exhibited a highly significant moderate ($r^2 = 0.47$) negative relationship with MOE_{tof}. However inclusion of dbh as a covariate did not account for the significant main or interactive treatment effects on MOE_{tof}. The consistency of findings between these two spatially separated sites highlights the importance of initial stand spacing in regulation MOE_{tof}.

The final part of this thesis investigates the effect of initial planting spacing on anatomical and mechanical properties of the corewood. Measurements were taken from 30 trees at Dalethorpe selected from 6 genotypes chosen from the two extreme initial planting spacings (833 and 2500 stems ha⁻¹). Results indicate that initial planting spacing significantly influenced six of the eight wood properties studied (dbh is excluded since it is not considered wood property). When averaged across years, lower initial planting spacing significantly reduced values for MFA (-18%) and ring width (-61%), and significantly increased MOE_{res} (+27), fibre length (+10%), latewood percentage (+17%), and cell wall thickness (+28%). Basic density and fibre width were not significantly different between spacings exhibiting treatment variation of 1% for both properties. In contrast to initial stand spacing genotype had a relatively small influence on wood properties and only significantly influenced MOE_{res}, MFA and ring width.

Tree dbh exhibited significant correlations with all the variables with the exception of fibre width and basic density. MFA exhibited highly significant correlations with fibre length, ring width, MOE and dbh. Significant although less strong correlations were found between MFA and cell wall thickness and latewood percentage. MOE_{res} exhibited highly significant correlations with MFA, fibre length, cell wall thickness and ring width.

SILCOCK, Paul (2005)

Non Destructive Evaluation of *Nothofagus fusca* (Red Beech) Properties within the North West Coast of the South Island, New Zealand

This study is comprised of two major research objectives: 1) to quantify the incidence and proportion of defect in beech forests and explore the efficacy of applying defect detecting technology to natural forest management; and 2) to identify and assess those physical and mechanical wood properties of red beech that influence wood quality and forest operations from two sites (Howard Valley and Woolly River) managed by Forever Beech Ltd.

Overall there is a significant incidence of defect (56%) in standing red beech and a low stem-to-timber conversion rate (40%). An acoustic tomographic tool, Fakopp 2D, can be used to detect the presence of internal defect in standing trees, although the software used in this study was not able to consistently predict the location or volume of defect, it was a cumbersome instrument to use in the forest and data collection

was a slow process. No case could be made for incorporating this technology in beech forest management practice.

Four wood quality properties were used to assess beech forest in the NW coast of New Zealand. **Basic density** and **hardness** are measures of wood quality and quantity on which many end-use and customer specifications are based. **Green density** is a measure of wood quantity which is used in forest operations to determine log bucking patterns for heli-lifting. The green **dynamic modulus of elasticity** (MOE) is another useful measure of wood quality, assessed using the TOF instrument – TreeTap. Measuring stress wave velocity (SWV) in standing reed beech using time of flight (TOF) instruments provides a means to evaluate wood quality prior to harvesting.

Forests of the North West (NW) Coast of the South Island were found to have low average basic density in comparison to average national values. Basic density and associated wood properties exhibited greater variation between trees than between sites. Trees sampled in the Woolly River site had higher basic density, green density, MOE and hardness values than those growing in the Howard Valley. The trees of Woolly River also exhibited higher growth rates and a lower incidence of defect. All assessed wood properties of red beech decreased with altitude. MOE increased with increasing growth rate. These data provided for customer specifications and the operations and management of Forever Beech Ltd. The advantages of using MOE as a measure of timber quality are discussed.

SUSAETA LARRAIN, Andres I (2005)

Comparative Analysis of the Discounted Cash Flow Approach and Option Pricing Theory for Forest Valuation: a Chilean case study

Forest valuation is an important process when it comes to making decisions for forestry investment. Different approaches have been developed to value forests, the Faustmann approach (NPV) being one of the most commonly used. The Option Pricing (OP) approach is an alternative approach that has been proposed but not commonly used in practice. The main aims of this study are to compare these two approaches, analyse their differences and identify their most relevant variables. A Chilean forest estate of 100 000 ha was used as a case study.

A key input to both approaches is future log prices. Prices were forecast for this study using a Chilean log prices time series for 1983-2002. In addition, the same time series

was used to calculate the historical volatility, another important input of the OP approach.

One of the conditions of the time series in order for it to be statistically reliable is that it has to be stationary. This means that the mean, variance, and covariance do not change over time; the condition of stationarity is needed to obtain an accurate forecast. Chilean log prices were first difference stationary. The Box and Jenkins approach was used to determine the model (ARMA models) to forecast log prices. The models chosen for pulplog, sawlog and pruned log prices were ARIMA(0,1,1) (no intercept) obtaining prices of US\$17/m³, US\$38/m³ and US\$82/m³. Despite the model predicting constant prices over time, stationarity was achieved.

In the case of the OP approach, prices are supposed to follow a Geometric Brownian motion (GBM). This means that log ratios between prices have to be normally distributed and independent from past values. Pulplog prices followed a GBM. Sawlog and pruned log prices showed independent from past prices but the normality was not clearly achieved.

The OP approach provided similar values to the NPV approach at a forest estate level. In fact just a difference of 3.7% was found between the Forest Option Value (US\$643 million, FOV) and the Forest Expectation Value (US\$619 million, FEV). For both approaches, in the case study, the discount rate and the harvest cost were the more sensitive variables. The NPV approach was more sensitive than the OP approach when the discount rate and the harvest cost were changed.

The OP approach generally gives higher values than the NPV approach. The main factors that determine the difference between FOV and FEV are the level of historical price volatility, harvest cost and the intensity of silviculture. When volatility was increased to 20% for pulplog and sawlog prices and 10% for pruned log prices, differences in value were over 30% between FOV and FEV. When the harvest cost was increased by 20%, the difference was over 14%. Thus, there was a threshold, above which the OP approach started to provide considerably higher values than the NPV approach.

In the Intensive Management regime the difference between FOV and FEV was low (around 1.5%). When the silvicultural treatment was changed (to Extensive Management), the difference reached approximately 30%. The relatively low volatility of pruned logs, produced under Intensive Management, appears to be the cause of the small difference between FOV and FEV for the Intensive Management regime.

When a stochastic component (prices) is added to forest valuation, values tend to be higher than using deterministic prices. The OP approach incorporates price volatility, there forest values are usually higher than the for NPV approach. However, for this case study, similar results were obtained for both the NPV and OP approach, because of the low level of volatility used.

JAY, Julien PA (2006)

Modeling the Germination of *Buddleia davidii* under Constant Conditions with the Hydrothermal Time Concept

Buddleia davidii is a weed naturalised in New Zealand. It invades radiata pine plantations and causes major growth reduction and economic losses. Modeling its germination for predicting its occurrence will help foresters minimise its influence in forest plantations. Germination experiments have been carried out in laboratory to assess the influence of seed origin, defoliation, temperature and water stress on germination.

Defoliation treatments did not significantly affect germination. The pattern of germination for seeds from four different places within New Zealand revealed so little difference that there is no need to define different models according to the site considered. However, this similarity in germination pattern is limited to New Zealand and cannot be generalised to other countries where germination appears to be significantly different.

The germination of *Buddleia davidii* seed appeared to be a function of hydrothermal time. The base, optimum and ceiling temperatures for *Buddleia* are respectively 9, 25 and from 30 – 35°C, and *Buddleia* seed germinate between – and approximately -6 bars.

In constant conditions, the predicted germination for *Buddleia davidii* with the thermal time model was limited to sub-optimal temperatures and the hydrotime and hydrothermal time models described well the germination pattern at any temperature and water potential. The modified hydrothermal time model proposed by Alvarado and Bradford (2002) most accurately predicted germination although it tended to overestimate the asymptotes.

Overall the hydrothermal time model allowed prediction of actual timing of germination with much accuracy. This threshold model can therefore be used for modeling the germination of *Buddleia davidii* subjected to constant temperature and water potential conditions.

Master of Forestry Science Reports

McKENZIE, Timothy M (2004)

Integration of GPS, GIS and Remote Sensing to Facilitate Explicit Red Deer-Resource Interactions in the Canterbury High Country of New Zealand

A case study investigation involving the use of Global Position System (GPS) collars attached to red deer (*Cervus elaphus*) was conducted at Craigieburn Station, in the Canterbury high country, to demonstrate explicit animal-resource use and illustrate the benefits of GPS collars for defining wildlife ecology complexes. Resource utilisation was facilitated by categorising spectral components of various vegetation matrices from satellite imagery of the study site. Integration of GPS fix data and satellite imagery was performed in Arc View Geographic Information System (GIS) to draw accurate inferences from spatially explicit data.

Home range analysis using minimum convex polygon (MCP) analysis indicated range areas of 4742 hectares for red deer stag and 3047 hectares for red deer spiker. Range lengths were 10.695 kilometres and 8.385 kilometres respectively. Kernel home range estimates at 95% confidence reduced these home ranges to 453.99 hectares for the red deer stag, and 132.53 hectares for red deer spiker. Home range overlap existed between study animals. Overall movement between fixes indicated that red deer stag travelled 492.5 kilometres and red deer spiker travelled 334.45 kilometres. Increases in movement by month, corresponds with increasing vegetation abundance with the upcoming spring. Maximum movement between fixes (160 minutes) for red deer stag was 3.115 kilometres and 4.21 kilometres for red deer spiker.

Resource selection was variable between study animals, by month, and diurnally and nocturnally; with deer utilising areas offering cover diurnally (beech forest, high scrub) and selecting open areas offering highly palatable vegetation at night (tussock/grassland, improved grassland and low scrub). Preference indices of resource selection also indicated differences between study animals. Red deer stag had preference for improved grassland (0.467), tussock grassland (0.236), scrub tussock (0.274) and low scrub (0.196). Red deer spiker indicated preference for tussock grassland (0.104), high scrub (0.039) and beech forest (0.023).

Because introduced wildlife has ecological, emotional and cultural dimensions; unbiased biological data of such accuracy and precision will be of profound benefit to facilitate the understanding of introduced animal-resource use, and aid acceptance of management operations by the public.

MARTANA, Kadim (2004)**Assessing Decision-Makers' Perceived Preferences to Plantation Establishment in Indonesia**

This study tests the potential application of a hybrid method between the Analytic Hierarchy Process and a popular decision analysis – SWOT Analysis, to assess decision-makers' perceived preferences to plantation forest in Indonesia. In order to be able to carry out the assessment, a set of scenarios for developing plantation forest is constructed accompanied by their descriptive consequences.

In the study, the use of SWOT analysis as a qualitative tool to analyse the internal and external environment of plantation establishment is efficiently enhanced, by integrating AHP into the analysis. The AHP's benefits such as simplicity, effectiveness, and the ability to handle both qualitative and quantitative criteria are complementary with the SWOT analysis. The AHP also makes SWOT factors commensurable for further quantitative analysis.

The report commences with a brief of current plantation forest in Indonesia and the objective of the study. A literature review, a SWOT analysis of plantation establishment in Indonesia, and methods to analyse group preferences are then presented. Processes to derive decision-makers' preferences are then employed. Three variations of the AHP are tested: aggregation of individual judgements, aggregation of individual priorities, and the inclusion of decision-makers as elements in the hierarchy. Results are then interpreted and a comparison of the three methods is made. Possible application of the hybrid method is also discussed. Finally, a conclusion and recommendation is provided as a closing remark.

WHITE, Antony J (2005)**Regeneration in Natural and Single Tree Selection Harvest Gaps in Saltwater Forest, south Westland**

Natural canopy gaps created by single and group tree falls in windthrown rimu (*Dacrydium cupressinum*) are a key ecological process in the Saltwater Forest, south Westland, one which natural forest management has sought to emulate. To determine the effect of anthropogenic disturbance on regeneration, 22 natural gaps of known age (11 aged 3-5 years and 11 aged 6-8 years) were sampled and compared to 22 harvest gaps of known age (11 aged 4 years and 11 aged 7 years). Species abundance and cover

abundance were recorded in the area surrounding the central zone of disturbance in each gap.

Examination of the expanded gap areas showed that harvest gaps were significantly larger than natural gaps, although overall these would be classed as small gaps. Species richness (number of species per gap) for total species, woody species and the fern and herbaceous species in gaps by type, age and type*age interaction were not significantly different. Using the cover abundance values for all species, ordination by detrended correspondence analysis indicated little floristic difference between gap type or age. Using the mean species abundance for the 18 most common woody species and mean cover abundance for vegetative variables: moss and liverwort, litter, and exposed soil, a canonical discriminant analysis, however, showed a significant age effect between natural and harvest gaps. Natural gaps aged 3-5 years compared to harvest gaps aged 4 years, showed distinct separation, however, both natural and harvest gaps converge with increasing age. In the younger natural gaps, pepperwood (*Pseudowintera colorata*) is more abundant than in harvest gaps of the same age, while the converse is the case for litter. Overall kamahi (*Weinmannia racemosa*) was the most abundant species in gaps.

Despite the difference in the mean area of natural and harvest gaps, the extraction of single rimu trees by helicopter, as was practised in this forest, did not appear to be changing species composition or negatively impacting on species presence in the short-term. Although a harvest process that emulates small-scale tree falls (natural gaps), this did not appear to be conducive for rimu regeneration as few regenerating rimu were recorded.

Master of Science (Environmental Studies) Theses

LEIGHTON, Amy L (2003)

An Investigation of the Issues Surrounding Biodiversity Conservation on Private Land: a Banks Peninsula case study

This thesis has examined the issues surrounding biodiversity conservation on private land in the Banks Peninsula district. The negative community reaction to the proposed Banks Peninsula District Plan and the Rural Task Force process that resulted from this provide the context for the research. Due to the multifaceted nature of the issue an interdisciplinary research approach was adopted, which involved two tiers of investigation. The aim of the research was to identify suitable mechanisms to achieve positive outcomes for biodiversity conservation on private land.

Nine Recommended Areas for Protection were selected as study sites with assistance from the Banks Peninsula Conservation Trust. Each site was visited and the current ecological values, threats to these values and landscape context were evaluated. Following this the landholder(s) at each site were interviewed to gain an understanding of their land management practices, conservation beliefs and values associated with natural areas on their land. A major finding of these inquiries was that areas identified as ecologically significant often have key roles in the farm environment (such as shelter and grazing), which results in conflicting values between land users and those concerned with the preservation of indigenous biodiversity. However, many of the landholders included in my research were willing to be involved in conservation initiatives to protect indigenous biodiversity on their properties if financial assistance was more readily available.

Seven key stakeholder groups involved in the Banks Peninsula district planning process were included in my research. Interviews were conducted with a key representative from each group to gain an understanding of the wide ranging perspectives and attitudes towards biodiversity conservation and land use practices on private land. The research identified a number of key differences and similarities between stakeholders attitudes and perspectives in relation to the perceived threats to biodiversity on private land and their support for various mechanisms for protection (such as the use of rules and regulations governing land use activities).

The research concludes that achieving positive outcomes for conservation on private land requires ongoing and open communication within and between stakeholder groups and landholders. Education and the provision of information is important, while time and financial resources are essential for facilitating two-way

communication and to fund initiatives to protect indigenous biodiversity on private land. Leadership and support from local authorities in conjunction with non-government organisations was found to be necessary to encourage efforts 'on the ground' and to demonstrate that successful outcomes for biodiversity conservation on private land can occur with collaboration and community involvement.

BROWN-SANTIRSO, Martin M (2005)

Sustainable Development Indicators: an alternative systems based framework for conceptualisation and analysis applied to a Christchurch study

Amid the ever-increasing hype about Sustainable Development, Global Climate Change and environmental deterioration, there has been an ever-increasing number of attempts at assessing humanity's development and its relationship to the natural environment. These attempts, however useful in their own way, fall short of representing all the variables and relationships of the immense complexity that is Sustainability. This thesis represents a contribution to the currently available assessment methods.

Several authors coincide in their comments regarding the current official systems to assess Sustainable Development. Summarised in the words of John Peet, this information "is generally fragmented, often parochial, missing vital information and lacking an overall organising framework". The commonly used pressure-state-response (PSR) approach is heavily criticised for its inability to account for relationships and dynamics between variables and systems.

In recent years, alternative methods have gained momentum, in particular those that look to provide an organising framework to structure the process. The focus of this thesis is one such approach developed by M. Max-Neef. By using the conceptualising power of General Systems Theory, Bossel's framework is able to analyse a system more effectively and thoroughly than a PSR approach. The inclusion of Max-Neef's "needs satisfaction" concept into the equation gave the process a human dimension necessary to guide the process in the desired direction.

The research shows that this Bossel-Max-Neef approach does provide enough structure to carry out a thorough assessment of Sustainable Development for a desired system. Comparisons carried out for different scales (global, national or regional) demonstrate the advantages of the Bossel-Max-Neef framework, such as

thoroughness, organised analysis, and its focus on the ethical guiding principle. Finally, I conclude, that for all the aforementioned qualities, this framework provides a secure basis for an extremely viable official sustainability reporting tool.

Bachelor of Forestry Science Dissertations

2003

Dickinson, Yvette – Ecological Management Planning of Native Plants on Plantation Forest Estates

Kerr, James – The Effects of Roadside Pruning on Forest Road Strength

McConnon, Hamish – The Effect of Provenance on Bark Thickness of Douglas-fir

Schionning, Michael – A Study of how Two Final Crop Stockings of *Pinus nigra* var. *laricio* (Corsican pine) in the South Island High Country Compare Relevant to Current worth in the New Zealand Roundwood (Post/Pole) Market

Shattock, Paul – The Development and Evaluation of Tactical Planning Models within a Spreadsheet Environment

Wedding, Adele – Evaluation of Non-Destructive Rapid Screening Methods for MOE of Standing *Pseudotsuga menziesii* Trees

2004

Bosman, Maria – The Analysis of New Zealand Log Price Trends

Brown, Timothy – The Movement and Habitat Utilisation of Red Deer (*Cervus elaphus scoticus*) in the Canterbury High Country

Cain, Jessica – The Ecology and Status of *Carmichaelia torulosa*, the 'Canterbury Pink Broom'

Fortune, Adrienne – Regional Pest Management Strategies in New Zealand

Giles-Hansen, Krysta – The Viability of Broom (*Cytisus scoparius*) Seed after Passage Through Wild Quail

Leahy, Erin – Distributions of Maximum Branch Diameter for *Pinus radiata* in Two Northland Thinning Experiments, New Zealand

Waugh, Gareth - The Effect of Wind on Outerwood Stiffness using TreeTap Acoustic Tool.

2005

- Bradley, Colin – Vegetation Changes in the Te Oka and Tumbledown Valleys, Banks Peninsula from 1984-2005, and the Accuracy of Using GIS Aerial Photograph Categorisation in Identifying Vegetation Types
- Gloyn, Travis – Development and Comparison of Log Grade Predictor Functions for *Eucalyptus nitens* in Southland and Taupo
- Keenan, Samuel – Factors Influencing the Location of Cannabis Crops Cultivated within the Central North Island
- Mansell, Jeremy – Estimation of Diameter at Breast Height from Diameter at Stump Height for Four New Zealand Indigenous Tree Species
- Neylon, Simon – The use of the *Optigrade* System to Objectively Measure Road Roughness of an Unsealed Road Network
- Nicholls, Kerry – The Main Perspectives of Stakeholders that Drive Policy Development for the Use of Chemicals in Wood-Based Products in Key Foreign Markets
- Scarlett, Samuel – Incidence of *Dothistroma pini* in Central North Island Forests Managed by KTMML
- Tolan, Alex – Documentation and Analysis of Catastrophic Wind Damage in the Nelson Region Following the Storm of October 14th 2004
- Toulmin, Michael – The Development of a Sampling Strategy for Measuring Acoustic Velocity in Standing Radiata Pine using the TreeTap Time of Flight Tool
- Watts, Matthew – Improved Stand-Level Volume Functions for Douglas-fir
- Wilson, Daniel – A Comparison Between Site Index and 300 Index: comparison between using Site Index and 300 Index as forestry productivity measures

Publications 2003-2006

Book

- Sands, R. (2005). *Forestry in a Global Context*. CABI Publishing, Wallingford.
- Walker, J.C.F. (2006) *Primary wood processing: principles and practice*. Springer, Dordrecht, The Netherlands, 596 pp.

Edited Book

- Entwistle, K.M., Walker, J.C.F. (Ed.) (2005) *The Hemicelluloses Workshop 2005*. Christchurch: University of Canterbury, 186 pp.
- Mason, E.G.; Perley, C.J. (Ed.) (2003) *Proceedings of the Australian and New Zealand Institutes of Forestry Conference*.

Chapter in Book

- Beadle, C. & Sands, R. Physiology and Silviculture. (2004) In *Encyclopedia of Forest Sciences* (Eds: J. Burley, J. Evans and J.A. Youngquist) Academic Press, London. pp1568-1577.
- Cochrane, C.H. (2005) Wild Animal Management. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (51-55). Auckland: New Zealand Institute of Forestry.
- Hobbs, R.J., Norton, D.A. (2004) Ecological filters, thresholds and gradients in resistance to ecosystem reassembly. In V.M. Temperton, R.J. Hobbs, T.Nuttle, S. Halle (Ed.), *Assembly Rules and Restoration Ecology*. (72-95). Washington DC: Island Press.
- Manley, B.R. (2005) *Discount Rate*. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (268-269). Auckland: New Zealand Institute of Forestry.
- Manley, B.R. (2005) *Modeling at the Estate Level*. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (162-164). Auckland: New Zealand Institute of Forestry.
- Manley, B.R. (2005) *Valuation*. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (267-268). Auckland: New Zealand Institute of Forestry.
- Mason, E.G. (2005) Growth and Yield Modeling. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (154-156). Auckland: New Zealand Institute of Forestry.
- Mason, E.G., Watt, M.S. (2005) Initial Growth Modeling. In M.J. Colley (Ed.), *New Zealand Institute of Forestry Handbook*. (3rd Edition) (157-158). Auckland: New Zealand Institute of Forestry.

- Norton, D.A. (2003) Sustainable forest management in New Zealand. In Lindenmayer, D.B.; Franklin, J.F. (Ed.), *Towards forest sustainability*. (167-188). Collingwood, Victoria: CSIRO Publishing.
- Raymond, C.A. and Apiolaza, L.A. (2004). Incorporating wood quality and deployment traits in *Eucalyptus globulus* and *Eucalyptus nitens*. In *Plantation Forest Biotechnology for the 21st Century*. pp 87–99.

Journal Article

- Andrews, M., Lausberg, M., Nakada, R., Walker, J.C.F. (2003) Singing softwoods: sorting logs with sonics. *Scottish Forestry*, 57 (4) 199-202.
- Apiolaza, L.A., Raymond, C.A. and Yeo, B.J. 2005. Genetic variation of physical and chemical wood properties of *Eucalyptus globulus*. *Silvae Genetica* 54: 160–166.
- Bachle, H., Walker, J.C.F. (2006) Influence of temperature on the velocity of sound in green radiata pine logs. *Holz als Roh- und Werkstoff* (in press)
- Biggs, J., S. Laaksonen-Craig, K. Niquidet and G.C. van Kooten. (2006). Resolving Canada-U.S. Trade Disputes in Agriculture and Forestry: Lessons from Lumber. *Canadian Public Policy* 32: 43-156.
- Bradley, A., Chauhan, S.S., Walker, J.C.F., Banham, P. (2005) Using acoustics in log segregation to optimise energy use in thermomechanical pulping. *Appita Journal*, 58 (4) 306-311.
- Burdon, R.D., Kibblewhite, R.P., Walker, J.C.F., McGraw, R.A., Evans, R., Cown, D.J. (2004) Juvenile versus mature wood: a new concept, orthogonal to corewood versus outerwood, with special reference to *Pinus radiata* and *P. taeda*. *Forest Science*, 50 (4) 399-415.
- Burdon, R.D., Walker, J.C.F., McGraw, R.A., Evans, R., Cown, D.J. (2004) Juvenile wood (sensu novo) in pines: conflicts and possible opportunities for growing, processing and utilization. *New Zealand Journal of Forestry*, 49 (3) 24-31.
- Carter, P., Chauhan, S.S. and Walker, J.C.F. (2006) Sorting logs and lumber for stiffness using Director HM200. *Wood and Fibre Science* 38 (1) 49-54.
- Chauhan, S.S. and Walker J.C.F. (2006) Variations in acoustic velocity and density with age, and their interrelationships in radiata pine. *Forest Ecology and Management*, 229: 388-94.
- Chauhan, S.S., Entwistle, K. Walker, J.C.F. (2005) Differences in acoustic velocity by resonance and transit-time methods in an anisotropic laminated medium. *Holzforschung*, 59 (4) 428-434.
- Chauhan, S.S., Walker, J.C.F. (2004) Relationships between longitudinal growth strain and some wood properties in *Eucalyptus nitens*. *Australian Journal of Forestry*, 67 (4) 254-260.
- Cochrane, C. H. & Norton, D. (2000) Overlap in diet, impacts and habitat use of introduced mammalian herbivores in New Zealand. *Conservation Science Newsletter*, 39: 9-10.

- Cochrane, C.H. (2003) Biosecurity: its implications for the primary industry sector. *Primary Industry Management*, 6 (1) 6-7.
- Cochrane, C.H. and Haslett, D (2005) Deliberate acts in the primary industry sectors - passing fad or growing risk? *Primary Industry Management*, 8 (3) 17-18.
- Cochrane, C.H.; Haslett, D.S. (2002) Deliberate release: what are the risks. *New Zealand Journal of Forestry*, 47 (2) 16-17.
- Cochrane, C.H.; Norton, D.A.; Miller, C.J.; Allen, R.B. (2003) Brushtail possum (*Trichosurus vulpecula*) diet in a north Westland mixed beech (*Nothofagus*) forest. *New Zealand Journal of Ecology*, 27: 61-65.
- Cochrane, C.H.; Norton, D.A.; Miller, C.J.; Allen, R.B. (2003) Possum diet in a lowland mixed beech forest. *New Zealand Journal of Ecology*, 27 (1) 61-65.
- de Lange, P.J., Norton, D.A. (2004) The ecology and conservation of *Kunzea sinclairii* (Myrtaceae), a naturally rare plant of rhyolitic rock outcrops. *Biological Conservation*, 117: 49-59.
- de Lange, P.J., Norton, D.A., Heenan, P.B., Courtney, S.P., Molloy, B.P.J., Ogle, C.C., Rance, B.D., Johnson, P.N., Hitchmough, R. (2004) Threatened and uncommon plants of New Zealand. *New Zealand Journal of Botany*, 42: 45-76.
- Didham, R.K.; Watts, C.H.; Norton, D.A. (2005) Are systems with strong underlying abiotic regimes more likely to exhibit alternative stable states? *Oikos*, 110: 409-416.
- Douglas, R.A. & Cochrane, C.H. (2001) Where have all the culverts gone – a GIS-based approach to finding stream crossings. *International Journal of Forest Engineering*, 12 (2) 79-81.
- Douglas, R.A. (2003) Regional network analysis of primary industrial truck traffic on public roads in New Zealand using GIS. Transportation Research Record: *Journal of the Transportation Research Board*, 1819: 104-108.
- Douglas, R.A. (2004) Wanted: more forest engineers. Growing concerns - a forum for forest issues. *New Zealand Forest Industries*, 35: 6, 35.
- Douglas, R.A.; Woodward, W.D.H.; Rogers, R.J. (2003) Contact pressures and energies beneath soft tires: modeling the effects of CTI-equipped heavy truck traffic on road surfaces. Transportation Research Record: *Journal of the Transportation Research Board*, 1819: 221-227.
- Dungan, R.J., Norton, D.A. (2003) Possums as seed dispersers in New Zealand: A response to Williams (2003). *New Zealand Journal of Ecology*, 27 (2) 225-226.
- Dzierzon, H. and Mason, E.G. (2006, in press) Towards a nationwide growth and yield model for radiata pine plantations in New Zealand. *Canadian Journal of Forest Research*.
- Grabianowski, M., Manley, B. and Walker, J.C.F. (2006) Acoustic measurements on standing trees, logs and green lumber. *Wood Science & Technology*, 40 (3) 205-16.
- Grabianowski, M., Manley, B., Walker, J.C.F. (2004) Impact of stocking and exposure on outerwood acoustic properties of *Pinus radiata* in Eyrewell Forest. *New Zealand Journal of Forestry*, 49 (2) 13-17.

- Hsu, L.C.Y., Walker, J.C.F., Butterfield, B.G., Jackson, S.L. (2006) Compression wood does not form in the roots of *Pinus radiata*. *IAWA Journal*, 27 (1) 45-54.
- Kirongo, B.B., Mason, E.G. (2003) Decline in relative growth rate of 3 juvenile radiata pine clones subjected to varying competition levels in Canterbury. *Annals of Forest Science*, 60 (7) 585-591.
- Lanwert, D., Dzierzon, H. and Sloboda, B. (2004) Elearning in Forest Science presented by a multimedia based CD, which aids the lecture: 'creation of ecological models using Lindenmayer Systems and the software tool GROGRA' (in German). *Die Grüne Reihe (The Green Series)*.
- Lasserre, J.P., Mason, E.G., Watt, M.S. (2004) The influence of initial stocking on corewood stiffness in a clonal experiment of 11 year-old *Pinus radiata* D. Don. *New Zealand Forestry*, 49 (2) 18-23.
- Lasserre, J-P., Mason, E.G., Watt, M.S. (2005) The effects of genotype and spacing on *Pinus radiata* [D. Don] corewood stiffness in an 11-year old experiment. *Forest Ecology and Management*, 205 (1-3) 375-383.
- Li, Y., Dutkowsky, G.W., Apiolaza, L.A., Pilbeam, D.J., Costa e Silva, J. and Potts, B.M. (2006). The genetic architecture of a *Eucalyptus globulus* full-sib breeding population in Australia. *Forest Genetics* (in press).
- Lindenmayer, D.B., Franklin, J.F., Angelstam, P., Bunnell, F., Brown, M.J., Dovers, S., Hickey, J.E., Kremsater, L., Niemela, J., Norton, D.A., Perry, D., Soule, M. (2004) The Victorian forestry roundtable meeting: a discussion of transitions to sustainability in Victorian forests. *Australian Forestry*, 67, 1-5.
- Lopez, G.A., Potts, B.M., Vaillancourt, R.E. and Apiolaza, L.A. (2003). Maternal and carry-over effects on early growth of *Eucalyptus globulus*. *Canadian Journal of Forest Research* 33: 2108-2115.
- MacDonald, M.A., Apiolaza, L.A., Grove, S. (2005). The birds of retained vegetation corridors: a pre- and post-logging comparison in dry sclerophyll forest in Tasmania. *Forest Ecology and Management* 218: 277-290.
- Manley, B.R. (2003) Discount rates used for forest valuation - Results of 2003 survey. *New Zealand Journal of Forestry*, 48 (3) 29-31.
- Manley, B.R; Bare, B.B. (2003) Equivalence of the expectation and cost compounding methods of forest valuation - Faustmann revisited. *New Zealand Journal of Forestry*, 48 (1) 25-31.
- Manley, B.R.; Somerville, O.; Turbitt, M.; Lane, P. (2003) Review of new forest planting estimates. *New Zealand Journal of Forestry*, 48 (3) 34-37.
- Manley, B. (2004) What's the future for the Central North Island? *New Zealand Journal of Forestry*, 49 (2) 2-4.
- Manley, B.R. (2005) Discount rates used for forest valuation. *New Zealand Journal of Forestry*, 50 (3) 7-11.
- Mason, E. (2003) Let's Opt for the Cordon Bleu. *New Zealand Forest Industries*, 34: 3, 40.
- Mason, E. (2004) Watch This Space! *New Zealand Forest Industries*, 35 (10) 34.

- Mason, E.G. (2004) Effects of soil cultivation, fertilisation, initial seedling diameter and plant handling on the development of maturing *Pinus radiata* D. Don on Kaingaroa gravelly sand in the Central North Island of New Zealand. *Bosque*, 25 (2) 43-55.
- Mason, E.G. and Dzierzon, H. (2006, in press) Applications of modeling to vegetation management. *Canadian Journal of Forest Research*.
- Michael S. Watt, John R. Moore, Jean-Philippe Façon, Geoff M. Downes, Peter W. Clinton, Graham Coker, Murray R. Davis, Robyn Simcock, Roger L. Parfitt, John Dando, Euan G. Mason, and Horacio E. Bown, (2006) Modeling environmental variation in Young's modulus for *Pinus radiata* and implications for determination of critical buckling height. *Annals of Botany* (98) 765-775
- Miller, C.J., Norton, D.A., Miller, T.K. (2004) Kahikatea *Dacrycarpus dacrydioides* and Totara-Matai *Podocarpus totara-Prumnopitys taxifolia* forest patches in the agricultural landscape, Westland, New Zealand: representatives of a past and future condition. *Pacific Conservation Biology*, 9: 278-293.
- Nagashima, K., Sands, R., Whyte, A.G.D., Bilek, E.M. & N. Nakagoshi. (2003). Plantation expansion possibility and its influence on land-use pattern in the Nelson region, New Zealand. *Forest Ecology and Management* 184: 263-275.
- Nagashima, K., Sands, R., Whyte, A.G.D., Bilek, E.M. and Nakagoshi, N. (2006, in press). Nature Conservation under the Resource Management Act: A case study of the Tasman District, New Zealand. *Forest Ecology and Management*.
- Niquidet, K. (2006). Revitalized? An Event Study of Forest Policy Reform in British Columbia. *Submitted to Journal of Forest Economics*.
- Niquidet, K., and G.C. van Kooten. (2006). Transaction Evidence Appraisal: Competition in British Columbia's Stumpage Markets. *Forest Science* 52 (4) 451-9.
- Niquidet, K., Nelson, H., and I. Vertinsky. (2006). Pricing the social contract in the British Columbian forest sector. *Submitted to the Canadian Journal of Forest Research*.
- Norton, D. (2003) Variety is the spice of life. *Open Space*, 59: 12-13.
- Norton, D. (2004) Invasive species in New Zealand. *Open Space*, 60: 20-21.
- Norton, D. (2005) Nature and landscapes in a commercial plantation. *Indigena*, December 2005, 21-24.
- Norton, D.A. & Cochrane, C.H. (2000) Are we delivering indigenous biodiversity conservation outcomes in the best possible way? *Victorian Economic Commentaries*, 22-29.
- Norton, D.A. (2004) Echoes of Timberlands in high country debate - are more decisions being made on the basis of political ideology rather than the principles of ecological sustainability? *New Zealand Journal of Forestry*, 49 (3) 39-41.
- Norton, D.A., Roper-Lindsay, J. (2004) Assessing significance for biodiversity conservation on private land in New Zealand. *New Zealand Journal of Ecology*, 28: 295-305.

- Norton, D.A.; Cochrane, C.H.; Reay, S.D. (2005) Crown-stem dimension relationships in two New Zealand native forests. *New Zealand Journal of Botany*, 43: 673-678.
- Norton, D.A.; de Lange, P.J. (2003) A new species of *Coprosma* (Rubiaceae) from the South Island, New Zealand. *New Zealand Journal of Botany*, 41 (2) 223-231.
- Norton, D.A.; de Lange, P.J. (2003) Fire and vegetation in a temperate peat bog: implications for threatened species management. *Conservation Biology*, 17 (1) 138-148.
- Norton, D.A.; Leighton, A.; Buckman, I. (2003) Response of red beech to fertiliser, Island Block coal mine, North Westland. *New Zealand Journal of Forestry*, 48 (3) 32-33.
- Pawson, S.M.; Brockerhoff, E.G.; Didham, R.K.; Norton, D.A. (2005) Clearfell harvest size: a key issue for biodiversity conservation in New Zealand's plantation forests. *New Zealand Journal of Forestry*, 50 (2) 29-32.
- Richardson, B., Watt, M.S., Mason, E.G., Kriticos, D.J. (2005) Advances in modeling and decision support systems for vegetation management in young forest plantations. *Forestry*, 79 (1) 29-42.
- Rivas Palma, R. (2005) Social and environmental valuation as a tool for forest management. *New Zealand Journal of Forestry*, 50 (1) 23-26.
- Robertson, K., Manley, B. (2006) Estimation of the availability and cost of supplying biomass for bioenergy in Canterbury. *New Zealand Journal of Forestry*, 51 (2) 3-6.
- Sands, R. (2003). Professional forestry education in Australasia – looking from the past to the future. *New Zealand Journal of Forestry*, 48: 20-26.
- Shrivistava, A.C., Sands, R. and Bilek, E.M. Safety performance of the forestry sector in New Zealand. *Journal of Occupational Health and Safety* (under review).
- Sinn, D.L., Apiolaza, L.A. and Moltschaniwskyj, N.A. (2006). Genetic analysis and reproductive consequences of squid personality traits. *Journal of Evolutionary Biology* 19 (5) 1437-1447.
- Tsang, K., Manley, B., Maplesden, F. (2006) New product acceptance in China's industrial wood products market. *New Zealand Journal of Forestry* 50 (4) 24-30
- Walker, J.C.F. (2003) Finding a brighter future - in commodities. *New Zealand Journal of Forestry*, 48 (2) 29-31.
- Walker, J.C.F. (2004) Forestry: a Turning Tide. *New Zealand Forest Industries*, 35 (9) 33-34.
- Walker, J.C.F. (2004) Good wood and blind prejudice. *New Zealand Journal of Forestry*, 49 (2) 36-37.
- Watt, M.S., Clinton, P.W., Whitehead, D., Richardson, B., Mason, E.G., Leckie, A.C. (2003) Above-ground biomass accumulation and nitrogen fixation of broom (*Cytisus scoparius* L.) growing with juvenile *Pinus radiata* on a dryland site. *Forest Ecology and Management*, 184 (1-3) 93-104.
- Watt, M.S., Facon, J.P., Moore, J.R., Downes, G.M., Clinton, P.W., Coker, G., Davis, M., Simcock, R., Parfitt, R., Dando, J., Mason, E.G., and Bown, H., (2006). Modeling the influence of stand structural, edaphic and climatic influences on *Pinus radiata* dynamic modulus of elasticity. *Forest Ecology and Management*, 229 (1-3) 136-144

- Watt, M.S., G.M. Downes, D. Whitehead, E.G. Mason, B. Richardson, J.C. Grace, and J.R. Moore (2005) Wood properties of juvenile *Pinus radiata* growing in the presence and absence of competing vegetation at a dryland site. *Trees - Structure and function*, 19 (5) 580-586.
- Watt, M.S., Kimberley, M.O., Richardson, B., Whitehead, D., Mason, E.G. (2004) Testing a juvenile tree growth model sensitive to competition from weeds, using *Pinus radiata* at two contrasting sites in New Zealand. *Canadian Journal of Forest Research*, 34: 1985-1992.
- Watt, M.S., Whitehead, D., Mason, E.G., Richardson, B., Kimberley, M.O. (2003) The influence of weed competition for light and water on growth and dry matter partitioning of young *Pinus radiata*, at a dryland site. *Forest Ecology and Management*, 183 (1-3) 363-376.
- Watt, M.S., Whitehead, D., Richardson, B., Mason, E.G., Leckie, A.C. (2003) Modeling the influence of weed competition on the growth of young *Pinus radiata* at a dryland site. *Forest Ecology and Management*, 178 (3) 271-286.
- Whittock, S.P., Apiolaza, L.A., Kelly, C.M. and Potts, B.M. (2003). Genetic control of coppice and lignotuber development in *Eucalyptus globulus*. *Australian Journal of Botany* 51: 57-67.
- Whittock, S.P., Greaves, B.L. and Apiolaza, L.A. (2004). The comparative economics of genetically improved seedling and coppice crops in *Eucalyptus globulus* plantations. *Forest Ecology and Management* 191: 267-274.
- Whittock, S.P., Dutkowski, G.W., Greaves, B.L. and Apiolaza, L.A. (2006). Integrating revenues from carbon sequestration into economic breeding objectives for *Eucalyptus globulus* pulpwood production. *Annals of Forest Science (in press)*.
- Wood M.J., Douglas, R.A. and Sands, R. (2006). The Taringatura study: the effects of harvest machine traffic and tillage on a forest soil in New Zealand. *International Journal of Forest Engineering* 17 (1) 53-66.
- Wood, M.J., Sands, R., and Douglas, R.A. (2004). A comparison of three methods for measuring the density of a forest soil. *International Journal of Forest Engineering* 15(1) 71-80
- Xu, P., Donaldson, L., Walker, J.C.F., Evans, R., Downes, G. (2004) Effects of density and microfibril orientation on the vertical variation of low-stiffness wood in radiata pine butt logs. *Holzforschung*, 58: 673-677.
- Xu, P., Walker, J.C.F. (2004) Stiffness gradients in radiata pine trees. *Wood Science and Technology*, 38 (1) 1-9.
- Xue, J., Sands, R. and Clinton, P.W. Comparative effects of biuret, urea and atrazine on soil nitrogen mineralisation, immobilisation and nitrification in two forest soils incubated under laboratory conditions. *Australian Journal of Soil Research (under review)*.
- Xue, J.M., Sands, R., Clinton, P. (2004). Effect of biuret on growth and nutrition of Douglas-fir (*Pseudotsuga menziesii* (Mirb) Franco) seedlings. *Forest Ecology and Management*, 192: 335-348.

- Xue, J.M., Sands, R., Clinton, P. (2004). Growth and physiological responses of two Douglas fir provenances to nitrogen supply. *New Zealand Journal of Forestry Science* 34 (1) 59-76
- Xue, J.M., Sands, R., Clinton, P., Payn, T. & M. Skinner. (2003). Carbon and net nitrogen mineralization in two forest soils amended with different concentrations of biuret. *Soil Biology and Biochemistry* 35: 855-866.
- Sands, R., Haramburu, E., Wood, M. and Douglas, R.A. Effect of harvesting traffic and ripping on growth of radiata pine in the Taringatura Forest in New Zealand. *New Zealand Journal of Forestry Science* (under review)
- Xue, J.M., Sands, R., Clinton, P.W., Payn, T.W. and Skinner, M.F. (2005). Priming effect of biuret addition on native soil N mineralization under laboratory conditions. *Soil Biology and Biochemistry* 37: 1959-1961.
- Zhao, W., Mason, E.G., and Brown, J. (2006) Modeling height-diameter relationships of *Pinus radiata* plantations in Canterbury, New Zealand. *New Zealand Journal of Forestry*, 51 (1) 23-27.

Editorials

- Mason, E.G. (May 2006) "It makes you proud...." *New Zealand Journal of Forestry*, page 2
- Mason, E.G. (August 2006) "Less hot air in the greenhouse, please!" *New Zealand Journal of Forestry*, page 2

Conference Contribution

- Bascunan, A., Moore, J., Walker, J. (2004) Real influences of wind and drought on wood quality. Albury, NSW, Australia: Wood Quality 2004 : *Practical tools and new technologies to improve segregation of logs and lumber for processing*, 5-6 Aug 2004. 1-8.
- Cochrane, H (2003) Agricultural Terrorism. Wellington: *Inter-Departmental Counter Terrorism Seminar*, 4-5 November 2003.
- Cochrane, H (2003) How genes owned by your neighbour may create a threat for you. University of Tromso, Norway: *Holistic foundations for assessment and regulation of genetic engineering and genetically modified organisms*, August 4-13, 2003.
- Douglas, R.A. (2003) Contact energies beneath soft tyres, the effects on road surfaces of CTI-equipped logging truck traffic. Växjö, Sweden: *Proceedings of the Second International Forest Engineering Conference*, 12-15 May 2003. 8 pp.
- Douglas, R.A. (2003) Developing a comprehensive protocol for the study of forest floor compaction. Växjö, Sweden: *Proceedings of the Second International Forest Engineering Conference*, 12-15 May 2003. 4 pp.
- Douglas, R.A. (2003) Forest floor compaction study, Taringatura Forest, New Zealand. Växjö, Sweden: *Proceedings of the Second International Forest Engineering Conference*, 12-15 May 2003. 4 pp.

- Douglas, R.A. (2003) Large scale network analysis of the impacts of logging truck traffic on public roads on New Zealand's South Island. Växjö, Sweden: *Proceedings of the Second International Forest Engineering Conference*, 12-15 May 2003. 4 pp.
- Douglas, R.A. (2004) Encouraging innovation in forest operations. Albury, NSW, Australia: *AustTimber 2004*, 1-3 Apr 2004.
- Douglas, R.A., Mitchell, S. and Pidwerbesky, B. (2004) Adaptation of a grading management system for unsealed public road networks in New Zealand. University of Nottingham, UK: *6th Conference on Unbound Aggregates in Roads (UNBAR 6)*, 6-8 Jul 2004. 157-165.
- Dowdle, L.R., and Douglas, R.A. (2007) Regional network analysis of log truck transportation on public roads in New Zealand using geographic information systems. *TRB 9th International Low Volume Roads Conference*, Austin, Texas, June 24-27, 2007. In press.
- Dzierzon, H. and Mason, E. (2005) Nationwide Growth and Yield Modeling for Radiata Pine Plantations in New Zealand. Corvallis, Oregon, USA: *5th International Conference on Vegetation Management*, June 2005.
- Dzierzon, H. and Mason, E. (2005) Nationwide Growth and Yield Modeling for Radiata Pine Plantations in New Zealand. Christchurch, New Zealand: *Workshop on National Growth Modeling*, October 2005.
- Dzierzon, H. and Mason, E. (2005) Nationwide Growth and Yield Modeling for Radiata Pine Plantations in New Zealand. Rotorua, New Zealand: *Workshop on National Growth Modeling*, May 2006.
- Entwistle, K.M., Walker, J.C.F. (2005) Workshop Assessment. Christchurch, New Zealand: *The Hemicelluloses Workshop 2005*. 179-186.
- Mason, E.G., Sands, R., (2005) Science to Assist Forest Management in New Zealand. Brisbane, Australia: IUFRO World Congress 2005, 8-13 Aug 2005. In *Forest in the Balance: Linking Tradition and Technology - Proceedings of XXII IUFRO World Congress*, 258.
- Mason, E.G.; Lane, D.; Hansman, S.; Hunt, J. (2003) Integration of forestry-related software: A public good. Queenstown, New Zealand: *Proceedings of the Australian and New Zealand Institutes of Forestry Conference*, 27 Apr-1 May 2003. 235-245.
- McRae, T.A., Apiolaza, L.A., Dutkowski, G.W., Kerr, R.J., Pilbeam, D.J., Powell, M.B. and Tier, B. 2003. TREEPLAN® - A genetic evaluation system for forest trees. *Proceedings of the 27th Southern Forest Tree Improvement Conference*, Stillwater, OK, USA.
- Mercier, M.; Brown, M.; Provencher, Y.; Douglas, R.A. (2003) Improving road quality and user satisfaction while lowering road maintenance costs using Optigrade. Cairns, Queensland: *Proceedings of the 21st Australian Road Research Board (ARRB) Conference*, 18-23 May 2003.
- Moreno, J., Walker, J. (2004) Wood quality in radiata pine plantations. Why corewood? Why microfibril angle? Effects on stiffness, shrinkage and warp. Albury, NSW, Australia: *Wood Quality 2004 : Practical tools and new technologies to improve segregation of logs and lumber for processing*, 5-6 Aug 2004. 1-7.

- Nelson, H., K. Niquidet and I. Vertinsky. Assessing the Socio-Economic Impact of Tenure Changes in British Columbia: *A discussion paper prepared for the BC Forum on Forest Economics and Policy*. Vancouver: FEPA Research Unit, University of British Columbia, 2006.
- Pidwerbesky, B., and Douglas, R.A. (2007) An asset management strategy for unsealed low volume roads in New Zealand. *TRB 9th International Low Volume Roads Conference*, Austin, Texas, June 24-27, 2007. In press.
- Potts, B.M., Vaillancourt, R.E., Jordan, G., Dutkowski, G.W., Costa e Silva, J., McKinnon, G., Steane, D., Volker, P., Lopez, G.A., Apiolaza, L.A., Li, Y., Marques, C. and Borralho, N.M.G. 2004. Exploration of the *Eucalyptus globulus* gene pool. *Proceedings of the International IUFRO Conference "Eucalyptus in a changing world" on Silviculture and Improvement of Eucalypts*. 11-15 October, Aveiro, Portugal.
- Provencher, Y., Mercier, S., and Douglas, R.A. (2004) Améliorer l'impact des interventions d'entretien par l'emploi de techniques d'auscultation des chaussées économique.. Québec, Canada: *39iem Congrès Annuel de l'Association Québécoise du Transport et des Routes*, April 4-6, 2004.
- Whittock, S.P., Apiolaza, L.A., Dutkowski, G.W., Greaves, B.L. and Potts, B.M. 2004. Carbon revenues and economic breeding objectives in *Eucalyptus globulus* pulpwood plantations. *Proceedings of the International IUFRO Conference "Eucalyptus in a changing world" on Silviculture and Improvement of Eucalypts*. 11-15 October, Aveiro, Portugal. 146-150.

Report for External Body

- Brown, J.A., Woollons, R., and Manley, B. (2005) Estimating uncertainty in the Kyoto compliant carbon accounting system for New Zealand's planted forests. *MAF UCMS 2005/7*. 20pp.
- Cochrane, C.H., Norton, D.A., Miller, C.J. & Allen, R.B. (1999) Possum diet near Springs Junction, West Coast Conservancy and implications for biodiversity conservation in beech forest. *Report prepared for Department of Conservation, West Coast Conservancy*. 15 pp.
- Cochrane, C.H. & Denholm, P.M. (2001) (2001) "A delimiting survey of the Riccarton area (Christchurch) to locate the Argentine ant (*Linepithema humile*)". *Report prepared for Environment Canterbury*. 6 pp.
- Douglas, R.A. (2005) Report on fatal accident south of Kinloch, New Zealand: comments on road and materials. *Report to NZ Police*. 4 pp.
- Dzierzon, H. and Mason, E. (2005) Progress Report on 'Developing a National Model to Predict the Growth and Quality of Radiata Pine Plantations in New Zealand'. *Report prepared for 12 forest companies which provided the data material*.
- Nelson, H., A. Krcmar, K. Niquidet, G.C. van Kooten and I. Vertinsky. (2003) Evaluating the Socio-economic Impacts from Expanding the Use of Auction Systems for Timber in B.C. *Report prepared for the Forestry Innovative Investment Forest Research Program*. Vancouver: FEPA Research Unit, University of British Columbia.

- Niquidet, K., and G.C. van Kooten. 2004. "Are Log Markets Competitive? Empirical Evidence and Implications for Canada-U.S. Trade in Softwood Lumber." University of Victoria, *Department of Economics, REPA Working Paper 2004-04*.
- Norton, D.A., Leighton, A., Phipps, H. (2004) Otamahua/Quail Island restoration plan. *Otamahua/Quail Island Restoration Trust*. 84 pp.
- Wood, M.J., Douglas, R.A., and Sands, R. (2004) The effects of harvesting traffic and tillage on the mechanical properties of a forest soil in New Zealand – *final report to Rayonier, N.Z. Rayonier, N.Z.* 83 pp.
- Woollons, R., Brown, J., and Manley, B. (2005) *Estimation of errors associated with the calculation of carbon in Kyoto Forests*. MAF. UCMS2005/8. 24pp

Miscellaneous

- Donnelly, Flynn and Shields, DANA – *Rotorua Global Review for Eucalyptus Solid Wood Products*, 300 pages.
- Siddiqui, T. and Dzierzon, H. (2006, in progress). An introduction to forestry in Pakistan. *Lecture notes for first year students*.

Software

- Mason, E.G., Lane, D., Milne, P., and N. Ledgard (2005) *Tree Planter's Record System [Java]* NZ Farm Forestry Association.

Contact details

If you would like to obtain further details on the research published in this report, please contact the relevant researcher directly at:

NZ School of Forestry
University of Canterbury
Private Bag 4800
Christchurch 8020
NEW ZEALAND

Ph: +64 3 3642 109
Fax: +64 3 3642 124

E-mail addresses and phone numbers of individual staff members are shown in the staff directory on the School's web site. For more general enquiries, please contact the School Administrator initially at jeanette.allen@canterbury.ac.nz.

Further information about the School of Forestry can be found on our web site at www.forestry.ac.nz.

The School of Forestry also interacts with the Wood Technology Research Centre of the University of Canterbury. This Centre represents scientists with research interests in wood technology from nine departments across the University. For more information on the research programmes in this centre, please contact Associate Professor Shusheng Pang at +64 3 3642-987, Ext 6538.