MANAGING NATIVE TREES
Towards a National Strategy

Proceedings of the Tāne's Tree Trust
10th Anniversary Conference and Workshops held
at
The University of Waikato
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Ruth Gadgil
David Bergin

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About the Author

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It is a little over 10 years since the inaugural conference, "Native Trees for the Future" was held and it is more than timely for us to revisit the subject and hold another conference. The first one, which inspired the formation of Tāne's Tree Trust, was very successful and created momentum that has continued to the present. That conference strongly advocated managing native forests as part of New Zealand's forestry future. It focussed on new planting and the management of emerging second-growth forest. Old-growth forests were specifically excluded. Legal and regulatory barriers and the very limited investment in research were key issues at that time. They are still key issues today. We will be discussing them again at this Conference.

We also intend to review, and where appropriate, celebrate some of the highlights of the past ten years. Our Patron Gordon Stephenson will launch the new Handbook this evening. We also hope to point the way forward over the next ten years. Your contributions will be most important in identifying today's issues and will provide the lead-up to a discussion on a national strategy for native forests.

At the beginning of the Conference we will hear from a small number of invited keynote speakers who will provide insight into matters such as community involvement and the broader values of native forests. Over the two days of the Conference, four workshops will be used to draw out the information and experience held by all of you. This will be your opportunity for raising and discussing the issues that you consider to be important.

The four workshops will cover the following topics:

1. **Productive use of native species**. The work of the Northland Totara Working Group and Forever Beech will be used to show how regenerating natives can make a productive contribution to the country's economy. This workshop will address the key questions:- What is the way forward? What are the hurdles? Which species fit this mould? How can we encourage the integration of multiple-use native forestry? The Convenor will be Helen Moodie.

2. **Establishing natives economically**. What works? What doesn't? Where are the gaps? Cost-effective methods for large scale planting of native species still elude us. The workshop will address current work on this issue, identify options for successful establishment, and highlight areas where progress can be made. The Convenor will be Helen Percy.

3. **"Ecosourcing".** We shall learn that the term "ecosourcing" was coined on a whim over coffee. It has since become a rigid doctrine for some and an unnecessary obstruction to native tree planting for others. The workshop will consider whether the science behind ecosourcing supports current practice and policy, and will explore how the concept can be used to safeguard ecological values without hindering native planting. The Convenor will be Roger MacGibbon.

4. **Research**. How can we focus investment in research and development in order to get better establishment and management of native trees? The workshop will summarise what we know and identify gaps in our knowledge. It will also point out opportunities for further investment and the potential contributors. The Convenor will be Andrew McEwen.

When papers relevant to each Workshop session have been presented, Conference participants have been assigned to one of four workshop groups that will meet separately in nearby lecture rooms to discuss key questions. They will then reassemble to hear a summary of the results of group deliberations.

The plenary session tomorrow afternoon will be led by Helen Ritchie. She will attempt to pull things together, devise the direction of a strategy and provide guidance for future progress.

Finally, we are grateful for the support of Conference sponsors: the Commonwealth Forestry Association; Deed Print; the Indigenous Section of the NZ Farm Forestry Association; Scion; Future Forest Research; Environment Waikato; the NZ Landcare Trust; Naturally Native New Zealand Plants; the Greater Wellington Regional Council; the Northland Regional Council; and the Sustainable Farming Fund of the Ministry of Agriculture and Forestry.

Tāne's Tree Trust Conference, 18-20 November, 2009

Kate Wilkinson

About the Author

__Kate__ was formerly a partner in a Christchurch law firm and is now a List MP based in Rangiora. She is currently Minister of Labour, Minister for Food Safety, Associate Minister of Conservation and Associate Minister of Immigration.

Good morning. It is my pleasure to be attending today on behalf of my colleague David Carter, Minister of Forestry, who is currently in Rome with the Forestry and Agricultural Organisation.

I would like to begin by acknowledging the members of Tāne's Tree Trust and the work that is done by the Trust for the benefit of all New Zealanders. As Associate Minister of Conservation, native forestry in New Zealand is a topic close to my heart and your theme "Managing native trees towards a national strategy" is closely aligned to the principles of this Government. In ten years time, when Tāne's Tree Trust celebrates its next decade of achievement, we want to see indigenous forestry in New Zealand as a sustainably managed resource, highly valued by the community for its environmental, social, economic and cultural values.

I was impressed to see the latest findings from the 2008 Montreal Process Report that shows New Zealand has increased adoption of sustainable forest management best practices, and that there is an increasing use of forests for a range of recreation pursuits by both local and international visitors.

This work needs to continue. We want our sector to be innovative and profitable, taking full advantage of its potential to meet market demands – whether for timber and wood products, or for environmental services such as soil protection, water quality or storing carbon.

The recognition that we need to do more collectively to promote the good that forests can do in benefiting communities is part of the reason why we are all here today.

The Government values indigenous forestry

The profile of native forestry, both in New Zealand and internationally, has come a long way since the first conference on "Native Trees for the Future" was held at the University of Waikato some 10 years ago.

As a country, we are now far more aligned to the importance of trees and forests – as a natural habitat for our native species, protector of New Zealand's unique biodiversity, provider of tourism and recreation benefits and for timber production. And a value more recently acknowledged, for carbon storage.

Since that first conference, the Government has introduced a range of policies and schemes designed to encourage investment in forestry, including the restoration and sustainable management of indigenous forest land.

Most recent is our commitment to the future of kauri and the recent announcement of $4.7 million in funding for a programme targeting kauri dieback in the Upper North Island.

Ancient kauri forests are a vital part of the ecosystem as well as being part of our heritage. Government agencies, regional councils and Maori have been working together since late last year to combat the threat kauri dieback poses and the five-year programme now in place aims to contain the disease through research and public awareness.

Kauri is a species that we as New Zealanders are duty-bound to protect. Just recently I viewed some of these magnificent trees on a visit to Puketi Forest.

It was hard not to be impressed. The funding, which will go towards future management of kauri dieback, demonstrates the importance we place on the conservation of such a treasured species.

Conservation is a key theme of the Government's policies. Our commitment to manage Crown indigenous forest under the Conservation Act has led to around 80% of NZ's indigenous forest being managed in this way.

Harvesting of the around one million hectares of private indigenous forests is now controlled by the Forests Act which imposes strict sustainable forest management requirements and penalties for compliance.

Climate change policies provide significant new incentives for fostering indigenous tree planting and natural reversion on eligible land. For the first time landowners can now earn income from the non-timber value of their forests through carbon storage credits.

The East Coast Forest Grant Scheme now directly recognises the important role that indigenous forest reversion can make to land stabilisation and provides grants for this purpose.

Because of our nationwide regard for forests, a number of instruments have been established for the protection and enhancement of important habitats such as the Nature Heritage Fund and Nga Whenua Rahui.

Our commitment to these policies and outcomes remains.

Further, these policies are reflected in our participation in international initiatives such as the Montreal Process and the Convention on Biological Diversity.

Just three weeks ago David Carter delivered a key note address in Argentina at the World Forestry Congress.

The environment

Although it goes without saying, there are a number of opportunities and challenges for policy makers and practitioners alike in the current environment. We need to maintain our efforts and grow the interest of land managers in indigenous trees.

Achieving this requires partnerships with others in the sector – with government, forest and land owners, timber producers and manufacturers. Practitioners such as those here today also need to take advantage of opportunities to grow the sector through active participation in programmes currently available.

We recognise that the Government has a diverse and substantial role to play, from the protection and enhancement of the Conservation estate to ensuring sustainable management of indigenous forests and protecting New Zealand growers from the impact of illegal logging.

In order to support the Government in the achievement of its objectives, the Indigenous Forestry Development Group was established under the chairmanship of the Minister of Forests in 2009. The group meets twice a year and seeks to identify measures designed to assist the development of the indigenous forestry sector.

It is working with other organisations to promote commercial indigenous tree species and undertake or sponsor applied research, as well as contributing to policy work. One area in particular where the Group is supporting Government, is in developing our response to illegal logging and timber importation.

This Government takes illegal logging seriously and recognises that the cheapness of illegal wood can adversely impact the market for products made from New Zealand's indigenous timber.

The Government is currently considering a revised package of measures to address the issue of illegal logging. This revised package will include multilateral, bilateral and domestic actions and is expected to go to Cabinet shortly.

Beyond this, the Government's support for the forestry sector and indigenous forestry in particular, is broad and far reaching, highlighted by a range of initiatives and policy.

Sustainable management

The Forests Act provides for the sustainable management of indigenous forest land, the control of the export of indigenous timber and the milling of indigenous timber.

The purpose of this legislation is to enable an economic return from private forest while protecting its intrinsic values. While directed towards existing indigenous forest in the first instance, the Forests Act does recognise planted indigenous forest as a specific land use and provides for the utilisation of planted indigenous trees.

Currently there are 48 approved and registered Sustainable Forest Management Plans in the country, covering about 50 000 hectares and an allowable annual harvest of 78 000 cubic metres of native timber. A further 74 000 ha of forest are covered by Sustainable Forest Management Permits.

Permanent Forest Sink Initiative

In 2006, landowners were provided with a mechanism to access the value of carbon sequestration through the establishment of Permanent Forest Sinks.

The limited harvesting provided for under this initiative ultimately favours long lived species with the capacity to sequester and retain substantial quantities of carbon. Indigenous forests are ideally suited for this opportunity and there has been a growing level of interest from indigenous forest owners seeking to participate.

Afforestation Grants Scheme

Then there is the Afforestation Grants Scheme - a contestable fund designed to encourage the establishment of new forests. It is part of the Government's package of climate change initiatives and offers a way to absorb greater levels of greenhouse gases by increasing the area of Kyoto-compliant new forest in New Zealand.

While much of the funding is allocated to species with high carbon sequestration rates, there is a set pool reserved for species with low sequestration rates. This is as a result of public interest in planting indigenous species.

Both the Permanent Forest Sinks Initiative and the Afforestation Grants Scheme will support landowners to plant trees or manage the regeneration and reversion of indigenous forests.

Forestry in the Emissions Trading Scheme

Of course, the biggest forestry scheme currently in play is the Emissions Trading Scheme (ETS).

New Zealand's forests play a critical role in meeting the country's climate change objectives. The forest estate is already a significant store of carbon and there is potential for this to expand further with both farm and larger-scale plantings.

Importantly, indigenous plantings that qualify as post-1989 forests are eligible for the ETS.

While these schemes are already in place and delivering returns to land owners, there are further opportunities that can be explored and capitalised on, through investment in research and development.

Research and development

As part of the Government's role in supporting and promoting the sustainable management of private indigenous forests, there has been significant investment in research to underpin the Forests Act and provide guidance to forest management practitioners.

Collectively, these have contributed a substantial amount of new information and built on the existing information base. There continue to be opportunities for the indigenous sector, through organisations like Tāne's Tree Trust, to obtain co-sponsorship for projects designed to promote planting, utilisation and commercial development.

One channel is through the Sustainable Farming Fund and the more recent Primary Growth Partnership – an initiative that will invest in significant programmes of research and innovation to boost the economic growth and sustainability of New Zealand's primary, forestry and food sectors.

Conclusion

In closing, I would like to urge everyone here to maintain the momentum that has built since the first conference and set your sights high for the next decade.

We can all contribute to national efforts that will result in native trees as an inherent part of New Zealand's innovative and profitable forestry sector, highly regarded for their timber and non-timber values.

I would like to acknowledge the Trust's noteworthy achievements from the past decade, not least of which are the numerous workshops conducted nationally and the publications available on native forest establishment and management.

The work completed by the Trust continues to build the New Zealand people's understanding of the unique nature of indigenous plantation forests and the importance of their protection.

Together, with Government support for the protection and development of this critical resource, I am sure the next decade will be highly productive for native forestry.

Forests and timber: past mismanagement and future opportunities

Ian Barton

About the Author

***Ian** is Chairman and Executive Officer of Tāne’s Tree Trust. As a retired forestry consultant with a lifelong interest in kauri he has authored several papers on the species. He is currently working on trials to determine site requirements for kauri.*

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In November 2000, Bill Brownell, Roger MacGibbon and Ian Barton had a conversation and decided to implement the resolution of the October 1999 Tāne’s Tree Trust Conference, which was to develop a “continuing forum for discussion and the formulation of ideas and proposals to encourage and facilitate the planting of indigenous species in production plantings and otherwise.”

Carpe diem -“Seize the day” is a short version of the whole quotation from the Roman poet Horace (23BC).

“Scale back your long hopes to a short period.
While we speak, envious time will have already fled.
Seize the day and place no trust in tomorrow.”

Horace was undoubtedly right and this is what those involved in establishing Tāne’s Tree Trust did. Within 10 months the organising group had grown to 15 people (nine of whom are still Trustees) and the Trust had been launched at the Waharau Regional Park on the Firth of Thames.

Horace was obviously not a forester for if foresters scaled back their long hopes to a short period we would have no forests left today. If the Trust had not seized the day in November 2000, we would have lost momentum and Horace’s “tomorrow” would see indigenous forestry in a very sorry state indeed.

We have achieved quite a lot over the last ten years and you will learn more about this during the conference. In summary we have raised money - about $820,000 in cash and (conservatively) $180,000 in kind; set up a Trust network group; worked with government to protect the cutting rights of those who want to plant native species for production; produced bulletins and handbooks on indigenous species; and run workshops to get the information out to those seeking it. We are working with Future Forests Research and Scion to determine what research is needed and we have set up a fund to finance research. During the last three weeks we have begun to talk to the World Wildlife Fund about the possibility of working together.

The loss of forests due to over-cutting is one of the reasons why many early civilisations, like those of Mesopotamia and Crete, failed (Perlin, 2005). The Romans also over-cut the forests of Italy, necessitating the importation of wood from the extremities of the Empire. The English, before they learned how to smelt iron with carbon from coal, destroyed almost all of their forests. Why? Simply because the forests had at first seemed endless and because “forested land brought them a mere half ducat per field whereas each field made into pasture was worth 25 or more ducats.” (Perlin, 2005).

Wood became so scarce in Babylon that rented houses did not have doors. When you moved to a new house you took your doors with you or purchased new ones at huge cost! Although the consequences of over-cutting gradually became plainer, it has taken many centuries for the message to sink in. As early as 2000 BC the felling of vast forests in the upper Tigris and Euphrates basins was increasing siltation and salinity in the lower reaches. Continual dredging was necessary, and yields of barley were reduced from 2500 litres per hectare in 2400 BC to 890 litres in 1700 BC (Perlin, 2005). Once a seaport, the city of Ephesus on the west coast of Turkey was situated 3 km inland 900 years later (Figure 1).

The immediate effect of over-cutting and scarcity of wood was an increase in price. In the twenty-four years from 1570 to 1594, the price of wood in Sussex, England increased by 400% (Perlin, 2005).

In the Middle Ages, European States began to manage their forests in a more rational way. The forest of Sihlwald, owned by the city of Zurich since 1309 regulated the annual cut from 1417 onwards.

Forests were mainly used for fuel - 90% of the wood being used for that purpose three hundred years ago. In 1999, 63% of wood harvested worldwide was burned as fuel (FAO, 1999) for industry, domestic cooking and the heating of homes. Despite the major need for wood for fuel and other economic purposes such as ship building, scientific forest management did not really begin until the early 1800s (Cotta, 1902).

Forest management has always trailed behind the economic imperative to make the maximum amount of money out of any given piece of land in the short term. This is true today – witness the difficulties in preserving tropical forests despite overwhelming evidence of the value of their retention. Recently it was revealed that deforestation in the Amazon Basin is at the lowest level in 21 years (NZ Herald, 2009), so perhaps the message is beginning to trickle through. However the area cut last year was still more than 7000 km^2 – half the area of the Waikato catchment! New Zealand is a good example of a country with mismanaged forests, despite early input from people such as Potts, Campbell-Walker and Kirk. Even today we are deforesting – converting pine forest to dairy pasture on an economic whim. While I am not against land use change *per se*, it should never be done purely for economic gain.

The time is long past for placing a price on all of the values of the forest so that soil conservation and water purity in particular are taken into account. These factors, along with biodiversity and landscape values, are very much the concern of Tāne's Tree Trust. Another is carbon sequestration. For all of these values, the re-establishment of indigenous forests by planting and other means of regeneration is a vital objective of the Trust.

So where to in the future? What are the things we need to do to encourage the establishment of native forests? We need scientific information and we need to communicate it to those who need it. Over the first ten years of the Trust's existence we have put most of our effort into two activities. First, assessment of what we already know about indigenous trees and publication of this information; secondly, the holding of workshops to disseminate the information as widely as possible.

We have only dealt with the tip of the iceberg. Growth requirements and the ecology of many species have not yet been investigated, even superficially. We do not know much about the timber of many of them, despite utilisation for over a century. There is a need for further examination of research results that are often hidden in obscure Forest Service files. This will identify gaps in our knowledge and allow us to plan and prioritise further necessary work. In addition we must identify the new needs and opportunities. Carbon sequestration is currently the most topical of these. The sequestration potential of many species is currently being investigated by the Trust with assistance from the Sustainable Farming Fund.

I would like to examine one possibility for carbon sequestration by expansion of some current thinking about radiata pine. Use of indigenous species for this purpose could result not only in increased carbon uptake on a per hectare basis but also in the production of high quality timber.

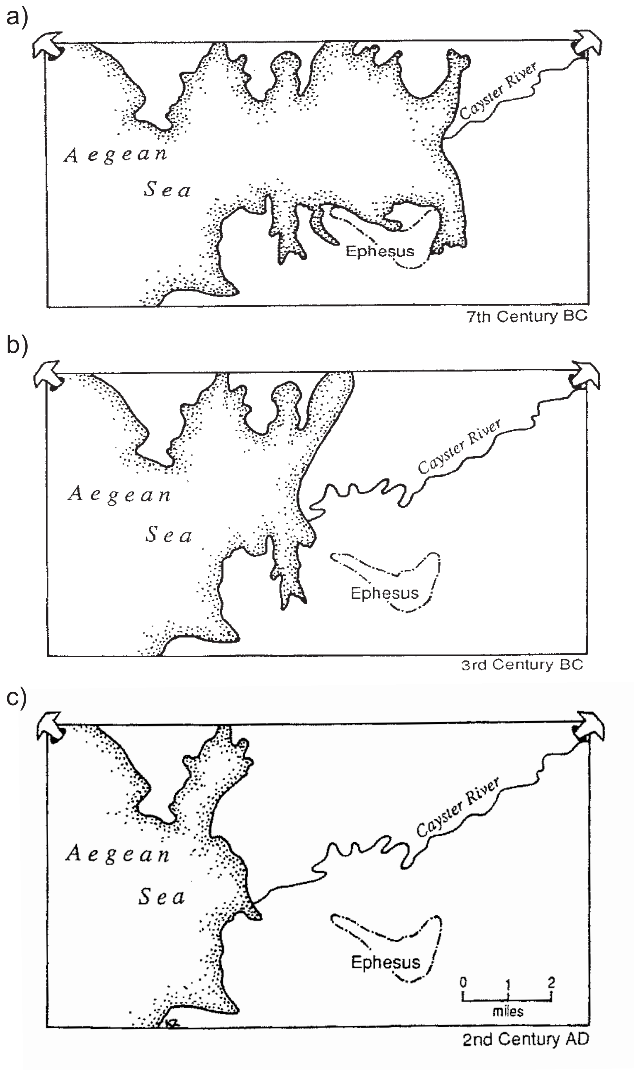

FIGURE 1: Effect of siltation on proximity of the city of Ephesus to the shores of the Aegean Sea. Location in: (a) 7 BC; (b) 3 BC; and (c) 2 AD (from Perlin, 2005).

It is currently considered that New Zealand could overcome part of our carbon problem by planting large areas of radiata pine. This despite the fact that we currently struggle to get reasonable prices for the best-quality radiata pine timber. Some people consider that we should plant radiata pine and leave the stands unmanaged – just grow them for carbon sequestration and collection of carbon credits. This solution is short sighted. The net effect would be the creation of huge areas of poor quality forest, prone to fire and disease. Perhaps I should remind you of approximately 121 000 ha of radiata pine that suffered 25 - 35% mortality from the wood wasp, *Sirex noctilio* after the Second World War. This was due to the absence of thinning during the war. The increase of combustible material in these stands contributed to the destruction of 121 000 ha in the Taupo fires of 1946 (Elliott, 1976).

What about the long term view? Let us use radiata pine as a carbon sink *as well as* a nurse for indigenous species. Rapid accumulation of carbon within the first few years could earn carbon credits which could then be used for thinning to produce high-value timber in residual trees. When conditions are right, these trees could be replaced with indigenous species with a high timber value which can, over a long period, sequester greater amounts of carbon than radiata pine. The timber would be employed to make long-lasting products that would continue to sequester carbon.

First we need to convince the government that in order to avoid the mistakes of past millennia, we start to define excess greenhouse gas emissions as pollutants. We must counter the cries of woe from polluting industries by placing a monetary value on the right to pollute. This can be used to pay for the pollution. Until government is prepared to take this unpopular step we will never come to grips with impending climatic challenges.

Let us manage indigenous forests using “continuous cover” systems, following methods that John Wardle is currently employing with radiata pine in mid Canterbury. He expects a sustainable timber harvest of 1100 - 1200 m^3 (40 m^3/ha/yr) in a 40 - 50 year cycle. Compare this with approximately 600m^3/yr for radiata pine managed on a clearfell system. Harvesting is carried out every two years in each stand in the forest. Yields are 15 - 20 stems/ha, each stem containing approximately 2.5 m^3. The lower cutting limit is 60 cm diameter at 1.4 m above ground level (DBH) and individual trees, rather than groups of trees, are selected for removal in order to maintain the wind stability of the stand. Stocking rates are high with first thinning to 750 stems/ha and subsequent thinning to 300 - 350 stems/ha. Keeping the stands tight decreases branch size, minimises wind-throw and reduces damage to residual trees during felling. The pruning regime is more intense than usual and the final number of pruned trees is approximately 500/ha.

Growth to a minimum size of 60 cm DBH maximises production of 6 m lengths of Class 1 pruned logs. In the first three years of harvesting more than 45% of the volume felled has yielded either peeler or P1 Class material. The New Zealand average yield is 24%. Tight stands and small upper branches increase the value of unpruned logs. Slower tree growth also means that both quality and stiffness of logs are improved (Barton, 2008).

The harvesting system creates small gaps in the stands. These will increase in size, because trees at the edges, having more space and light, will grow faster. At successive harvests an increased percentage of trees exceeding 60 cm DBH will be located at the edges of gaps, and gap size will increase more rapidly with successive fellings.

John expects regeneration from seed to begin when stocking rates drop to about 200 stems/ha. If we want to convert such stands to indigenous species we will either have to plant nursery-raised stock when light levels become sufficiently high, or encourage natural dissemination of seed by birds and wind. I suspect that for many shade-tolerant native tree species, the associated radiata pine stocking levels will have to be as high as 300 stems/ha. By the time the last pines are felled a well-stocked forest of indigenous trees 10 - 15 years old should be developing. This approach will not only produce more income from radiata pine than conventional clear-fell forestry, but also assist the establishment of a potentially-productive indigenous forest.

Another opportunity centres around the increasing interest of many iwi groups in managing existing indigenous forests and in planting indigenous tree species where radiata pine, Douglas-fir and other exotic species have been felled. An example of this is the effort of Ngati Whare o Te Whaiti on Project Whirinaki, aided by John Herbert and Tony Beveridge. I predict that this slowly-developing initiative will accelerate in the years ahead. Impetus could be given by a realistic price paid for sequestered carbon and also by combination of the Maori holistic approach to forest management with European scientific method. Together these two systems will achieve a great future for the indigenous forests of New Zealand.

Some other areas in which Tāne’s Tree Trust should be working:

- building up the Trust’s dedicated research fund so that the capital created can be used to increase the amount of research on indigenous species;
- increased investigation into the quality of faster-grown timber. A small amount of work is being done with totara

and kauri, but much more is needed;

- use of carbon credits;the genetics of the most important species should be examined. Again a small amount of work has been done with kauri and totara but work with other species is likely to be of immense value; and

- average world temperatures appear to be rising as a result of the burning of fossil fuels. What threats to indigenous tree species are associated with a warmer climate? Will the patterns of insect and fungal attack change? Will fire risk increase?

Find ways of changing the financing of indigenous forestry. Some ideas might be:

- use of carbon credits;

- payments to forest owners could be based on non-forestry values. For example, in a Tāne's Tree Trust trial in the Lake Taupo catchment, land owners are paid to plant trees on low-quality land, the aim being to reduce the amount of nitrogen entering the lake; and

- payments to foresters for increased bio-diversity and other positive attributes of sustainably managed forests. New Zealand must start to pay foresters for non-wood values.

Finally, implement all of the good ideas that this conference will come up with over the next three days.

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Using native forests to take carbon dioxide out of the atmosphere

Dr Jan Wright

About the Author

***Jan** is currently the Parliamentary Commissioner for the Environment. She has worked as an independent policy and economic consultant for a wide variety of government agencies; has taught policy analysis at Victoria University; was Chair of Land Transport NZ and Transfund NZ, and a Board member of Transit New Zealand, the Accident Compensation Corporation and the Energy Efficiency and Conservation Authority. She was appointed Commissioner for a five-year term in 2007 and is particularly interested in the growing alignment of environmental and economic interests.*

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Introduction

I want to talk about global community values – as I think climate change is the most serious environmental issue of our time - and in particular I want to talk about taking carbon dioxide out of the atmosphere, which of course trees do so well. There are two things we need to do about climate change: we need to mitigate - to reduce our emissions of green house gases to the atmosphere, and to adapt to the changes that will come. Today I want to talk about earning carbon credits and about the Emissions Trading Scheme (ETS) because the ETS has the potential to make growing native trees more profitable by generating an immediate income stream. But it is very complicated, and while you have people within your organisation who appear to be clued up about it, do they understand it?

There are some very big concerns with the ETS and the proposed amendments and I will suggest things you might like to lobby about. When this invitation was received I looked up your website and found your vision, and I want to ask whether the aim about the majority of landowners planting trees by 2020 includes city dwellers, because I suspect it doesn't? On my 1/8 acre in Wellington I found karaka, kowhai, ngaio, pohutukawa, tarata, mahoe and kawakawa. Now these are not important timber trees but this is not unusual in Wellington. A noted environmentalist said some years ago that she liked living in Wellington because the environment wins. There is so much green belt because of the steep land that has been left, and with the advent of the Karori Sanctuary the tui have returned. There are in fact complaints from the Hutt Valley that there is just too much noise from the tui! Rushing in to a select committee in Parliament two to three weeks ago, my heart lifted when I heard tui in the trees right outside Parliament. Even more inspiring, the next day I heard and saw them outside Treasury, so there is hope for all of us!

I want to now cover the area of my concern. Obviously carbon sequestration is just one of the ecosystem services provided by native forests but I want to talk about it because of knowing something about it as a consequence of my work. The Parliamentary Commission for the Environment (PCE) is important because it is independent and there is a lot of interaction through parliament via a variety of Select Committees. Also the Commissioner is accountable to Parliament not the Government, and it's really quite a privilege to be able to say exactly what you think – diplomatically of course. The work of my office takes two forms. One is to carry out reviews and investigations which result in reports that are tabled in the house; and then there is advice to Parliament and Select Committees. A lot of time is spent talking to Select Committees about some of those reports which are tabled in the House. So we are pretty busy.

Emissions trading scheme

My involvement in carbon sequestration by trees began with the original bill (the 2007 ETS Bill) under the previous Government. The PCE was asked to be an independent advisor on that and we gave some advice. It is worth noting that we actually have an ETS in place now. Because there is a Bill in parliament at the moment there is a perception that we don't have an ETS and this new Bill is somehow going to give us one. We do have an ETS in place; the current Bill is about an amendment to it. Following this a Review Committee was set up, as a special Select Committee, by the current Government and chaired by Peter Dunn, to review the last Government's scheme. I was an independent advisor for that as well and have also made a submission on the Amendment Bill that is sitting in Parliament at the moment. If you have been reading the newspaper you will find this is a very hot topic, with a Select Committee report back to Parliament that was extremely unusual, for it consisted entirely of minority reports - including one from Government members. It was stalemate; which means that the Bill will now be debated clause by clause in the House and each clause voted on separately. It will be a very complicated process; there will be long hours, grumpy MPs, a great deal of confusion and Parliament will go into urgency.

There are of course various problems with the ETS and some of my concerns are over the amendments, because they weaken it so much. I am not quiet about this and have spoken about it. There is great benefit going to major industrial emitters and agriculture from foresters and from the tax payer. It has become, with these amendments, extremely unfair and for that reason it is probably not politically sustainable because Kiwis value fairness very highly. You as foresters need to be aware of this; that you are the ones who are not doing well and yet the role of trees in sequestering carbon is extremely important. The Bill is focused on carbon and does not really consider the other benefits that trees provide. Earlier this year, before I got involved in the ETS, we released a report on the South Island high country and one of the great concerns was the spread of wilding pines. I went down there recently and was shocked. You get this unshaven chin effect with some really serious things happening in a number of ways. The dense impenetrable thickets of Douglas-fir are a fire risk to Queenstown, apart from anything else. The PCE rather likes them being called feral pines and made a recommendation in that report about the funding of weed tree control. But I include this issue in this talk because the ETS, both the one we currently have and the proposed amendments, actually exacerbate the weed tree problem quite seriously. I will explain this later.

Trading carbon credits

Figures 1 to 3 show why native trees are good for sequestrating carbon. Native forest provides ecosystem services such as biodiversity, soil conservation and flood protection; and of course we are not talking about a monoculture so it's far less vulnerable to pests.

In the ETS you trade these things called credits, which are the right to emit a tonne of CO_2, and NZ native forest carbon credits may well be worth more and sell for a higher price than exotic tree credits. You can imagine a company in USA buying carbon credits on the international market to offset its CO_2 emissions, using as part of its advertising that the carbon credits bought are for native forest in beautiful green NZ – and using that as a marketing ploy. I think that when this thing gets going internationally, the market prices will differentiate themselves along lines like this. Imagine trading these credits from indigenous forest in NZ on a stock exchange as A grade credits which attract a higher price.

FIGURE 1: Permanent indigenous forest provides a wide range of ecosystem services.

So when acting as an independent advisor on the first ETS, the one the previous Government passed, one of the recommendations made was to ensure the ability to identify the source, because you are not going to get a higher price for indigenous carbon credits if their origin is not clearly established. The response from the officials to that recommendation was that the paper trail would allow the tracing to the origin of the carbon credits. So far we have not done work in my office to satisfy ourselves that this is so and it is suggested that this could be an activity for your Trust; actually satisfying yourselves that the carbon origin is traceable, when the regulations come out from MAF.

Sequestering carbon

Another way in which native trees are good for sequestering carbon is that you will only burn small quantities of the wood. The greater part will remain as sequestered carbon in buildings, furniture etc.

However one of the problems NZ has in negotiating internationally around the ETS rules and Kyoto obligations is what's known as the instant oxidation rule; that is, trees that are felled are assumed to have instantly oxidised the carbon back to CO_2. NZ negotiators are arguing for a change to this because a lot of the timber, native or not, which is produced does get stored for long periods in the form of buildings and

FIGURE 2: Carbon stored for long periods in furniture and flooring.

furniture, and in roots and stumps and logs that don't rot instantly. The Kyoto rules around forestry were formulated around protection of tropical rainforest of course, and don't fit NZ conditions. Native trees are also better than exotic trees in sequestering carbon because they are not being used as fuel. A third reason is that in the long run natives store more carbon and the income stream continues for much longer.

FIGURE 3: Exotic monoculture is less effective at carbon sequestration than native forest.

One of the problems of the ETS is that it is so difficult to understand. A farm may have methane and nitrous oxide gases coming from it and these can be offset by planting exotic forest. Once that forest is mature, the sequestration of carbon ceases as a steady state is reached, so you can only offset your emissions for a period of time. At the end of the rotation, as they are exotics, you are going to fell them and then you really are in trouble because you will incur a carbon liability.

To me it makes a lot of sense, if you have a farm and you are trying to offset agricultural green house gases with forestry, that you actually diversify with indigenous forest, which means that the income stream will continue for much longer. It is expected that a mature native forest will sequester more carbon than exotics.

Now one of the major issues with the ETS and the regulations that will follow is around the sequestration rate. Figure 5 is based upon data from the Gisborne area. The black line is for radiata pine and you can see how it stores the carbon cumulatively and then with harvest, storage falls but increases again after planting. From this you get a saw-tooth pattern of carbon storage. Of course in a large exotic forest you don't have to fell everything at the same time –fellings can be staggered. The green band shows measured rates of carbon storage in regenerating manuka and kanuka, which is of course the first succession stage of the indigenous forest. Ultimately, as the dominant trees come in you will end up with more carbon stored than with pines. The red line shows the current default rate for native forest, a very conservative 3 tonnes/ha/yr regardless of where you are and what the rainfall is etc. whereas the green band shows actual rates that have been measured by Landcare Research.

FIGURE 4: Indigenous forest stores carbon in all forest strata.

Measuring the carbon sequestration rates of individual species

When the officials working with the existing ETS (the one the previous Government put in place) began to draft the regulations for measuring the carbon that is stored in trees, they had plenty of data on radiata pine. They had tables with variation in location, variation in rainfall etc. but when it came to indigenous trees there was much less data, and when you have little information the natural response is to be conservative. So you get a bias built in because of the small amount of information and the bias, of course, is exacerbated by the fact that pine does grow faster and removes the CO_2 from the atmosphere at a faster rate. When I was giving advice on that first ETS bill and during the Review Committee stage, both DOC and Landcare

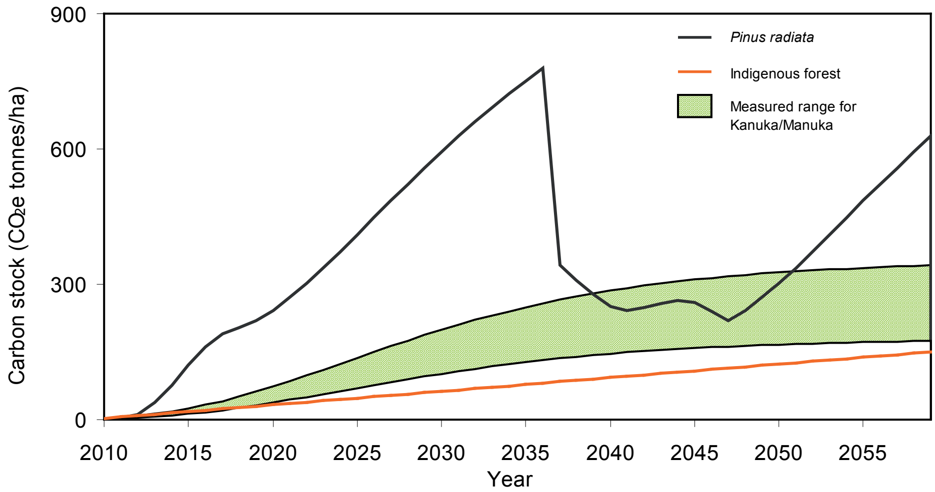

FIGURE 5: Measuring the sequestration rate – a Gisborne example.

were asking for measurements, not conservative assumptions, around the growth of native forest. MAF responded to that and are drafting up new tables as we speak. They weren't quite prepared to share these with me although we asked them last week if they were ready. We think they will be more accurate but we don't have any sense of how much they have shifted.

There are of course many people developing different ideas for calculating carbon sequestered by indigenous trees in different parts of the country. One man spent three years of his life designing a scheme that I thought was superb. He is now so disillusioned that he has given up after waiting for regulations and because the rate of 3 tonnes/ha was so low. His concept was to be applied to the classic steep eroding remnants of native bush in gullies. The idea was to do deals with individual farmers and take steep hill country with very marginal value for grazing; fence it off and sit back and collect the cheque for the carbon. But he wanted to do a deal with one of the big manuka honey producers as well so you could get two cheques a year, one for the carbon and one for the manuka honey. This scheme was extremely well planned right down to how fire insurance was going to work etc; but unfortunately it was abandoned. These false starts and stops kill off innovation!

Problems with the ETS

The problem with the ETS Bill is that there is a considerable weakening of the current scheme, away from emitter pays or polluter pays to the tax payer pays, and the weakening is such that if the Bill goes through in its current form it will have virtually no net effect in reducing NZ greenhouse gas emission. One of the big features of these amendments is the intent to follow Australia's scheme. Basically the Bill says "We don't know what to do in NZ, so we should follow Australia." Now Australia's scheme is still a proposed scheme and it seems rather odd to be setting legislation in place which will follow a scheme about which we know little. There is a lot of talk of aligning with Australia's scheme and that's all there is at the moment. Aligning might mean that different sectors could come in at the same time but we could well be linking with Australia's scheme. In Australia's proposed scheme, the credits that they have and our carbon credits would be the same - the NZU's and the Australian units would amalgamate. The Australia scheme says you can't sell credits offshore to any other country. So if you are producing carbon credits by sequestering carbon in trees here (NZ) and were linked with the Australian scheme you may not be able to get the best international price for your carbon credits since you would be forced sell at the price that emitters in Australia and NZ were prepared to pay. Do not underestimate how important it is to be able to sell forestry credits internationally. You could die in a ditch over this one!

The problem with wilding trees

Finally I would like to get back to the subject of wilding trees. As far as carbon is concerned there are two problems – one a liability, and the other a credit. The liability side - clear the wildings and you get an invoice because you have a carbon deficit. On the credit side – let the wildings go and you get a cheque. Both things exacerbate the wilding tree problem and we have recommended a number of amendments to the current Bill which you can read on our web site. There are a number of methods that could help but we don't actually see a way through to totally fixing the problem. This really does need attention. I realise of course that the wilding pine thing is essentially a South Island problem, although you have the Kaweka forest and wildings in the Central North Island and of course other species of weed trees. Moving to the liability problem, if you clear land that was in forest before 1990, you get a carbon liability. That's one of the basic components of the scheme.

Figure 6 shows Mid Dome in Southland. Well before 1990, 250 ha there were planted with contorta pine to stop soil loss and there didn't seem much else to do with the land.

FIGURE 6: Mid Dome Planting of Pinus contorta to control erosion.

In good faith it was believed that planting the area was the right thing to do for soil conservation but contorta pine turned out to be much more promiscuous than anyone thought. There is a problem and they are working hard, and at great cost, to get the wildings off Mid Dome (see their web site http://www.wildingconifers.org.nz). However, if they take out the original 250 ha which of course comprises the biggest, oldest trees with the most seed, they will incur a $3 million carbon liability. They can clear all of the small regeneration that has established since 1990, but you can't take out the big ones without making a payment for it. The current Bill, the amendments before Parliament at the moment, says you can get exemptions from carbon liability if they are wilding trees, but there is another clause in the March Treasury Bill amendments which is trying to control its fiscal risk. What it says is that you can get an exemption but when you do the Minister for Climate Change must consider the amount of money involved. And where is the biggest amount of money going to be – with the bigger older tress with the most seed, so of course that exemption is a real problem, in my opinion. Mid Dome is a particular problem because of course the wind spreads seed a great distance.

Figure 7 is a photograph of Molesworth in Marlborough. One of my recommendations is that we must "*Establish in which circumstances, if any, wilding pines or weed trees generally might be appropriate for carbon sequestration*".

FIGURE 7: Wilding regeneration on Molesworth Station.

It is being said that if Molesworth goes carbon farming we won't have any more problems. But these seeds can travel up to 30 km, so one farmer can encroach on someone else's property rights. This recommendation was adopted by the review committee but nothing has happened since. So the ETS as it is, incentivises carbon farming in such cases, because here are these wonderful carbon sequesters that you don't even have to plant. However if we just turn our backs we could end up with large parts of the high country covered in a monoculture of contorta pine. Now 25% of our visitor nights by tourists to NZ are spent in the high country. Imagine driving through dense impenetrable thickets of contorta – can't see the lakes, can't see the mountains, icy roads. Horrible and not a great advertisement! Once they have grown to their maximum, that's it! There's nothing else you can do and the cost of clearing for any other land use would be phenomenal. Leaving wildings to spread is very short term thinking.

Conclusion

In summary there are many reasons to store carbon in native trees and I haven't really gone through them exhaustively: there are ecosystems, services, the fact that you are not actually going to be burning the wood that you harvest from native trees. The income from the carbon actually goes for a longer time over a longer period and we end up with more carbon sequestration. There is also the point that indigenous forests may well attract a higher price for their carbon credits than exotic trees; another reason for growing native trees.

It is critical that you are able to sell carbon credits internationally otherwise you won't get the highest price and you certainly won't be able to get any premium for the fact that they are native trees - biodiversity credits if you like - and not just ordinary old radiata pine credits. The key here is that if we link with Australia, it means we really become part of the Australian scheme which is not going to sell carbon credits internationally. It is not in their proposed scheme.

Finally the wilding tree problem is made worse by the ETS and that whole situation needs some serious thought.

If you are interested, our website: http://www.pce.parliament.nz/home contains information on some of the things I have spoken about. Here you will find the submissions, the advice to Select Committees and so on. If you are interested in the wilding tree problem in high country you can order a report there and also ask questions that are detailed or technical. I have two experts in my office and you can email them and ask for those questions to be answered.

Thank you very much.

Endnotes

New lookup tables were published in February 2010, see: *http://www.maf.govt.nz/sustainable-forestry/ets/post-1989/ilut-consultation-doc.pdf*

Non timber values of planted indigenous forest

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Abstract

Since the first human settlement approximately 800 years ago, 65% of New Zealand's land surface area has been deforested. There is a long-held desire for indigenous tree species to be planted to provide wood products and a range of non-timber values. Currently most of our knowledge about the values associated with indigenous forests is derived from naturally-regenerating stands and old-growth forests. Extractive and non-extractive uses for indigenous forests, other than timber production, are listed and two of these (biodiversity and carbon storage) are considered in detail. Synergies and trade-offs between different types of values are analysed and discussed. Although benefits from increasing the area of planted and regenerating indigenous forest are apparent, planning must take into account potential risks such as fire and land-use change.

Keywords: multiple-use; carbon; biodiversity; non-timber values; ecosystem services; indigenous plantations; regenerating forest; beech thinning; indigenous forests.

Desire for establishment of new indigenous forests

Forests currently take centre stage internationally and nationally through issues of our times such as the mitigation of carbon emissions and the protection and restoration of biodiversity. They are important in New Zealand where, since human settlement approximately 800 years ago, 65% of the land surface has been deforested (Wardle, 1991). As a consequence, the remaining indigenous forests have enormous environmental, cultural and economic significance. Regeneration in deforested areas is commonly subject to weed competition, grazing and burning, particularly in low-rainfall areas, and forests have been slow to recover. In some other temperate regions of the world the situation is different. For example, forest cover in New England (USA), which had been reduced from 90% of the total area to 10% 150 years ago, has since expanded to 90% (Foster, 1992). It appears that New Zealand tree species are poorly adapted to recover from the effects of human-related disturbances (Wardle, 1984). As a counter measure, interest in the establishment of indigenous plantations has developed over a long period. Poor performance of such plantations led to increasing development of exotic plantations (Roche, 1990). In spite of a strong desire by some foresters for the establishment of indigenous trees, the planted area remains very small. Most of our knowledge about the non-timber values of indigenous forest has to be derived from naturally-regenerating stands and old-growth forests.

Creating novel ecosystems – new forests

Natural forests differ from plantations in that they consist of complex mixtures of tree species with different age structures. They support numerous life forms, and can contain large amounts of coarse woody debris (e.g. Richardson et al., 2009). New Zealand's indigenous forests are spatially variable due to the slow adjustment of species composition to periodic disturbance and differences in soil nutrient availability over short distances. Long-lived (up to 1000 yrs) podocarps often grow next to short-lived (up to 300 yrs) hardwood trees, and fern-rich ground layer vegetation influences tree regeneration.

The restoration of non-timber values such as biodiversity, in planted forests presents a challenge, especially in light of ongoing human activity. Local species extinction and reduction in genetic diversity have resulted from alteration of population size and range. Land management practices in deforested landscapes have altered the environment, for example through application of fertiliser, which has consequences for related processes such as productivity. The landscape is also being transformed by the establishment and spread of invasive species (Allen & Lee, 2006).

Most deforested areas are currently subject to the influence of exotic plant and animal species. For example, gorse and broom are now widespread and dominant in some localities. Both of these exotic shrubs fix atmospheric nitrogen, apparently at greater rates than any native plant species. Germination of their seeds is stimulated by fire, and both form distinctive pollinator assemblages. Sullivan et al. (2007) showed that early dominance of exotic species in plant communities affects biodiversity during later succession. The complexity of existing indigenous forest, history of the effects of human activity, and specific traits of exotic species all suggest that areas planted with indigenous trees will develop into novel ecosystems (Walker et al., 2008).

Non-timber values

Planted indigenous forests have a wide range of potential uses that are additional to wood supply. From a human perspective, the relative value of these uses will vary through time (e.g. Kirkland, 1988). They can be divided into two main groups:

- extractive uses – those that involve active removal of forest products, e.g.:
  - honey – targeted species or broad-spectrum collection;
  - game animals – commercial and recreational hunting for trophies, meat and fur; and
  - cultural harvest products – aspired to by some iwi.

- non-extractive uses, e.g.:
  - improvement of stream water quality and quantity; regulation of flow rates (Phillips, 2005);
  - control of soil erosion – long-term provision of protective canopy cover and a cohesive root network;
  - recreation – tramping, hunting, etc.;
  - identity – strong existing and legendary associations, especially for some iwi;
  - biodiversity – unique arrays of indigenous species, ecosystems, and ecological processes;
  - carbon storage – currently a contribution to New Zealand's international commitments; and
  - land value increase – there is some evidence that restored forests, and their

increased biodiversity, can improve the value of land.

We will consider biodiversity and carbon storage below in some detail, because of their current priority, and then present a general consideration of the relationships among non-timber values.

Biodiversity – a unique value

The establishment of native tree species provides a distinctive value through its contribution to the indigenous character of the New Zealand landscape. Indigenous dominance is one of three biodiversity indicators being developed by the Department of Conservation (Allen et al., 2009). Collateral benefits can also be expected for non-dominant indigenous biodiversity components. For example, on lands administered by the Department of Conservation it appears that endemic bird species are most diverse in indigenous forests, while introduced species are diverse in grassland (Figure 1). Grassland is often dominated by introduced plant species. The level and rate at which non-dominant biodiversity components typical of old-growth indigenous forests become established in new forests will depend upon such factors as seed dispersal distance, seedling habitat requirements (e.g. presence of rotting logs), physical disturbance, the presence of pests, frequency of fire events, and forest management regimes. Planned establishment of some components and related processes (e.g. carbon and nutrient cycling) is likely to take time, possibly centuries, and will present a challenge in new forests developed from the planting of a limited range of tree species.

Although the development of new indigenous forests may enhance some biodiversity components, an eventual desire may be to harvest timber from these forests for income generation. Research in existing indigenous forests has shown that harvesting carried out under low impact, small-coupe systems in beech forest can affect both above- and below-ground biodiversity in harvested patches (e.g. Wiser 2001; Dickie et al. 2009) as well as in the adjacent unharvested forest (e.g. Wiser et al. 2005). More generally, it appears trading of timber products may not always provide sufficient financial returns to protect other forest values (e.g. Newton 2008).

Carbon storage – a new opportunity

New forests offer opportunities for carbon storage and income generation, especially when they replace grassland vegetation (Table 1). Most of the carbon in forests is found above ground level. In grassland ecosystems, a greater proportion of the carbon is present below ground (Table 1). Mason et al. (2009) assessed the potential and actual carbon stocks on lands managed by the Department of Conservation and showed that the greatest gains would be made through reforestation of grassland. Estimated Kyoto-compliant gains of 231 - 682 million tonnes of CO_2[1] are considered to be possible on public conservation lands.

[1]Here we use CO_2 to denote the number of tonnes of CO_2 that have been removed from the atmosphere and stored as carbon in soil and/or vegetation. Each tonne of stored carbon is equivalent to 3.67 tonnes of CO_2 removed from the atmosphere. We use units of CO_2 throughout the text.

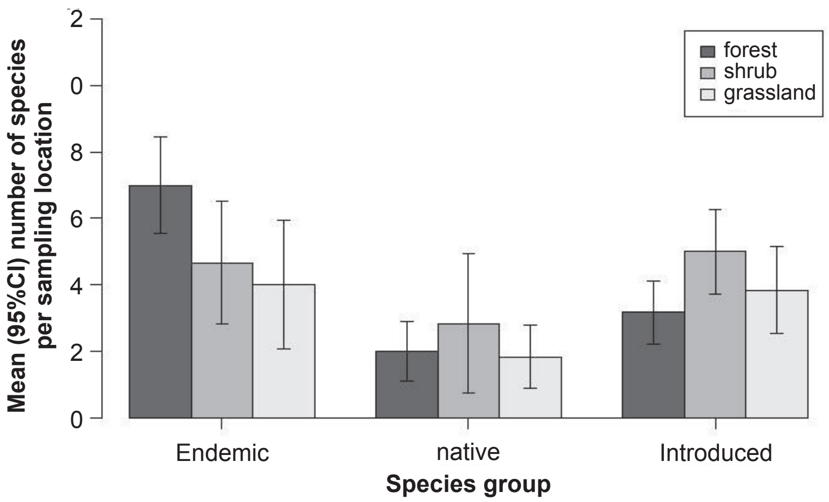

FIGURE 1: Bird species richness at systematically-located sites on lands administered by the Department of Conservation. Error bars = 95% Confidence Interval. Source: Allen et al., (2009).

TABLE 1: Estimates of carbon content of components of grassland and forest ecosystems. Values are expressed as tonnes CO_2/ha (adapted from Burrows et al., 2008).

	Total	Above-ground live vegetation	Soil carbon
Grassland	55–790	4–12	18–640
Forest	590–2670	249–1173	231–825

With Ministry of Agriculture and Forestry funding, this research is currently being extended to estimates for the whole of the New Zealand land surface. Carbon sequestration may present an attractive income-generating opportunity through the planting of new forests, but there is some reason for caution:

- the science underpinning carbon management is not fully developed; and
- there is instability in international and national regulations for carbon credit trading, particularly beyond 2012.

The rate at which new forests sequester carbon is likely to be highly variable (e.g. Benecke & Nordmeyer, 1982). Natural regeneration will be dependent on the proximity of seed sources; plantations on species selection and seedling quality. Possible constraints on sequestration rate are biotic factors such as competition with resident plants, herbivory, and the nature of soil organisms and physical effects such as those associated with fire and erosion. The Ministry of Agriculture and Forestry has set a default value of 3 tonnes CO_2/ha/yr for all post-1989 indigenous forests in the Permanent Forest Sink Initiative and Emissions Trading Scheme (Ministry of Agriculture and Forestry

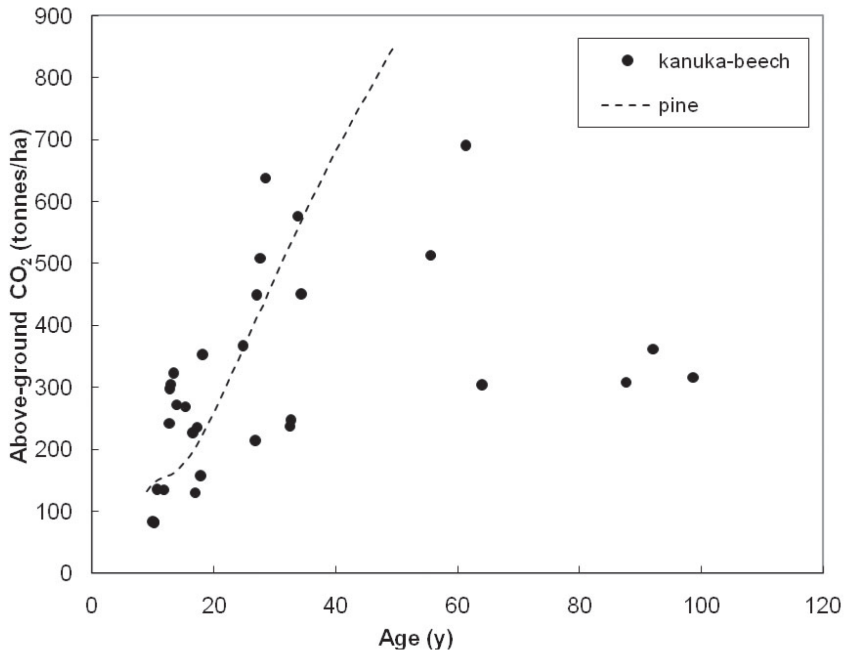

FIGURE 2: Carbon content of above-ground biomass in stands dominated by kanuka at Hinewai, Banks Peninsula (Source: Burrows et al., 2009). The dashed line indicates Ministry of Agriculture and Forestry default values for radiata pine in Canterbury. A voluntary system for carbon trading from regenerating indigenous forest on private land was established by Landcare Research in 2001 (Carswell et al., 2003). Under this system known as EBEX21®, carbon credits are sold through carboNZero[certTM], an entity established by Landcare Research. More than 25 000 tonnes of CO_2 have been sold from 4000 ha, giving a return in excess of \$40/ha/yr. Currently there is shift from voluntary to compliance credits registered as part of the Permanent Forest Sink Initiative. The demand for credits with a biodiversity premium has outstripped that for alternative credit sources. This suggests it is appropriate to consider interactions among multiple non-timber values.

2009). Measured values for naturally-regenerating areas of indigenous vegetation range between 1 and 12 tonnes CO_2/ha/yr. Previously-forested areas with a high potential carbon sequestration rate are likely to have the following characteristics:

- moderate to high rainfall (> 1200 mm/yr);
- warm temperatures during the growing-season; and
- fertile soil.

Estimates of the amount of carbon in above-ground biomass have been made in regenerating forest of various ages at Hinewai on Banks Peninsula (Figure 2; Burrows et al., 2009). These suggest sequestration rates greater than 10 tonnes CO_2/ha/yr. This is similar to the Ministry of Agriculture and Forestry default value for radiata pine in Canterbury (Figure 2). The Hinewai stands were dominated by kanuka. Carbon sequestration appears to be facilitated by the rapid establishment rate and high wood density observed in this species (Burrows et al., 2009).

Managing for multiple non-timber values

Limited financial returns from wood products, expectations of society with respect to the environment, and the need for other ecosystem services have led to a resurgence of interest in the concept of multiple-use forests. The importance of understanding the relationship between different uses has been underlined by Bennett et al. (2009). When grassland is replaced by planted indigenous forest, some benefits will be synergistic, some will have trade-offs, and the relationship between others is likely to be variable. More carbon would be accumulated in the developing forest, which would also have a positive effect on stream water quality. Stream water quantity, on the other hand, would be reduced (Jackson et al., 2005). The relationship between availability of wild game (e.g., red deer) and carbon accumulation is variable because the presence of herbivores may either increase or decrease the total carbon stored in forest ecosystems (Peltzer et al., 2010). Planting of indigenous trees would increase both biodiversity and carbon storage.

Relationships between different benefits of indigenous forest plantations may be more complex. As an example we present an analysis of trade-offs in carbon sequestration and merchantable timber from silver beech forest during silvicultural thinning. Easdale et al. (2009) demonstrated there were considerable gains in residual tree growth following thinning. The 58-yr-old trees had regenerated naturally after clearfelling. The growth response demonstrated the effect of inter-tree competition on individual tree growth noted for many indigenous tree species (e.g. Coomes & Allen, 2007;

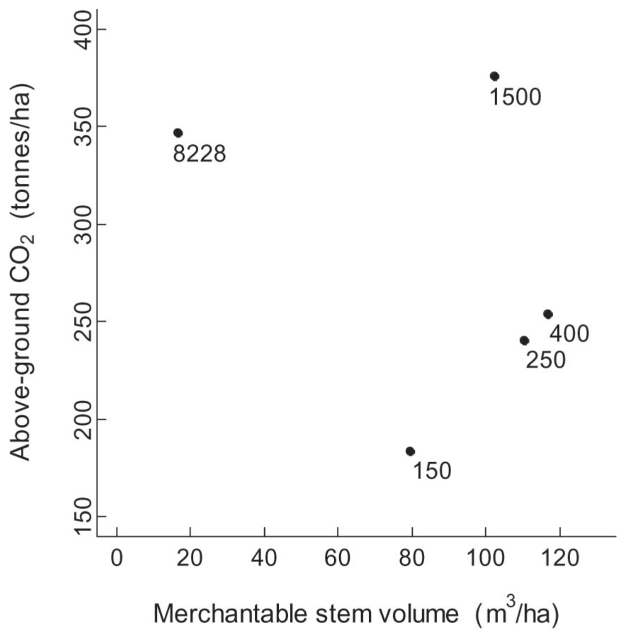

FIGURE 3: Relationship between above-ground carbon storage and merchantable stem volume in silver beech stands subjected to different second-thinning regimes. Values beside points are residual stockings (stems/ha). The value of 8228 stems/ha represents an unthinned stand; other stands had a first thinning to 1500 stems/ha at age 20.

Hurst et al., 2007). A second thinning (at 30 years) of silver beech was associated with higher above-ground carbon storage and greater merchantable stem volume when stocking rate was reduced from 8228 stems/ha to 1500 stems/ha (Figure 3), with more intense thinning leading to yet higher merchantable volume but lower carbon storage, and finally the most intense thinnings (150 and 250 stems/ha) led to both lower carbon storage and merchantable volume – with the overall relationship taking a “horseshoe” shape (Figure 3). Work by Easdale and co-workers is now examining the effects of rotation age on these trade-offs and the economic value from carbon storage and/or timber production.

Many benefits can accrue from an increase in the area occupied by indigenous forest. Benecke and Allen (1992) have argued that large parts of New Zealand should be reforested as part of a long-term land-use change. A desirable goal might be an increase of indigenous forest cover, currently 23% of the land area, to 30% by 2100. This would include naturally-regenerated and strategically planted forest. Increased understanding of associated values and trade-offs between benefits and costs would be essential for the realisation of this goal (e.g. Newton, 2008). The use of matauranga Maori (traditional knowledge) of indigenous forest management can assist this (e.g. Lyver et al., 2008). It will also be necessary to plan for appropriate management of risks such as fire and additional land-use change.

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Tāne's Tree Trust activities and projects – achievements during the last ten years

Ian Barton, Peter Berg, Roger MacGibbon and David Bergin

About the Authors

All four authors are founding Tāne's Tree Trustees. They have been involved in many of the Trust's activities and projects over the last decade. Ian Barton is Chair and Peter Berg Deputy Chair of the Trust.

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Introduction

Establishment of the Trust

The Trust originated in the Native Tree Forum, a highly successful conference held in October 1999 at the University of Waikato. The Forum was inspired by a need for "more incentive, more encouragement and more enthusiasm for replenishing our native tree heritage" (Silvester & McGowan, 1999). The Forum listed several objectives that it wished to achieve, including the dissemination of information on establishment, growth and sustainable management; improvement of the level of debate on the role of native species in our landscapes; and the discussion of issues identified by people keen to establish and manage native trees. It was successful in highlighting these aims and in establishing the need for them to be addressed in future meetings.

The Forum organising committee, consisting of representatives from science, forestry and community organisations, continued to meet after the conference. Within two years, Tāne's Tree Trust was officially launched at the Waharau Regional Park near Auckland (Tāne's Tree Trust, 2001). Objectives were formulated in accordance with the vision of the Trust, which is *"To promote indigenous forestry as an attractive land use"*. The objectives are:

- to build a network of knowledge-sharing among stakeholders;
- to retrieve past incomplete research projects pertaining to establishment, growth and productive uses of indigenous species;
- to establish new research projects;
- to maximise economic incentives for establishing indigenous trees by reducing establishment costs;
- to resolve tax-related, legal and political obstacles that are current disincentives to the planting of indigenous trees; and
- to raise funds to facilitate the required work.

Progress during the last decade

In the ten years of its existence, Tāne's Tree Trust (TTT) has built on the platform provided by the 1999 Forum and has addressed many of the above objectives. Activities can be grouped into four main categories:

1. the creation of a ***network*** of members interested in the work of the Trust;
2. the running of ***workshops and conferences*** promoting the establishment of indigenous forests;
3. the undertaking of ***research projects***; and
4. the production of supporting ***publications*** including proceedings, technical reports, bulletins and research papers.

Funding for this work has been obtained from a wide range of sources including individual and corporate membership subscriptions, which underpin all of the Trust's activities. Funds for specific projects have been received from many agencies including the Ministry of Agriculture and Forestry Sustainable Farming Fund under both General and Climate Change portfolios, the Forest Industries Training and Education Council, Forest Industries Development Agenda, and the Lake Taupo Protection Trust.

Direct and in-kind support for specific projects has come from collaborating agencies which include the NZ Forest Owners Association, the NZ Farm Forestry Association, Scion, Future Forests Research, Landcare Research, the ASB Community Trust, the Northland Totara Working Group, the NZ Institute of Forestry, the New Zealand Landcare Trust, the University of Auckland, the University of Waikato, Naturally Native NZ Plants Ltd., Taupo Native Plant Nursery and AgResearch.

Achievements to date

Twenty-two activities and projects, some of which are already complete, can be grouped under the four main category headings as follows:

1. Networking

- Production and dissemination of a regular TTT newsletter for members.
- Development of a TTT indigenous plantation database.
- Completion of the TTT Archive project.
- Development of a TTT website, including the recent launch of a new-look site with interactive components for members.

2. Workshops and conferences

- Nationwide collaborative workshops on planting and management of indigenous forests.
- Workshops on legal issues and taxation.
- Workshop held in collaboration with iwi and Nga Whenua Rahui.
- Seminar to launch TTT, based on the 1999 University of Waikato Native Tree Conference.
- Tenth Anniversary TTT Conference held at University of Waikato in 2009.

3. Research projects

- Tāne's Tree Trust Survey of Indigenous Plantations – location and assessment of planted native trees and shrubs.
- Silviculture of regenerating totara in Northland (in collaboration with the Northland Totara Working Group).
- Comparison of bare-rooted and container-grown nursery stock in field trials in the Taupo catchment (in collaboration with the Lake Taupo Protection Trust).
- Silviculture of a puriri spacing trial in North Auckland.

4. Publications

- Production of a Continuous Cover Forestry manual (Barton, 2008).
- Technical report on the performance of planted kauri in the Bay of Plenty (Steward & Barton, 2003).
- Reprinting of three volumes (Bergin, 2003; Bergin & Steward, 2004; Bergin & Gea, 2007) in the Indigenous Tree Bulletin Series, in collaboration with Scion.
- Support for the publication of New Zealand Forest Research Institute Indigenous Tree Bulletin No. 4 (Bergin & Hosking, 2006), in collaboration with Scion and Project Crimson.
- Production of New Zealand Forest Research Institute Indigenous Tree Bulletin No. 5 (Dodd & Ritchie, 2007), in collaboration with AgResearch.
- Technical report on methods for assessing the totara resource in Northland (Kennedy, 2007), in collaboration with the Northland Totara Working Group.
- Production of the Tāne's Tree Trust Technical Handbook, launched at the TTT Tenth Anniversary Conference.
- Production of New Zealand Forest Research Institute Indigenous Tree Bulletin No. 6 on ecology, establishment, growth and management of the beech species (Smale et al., in preparation).
- Development and maintenance of a bibliography on indigenous forest plantations.

Project outlines

The following is a brief outline of most of the projects and activities undertaken by TTT during the past ten years:

TTT National Planted Native Tree Database

For well over a century, millions of trees belonging to indigenous species have been planted throughout New Zealand. This has been done to provide a long-term timber resource as well as to provide a range of non-timber benefits, e.g. restoration of biodiversity, improvement of water quality, provision of shelter, and enhancement of aesthetic values. The trees have often been established in small plantations containing one or more species. With only a handful of exceptions, these plantings have not been easy to identify or locate, and their growth performance is unknown. Without a nationwide register of their location and stand characteristics, information representing tens of millions of dollars worth of planting effort would have been lost.

This project centres around the collection of historical descriptions and growth data from old plantings and records from recently–planted stands. Systematic inclusion of the many combinations of species and sites throughout the country will be achieved by:

- setting up a database system for consistent recording of the location and stand history of native tree plantations;
- standardising and centralising methods for recording establishment practice, management information and growth performance data in native tree plantations; and
- providing an interactive web-based system that enables landowners to compare and contribute regional and nationwide information about native plantations.

The project aims to improve knowledge and to increase the availability of robust data from indigenous plantations. The database will include information about species choice, suitability of species for particular sites, site preparation, establishment practice, performance monitoring, stand maintenance, stand management, and growth and carbon-accounting models. It complements the Permanent Sample Plot System at Scion and also the TTT Plantation Survey project. Most of the set-up work has been completed. The project has been partly funded by Forest Industries Development Agenda.

TTT Technical Handbook

In consultation with landowners, local community groups and agency representatives attending TTT workshops at Hikurangi (Northland) and Kaukapakapa (north of Auckland), it was agreed that the Trust should collate historical and recent information in the form of a handbook that is easy to update. The preparation of a TTT Technical Handbook on planting and managing native trees is funded mainly by the Forest Industries Training and Education Council.

The Handbook is intended to be a comprehensive reference guide that can be updated regularly in order to disseminate information about best-practice methods for the establishment and management of indigenous plantations. It will be used at TTT workshops, seminars and field days, and as resource material for proposed tertiary courses on indigenous plantation forestry. It will be made available to the Forest Industries Training and Education Council and other educational institutions.

The book consists of a high-quality ring binder with dividers. Each colour-coded and numbered section contains stand-alone technical articles written in a user-friendly style and fully illustrated in colour. The articles present referenced material and are peer-reviewed. New sections and articles will be distributed as they become available.

Eight sections have been completed to cover the following topics:

1. ***Introduction***
   - 1.1. Why do we need a Handbook?
   - 1.2. How to use this Handbook
   - 1.3. Introducing Tāne's Tree Trust
2. ***Objectives for establishing natives***
   - 2.1. Objectives and strategies for planting
   - 2.2. Options for establishing native trees
3. ***Cultural and historical perspective on planting native trees***
   - 3.1. Nga Taonga o te Wao Nui a Tane – a cultural perspective
   - 3.2. Native forests – a historical perspective
4. ***Requirements for establishing native trees***
   - 4.1. Physiological factors – trees and environment
   - 4.2. Lessons from nature – using ecology to help grow native trees
5. ***Seed and propagation of natives***
   - 5.1. Seeding of native trees and shrubs
   - 5.2. Eco-sourcing natives
   - 5.3. Choice of nursery stock
6. ***Site selection***
   - 6.1. Key factors in site selection
   - 6.2. Sites for planting native trees
7. ***Site preparation***
   - 7.1. Planting – getting started
   - 7.2. Livestock and pest management
   - 7.3. Preparing grass sites for planting – use of herbicides
   - 7.4. Preparing gorse, broom and blackberry sites for planting natives

8. ***Planting and maintenance of natives***

8.1. Planting techniques for natives
8.2. Planting pattern and density for natives on open sites

9. ***Planting and managing natives in riparian areas***

9.1. Riparian margins – an introduction
9.2. Riparian planting for sediment, nutrient and pathogen management
9.3. Riparian planting for aquatic and terrestrial biodiversity
9.4. Riparian planting for native timber and multiple purposes

Further sections are already being planned and it is intended that the Handbook will be continually updated over time as new and additional information becomes available. Copies can be ordered via the Tāne's Tree Trust website or from Tāne's Tree Trust, PO Box 1169, Pukekohe.

New Zealand Indigenous Tree Bulletin Series

In collaboration with Scion, TTT has seen the production of two bulletins in the New Zealand Indigenous Tree Bulletin series: No. 4 *Pohutukawa – ecology, establishment, growth and management* (Bergin & Hosking 2006) in collaboration with Project Crimson, and No. 5 *Native Trees on Farms* (Dodd & Ritchie, 2007) in collaboration with AgResearch.

This bulletin series has been in high demand. Funding for several reprintings of Bulletins 1-5 has been organised by TTT and received from several sources, principally the Forest Industries Training and Education Council and the NZ Forest Owners Association.

A sixth bulletin to be entitled *The beeches — ecology, establishment, growth and management* is being prepared in response to requests from southern areas of New Zealand where beech species have fast growth rates and respond to management. Emphasis will be placed on timber production. The bulletin will provide up-to-date information including the latest developments observed during site visits and focus group meetings. This is a collaborative project undertaken by Landcare Research and Scion with funding from the Sustainable Farming Fund, Future Forests Research and Scion. In-kind support has been received from the NZ Institute of Forestry and the NZ Farm Forestry Association. The bulletin will be published in mid-2011.

Lake Taupo planting trials

A large amount of land within the Lake Taupo catchment is likely to be converted from pastoral farming to forestry. This will assist the realisation of the goal of the Lake Taupo Protection Trust - to reduce the amount of nitrogen leaching into the lake by 20% over the next 15 years. Impediments to the establishment of indigenous forest include slow growth of native tree species, high cost of seedlings, uneven plant quality, and high cost of weed control.

The TTT project aims to identify cost-effective options for establishment of indigenous tree species, using knowledge gained at the Forest Research Institute Nursery between 1960 and the 1980s. Information will also come from nursery and field trials in North Auckland established and managed by the Mahurangi Action Group.

The TTT trials at Taupo will compare the performance of a wide range of species including native conifer and hardwood trees and shrubs. The cost and quality of plants raised in a variety of container types and as open-ground transplants will be assessed. The first planting trial established in mid-2009 will be extended in 2010. The project is funded by the Lake Taupo Protection Trust and TTT in collaboration with Scion, Future Forests Research, Taupo Native Plant Nursery and Environment Waikato.

National survey of indigenous plantations for carbon accounting

Preliminary calculations indicate that at least 80 million seedlings of indigenous timber trees have been planted throughout New Zealand over the past 150 years (Ian Barton, pers. comm.). Planting programmes involving hundreds of thousands of seedlings of many different species were initiated by the Lands Department before 1900 and were continued with varying effectiveness by the NZ Forest Service into the 1980s (Bergin & Gea, 2007). Most local authorities have planted indigenous trees in parks and gardens during the past century, and many stands exist today. Interest in the planting of indigenous timber species by private individuals and public organisations has intensified during the last decade.

Assessment of growth in historical and recent tree stands has been spasmodic, and available data are inadequate for estimation of carbon sequestration by indigenous species. The TTT project is based on a nationwide survey of significant plantings. The history and growth performance of these stands will be recorded and added to existing databases in order to increase the reliability of growth models and carbon sequestration estimates.

The project, managed by TTT, is funded for three years by the Ministry of Agriculture and Forestry Sustainable Farming Fund and TTT with support from the Scion Diverse Forestry Species Programme funded by the Foundation for Research, Science and Technology through Future Forests Research.

More than 120 landowners and managing agencies have responded to a questionnaire requesting information about plantations or stands of native trees and shrubs. Most of these stands will be inspected and Permanent Sample Plots (PSPs) or growth plots will be established. Stand management and growth data recorded by species and region will be added to the TTT Indigenous Plantation Database.

Silviculture trials in naturally-regenerating totara stands

The Northland Totara Working Group was formed in 2005 to explore the timber production potential of totara. The prolific natural regeneration capacity of this species offers a unique opportunity for farm diversification in Northland and other regions of New Zealand.

The Working Group, co-ordinated by the NZ Landcare Trust, includes TTT, Scion and Future Forests Research. A regional resource assessment (Kennedy, 2007) has been carried out and thinning and pruning trials have been established in three Northland regions (Bergin & Kimberley, 2010). Numerous field days and seminars have been held and articles, conference papers and newsletters have been produced. The work is funded by the Sustainable Farming Fund, TTT and the ASB Community Trust, and in-kind contributions have been received from landowners and local Northland Councils.

The Working Group is currently engaged in market research studies, supply-chain issues and steps required for the development of a viable regionally-based timber industry. Tāne's Tree Trust is exploring opportunities for nationwide extension of this work and is collaborating with the Mountford Trimble Foundation in the management of pole totara in the Wairarapa.

Indigenous Forestry Archive

It has been estimated that in today's terms, more than $50 million was invested on indigenous research between 1920 and 1987. Much of the early work was never written up formally, let alone published, and is only known from file and diary notes. With the demise of the New Zealand Forest Service in 1987, many departmental files were archived. Others were destroyed or fragmented and some were stored by former forest officers. It was known that intact files are held by Forest Research, Landcare Research, the Department of Conservation and Archives New Zealand.

The absence of any unified record of the location and content of these research files was impeding access to information. It was clear that new trial work would be more effective if it could build on previous research and experience. In one of its early projects, TTT organised the retrieval and documentation of as many historical records relating to planted indigenous forests in New Zealand as possible.

Supported mainly by the Sustainable Farming Fund and in collaboration with many agencies and former employees of the Forest Service, TTT contracted several individuals to locate relevant documents. Content and quality of the information was reviewed and potentially-useful material was annotated and indexed. Location was noted and important files were moved into safer storage.

The new archive consists of an annotated bibliography on indigenous forestry, now available on the internet. The TTT Indigenous Forestry Archive Database can be accessed at www.tanestrees.org/archive where users can obtain information through keyword searches.

Indigenous forestry bibliography

An ongoing project funded by the Trust is the development and maintenance of a list of references to publications, reports and articles relevant to the planting and management of indigenous forest. This list will eventually be available on the TTT website and will allow searching by keyword.

Nationwide TTT workshops

During the past 10 years, Tāne's Tree Trust, with support from the Sustainable Farming Fund, has run workshops and associated field trips in order to encourage the planting and management of native forest. The workshops have involved collaboration with local branches of the NZ Farm Forestry Association, Regional Councils and the NZ Institute of Forestry, as well as community groups and other local councils. Analysis of formal feedback forms has indicated that the quality of the presentations, the material provided and the field trips have all been greatly appreciated.

Up to five of the Tāne's Tree Trustees speak at each workshop and cover a range of topics including ecology and physiology of native trees, choice of species, establishment methods, use of nurse crops, long-term management, and the principles of Continuous Cover Forestry. There is always a local perspective and a visit to nearby planting sites. To date North Island workshops have been held in Kaitaia, Whangarei, Kaukapakapa, Hamilton, Rotorua, New Plymouth, Hawkes Bay, Marton, Wairarapa and Wellington; South Island workshops in Nelson, Marlborough, Rangiora, Geraldine, Gore and Invercargill.

The Trust has been inundated with requests for further workshops. Funding is being sought for extension of the programme to include other centres, Maori Trusts and iwi gatherings.

The TTT Website

A website designed to keep members informed about Trust activities has been available for the past 10 years. A new-look TTT website launched at the TTT Tenth Anniversary Conference contains the following features:

- **An "About us" page,** which includes a summary of the history, mission and objectives of TTT.
- **A "Contacts" page** showing useful addresses and membership information.
- **A List of current Trustees** with brief background details.
- **The Indigenous Forestry Annotated Bibliography** containing reference to historical records.
- **The Indigenous Plantation Database –** A new feature that allows web users to search by species and region for information on growth, establishment and management of planted and naturally regenerating indigenous trees and shrubs.
- **Information about TTT workshops and conferences –** Records of past and planned workshops, fieldtrips and conferences.
- **Information about research projects –** Lists of past and current research trials with background details and summaries of progress to date.
- **A list of publications, newsletters and reports** produced by TTT or TTT collaborators.

Access to the TTT website is through:
www.tanestrees.org.nz

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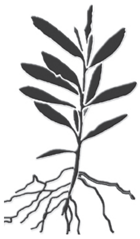

Introduction to Workshop 1
- Productive use of regenerating native species

Helen Moodie

About the Author

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This workshop aims to show how regenerating native tree species can make a contribution to New Zealand's "bottom line". This needs to be done in the context of sustainable management for timber production within the perspective of the Forests Act. Totara and beech will be used to illustrate the way in which "working circles" have been formed to share knowledge and experience in promotion and management of the productive potential of native timber species.

Regenerating totara in Northland

Clearance of the original forest by early settlers and conversion to farmland has created conditions which favour the regeneration of totara. In many regions throughout New Zealand, second-growth totara stands 50-120 years old have become established on farm grassland and areas reverting to manuka or other woody shrub species including gorse.

The Northland Totara Working Group was established in September 2005 as a local initiative. Its aim is to encourage Northland farmers to regard their totara as a valuable part of their property – not just firewood! The Group includes local farmers and representatives from the NZ Farm Forestry Association, the Far North District Council, the Northland Regional Council, wood millers and processors, Tāne's Tree Trust, the NZ Forest Owners Association, and Scion. It is convened by the NZ Landcare Trust.

Beech management on the West Coast of the South Island

A "working circle", developed by the company known as Forever Beech, has for some years been involved in sustainable management of beech forest (mainly red beech in the Buller and Murchison areas. An area of approximately 7000 ha, consisting of several privately-owned properties secured under the Sustainable Management Plans of the Forest Act, is being selectively logged for high quality timber.

Recently, a company known as New Zealand Sustainable Forest Products, formerly Forever Beech, has been established to commercialise the work done to date. The company has invested funds in a sawmill site and in state-of-the-art drying and processing equipment. New technology, including kiln-drying, has opened up marketing opportunities for niche joinery and flooring products.

Questions for this workshop

Two overarching questions are:

1. What lessons learned from these working circles can be used to encourage productive use of native timber species in New Zealand?

2. What more can be done to help farmers and foresters to participate in the sustainable management and promotion of high-value specialty timber production from native tree species?

Answers to the following specific questions would be helpful:

1. What are the barriers to productive use of native timbers?

2. What would the ideal situation look like?

3. What actions can be taken now to help to achieve this ideal?

4. Who are the key players? (Tāne's Tree Trust, Ministry of Agriculture and Forestry, NZ Farm Forestry Association, NZ Institute of Forestry, Northland Totara Working Group, New Zealand Sustainable Forest Products…(this may not be a complete list).

5. Which other native species have potential for management for timber production?

6. How can we encourage the integration of multiple-use native forestry into overall productive land use?

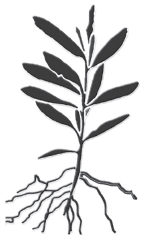
Presentations on the following topics will provide background and perspective for discussion:

Managing totara in our productive landscapes - Paul Quinlan will provide a regional perspective on the Northland totara resource. He will outline the potential for a sustainable regional industry based on timber production.

Managing and marketing our beech resource - Jon Dronfield will provide insights on the need for development and marketing of our indigenous timber resource.

Improvement of naturally-regenerating totara on farms - David Bergin will report on early results from thinning and pruning trials in totara stands developing in Northland.

Sustainable management of indigenous forests - Alan Griffiths will cover the major issues for indigenous forestry relating to the Forest Act.



A role for totara in rural production landscapes

Paul Quinlan

About the Author

***Paul** is a consultant landscape architect and a founding member of the Northland Totara Working Group. He is a land owner and has a Sustainable Forest Management Plan for regenerating totara approved and registered under the Forests Act. He is particularly interested in the relationship between legislation and landuse.*

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This afternoon I'm presenting a vision for a productive role for naturally regenerating totara on private farms and scrubland. I'm also making a case for promoting commercial-scale use of totara as an appropriate and practical way of introducing more native trees into our rural production landscapes. To do this I'll be outlining the characteristics of this species and the specific opportunities and restraints, as I see them, associated with realisation of commercial use of an emerging resource.

Promotion of native trees: their use and conservation

Native trees are highly-regarded and perceived by many people to enhance landscape values. Research has shown that people prefer and value landscapes with higher degrees of "natural character" (Fairweather & Swaffield, 2003) and that tall vegetation (particularly indigenous species) is often associated with that perception (Fairweather et al, 2003). This is consistent with priorities expressed in Section 6 of the Resource Management Act. In consequence, many District Plans have objectives, policies and rules relating to the protection of native trees on private land.

For many reasons associated with environmental and landscape values, farmers are increasingly being encouraged to plant more native trees on their property (PCE, 2001) – that is, within the space used for conducting their business.

In Northland, totara trees are common on farms; so much so that many farmers view regenerating totara as a weed. Nevertheless the trees are often used to shade and shelter animals, for erosion control and for their aesthetic value. What about commercial-scale timber production?

In New Zealand there is a tradition of spatial separation of conservation and production activities. Thoughts of felling native trees still tend to be associated with many negative connotations of "native logging" and exploitation, but are these attitudes perhaps limiting our thinking and the opportunities for more native trees on private farmland? In some other countries there is far less conflict between utilisation and conservation. One facilitates the other. In this respect I think that naturally-regenerating totara presents us with a unique opportunity. The Northland Totara Working Group was formed to explore this potential.

Attributes of totara

Totara has the following characteristics:

- It is a pioneer tree species, ecologically suited to disturbed environments.
- It is "stock-resistant", even establishing where grazing animals are present.
- It regenerates naturally and abundantly.
- It responds well to silviculture.
- It has excellent potential for sustainable management.
- It is a significantly-scaled regional resource (important for commercial mass).

These attributes present a unique and practical opportunity for integration of this native tree species into the pastoral environment (Moodie et al., 2007).

Lifecycle of totara on farms

The following is a brief account of the life-cycle of totara on farmland:

- Because it is stock-proof, the species has a weed-like ability to colonise poor-grade pasture. Establishment on steep slopes is positively correlated with the presence of species typical of poor pasture (Bergin, 2001).
- Birds spread seed from existing tree stands, and grazing seems to assist seedling establishment.
- Dense thickets containing up to 60 000 stems/ha can develop in paddocks.
- Dense pole stands are formed at the sapling stage. Here competition is so intense that stem diameter growth slows to only a few millimetres per year.
- Natural attrition (self-thinning) occurs.
- Merchantable-sized trees develop as the stand grows.

I believe that naturally-regenerated totara stands on farmland constitute a unique native forest type. This has a highly modified character, but that should not make it unacceptable. It has considerable potential for sustainable management (Bergin, 2001).

Scale and characteristics of the resource

Scale is another very important attribute. Funding was obtained to carry out an inventory project designed to estimate the amount of totara already existing on private land. A pilot study using high-resolution aerial photography (Kennedy, 2007) surveyed more than 47 000 ha of private land in the Whangaroa area. Paddock trees were counted, and different forest types and ages were mapped. Randomly-located sample plots were established in which all totara were measured and recorded. Results were combined with the land cover information and extrapolation produced a crude regional estimate of the totara present in the area.

Allowing for a very wide margin of error (more inventory work would be needed to refine the estimate), there is evidence that a totara resource of significant size exists already in the Northland region. In future it will be much greater. Approximately 344 000 ha of private land currently contains totara at various stockings; possibly 8 million m^3 total tree volume. The volume of merchantable timber at present will only be a fraction of this amount.

It is clear that there is a substantial regional resource out there. Only 6% of the totara population consists of the lollypop-shaped paddock trees - the majority is found in scrub areas and in stands or groups. Most of the stem diameters are less than 30 cm. It is clearly a young resource which has the potential for silvicultural intervention and sustainable management.

Harvestable trees resulting from regeneration on previously cleared land are already present on many farms. It is not a case of planting and waiting for 100 years. Some sustainable regional production could start now.

The vigour of natural regeneration

The natural regeneration process is remarkably vigorous. Regeneration is typically associated with previously-cleared land. In Figure 1 the central block is a 35 ha portion of a large hill-country sheep and beef farm. Since the 1960s, trees have spread naturally from a small bush remnant. By 1981 39% of the area was covered, mainly by totara. Despite continued grazing, cover has increased to 61% of the area during the past 27 years.

Further interesting characteristics of the totara resource are that:

- prevalence is often related to the modifying influence of past and continuing farm activity
- the distribution pattern is sporadic and spread over large areas. Trees are often found in patches of scrub, but also in small groups and as scattered individuals in paddocks. It is therefore difficult to define and map the totara as “forest”. This presents difficulties in application of the Permit and Plan provisions of the Forests Act.

Practical implications

Although much of the totara resource is relatively easy to access and extract from the perimeter of farms or bush areas, its distribution is fragmented. It consists of small quantities of timber located on many different properties. Portable sawmills could be used to recover small quantities of farm-grown timber, but a piecemeal approach may not be efficient enough to support a viable industry. Should we be thinking about collective management on a larger scale?

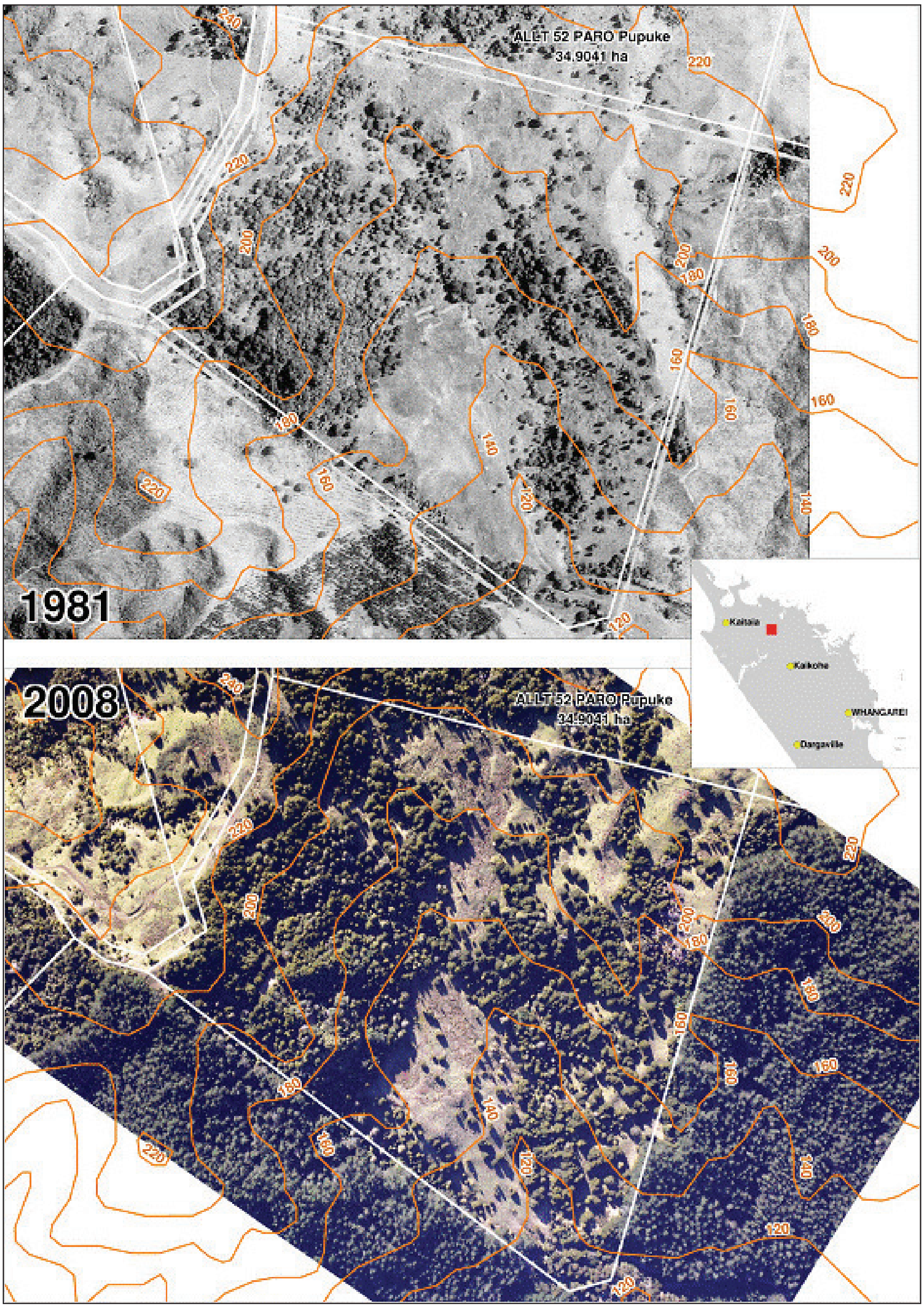

FIGURE 1: Natural regeneration of totara is remarkably vigorous on many Northland farms despite continued grazing.

Wood quality and utilisation

Totara is easily milled and at least one sawmiller considers that farm-grown Northland totara wood is much stronger than that of old totara grown in the central North Island. Preliminary studies indicate that the wood may indeed be denser. Another difference between old-growth totara and younger farm-grown trees is seen in the relative proportion of heartwood and sapwood (Figure 2). There is often a transitional zone containing incipient heartwood and a small core of heartwood. Although it is not considered to be durable for exterior uses, the sapwood still has many of the inherent qualities and properties of old-growth

FIGURE 2: The above cross-sectional views of logs from farm-totara trees show varying amounts of heartwood. Log number 35 displays the deep reddish-brown colour traditionally associated with heart-totara. In contrast, log number 7 (a top log in this case), shows the more typical characteristics of younger stems; a larger proportion of sapwood, and often an in-between area of incipient heart, and a small core of heartwood.

timber.
Old-growth totara has a well-established reputation as one of the most durable of our native timbers, easily worked and very stable. It is revered by Maori and was valued by early settlers. It is part of our cultural heritage.

Farm-grown totara has been used for a wide variety of purposes with encouraging results. John Marley (Natural Timber Creations, Kerikeri) has reported success with the use of sapwood and heartwood totara in fine furniture and joinery. He considers that totara is superior to macrocarpa. He refers to sapwood from younger trees as "light totara" and to heartwood as "dark totara". He likes to use this material, but finds that clients seldom ask for it. It is sometimes hard to locate a source of supply.

Constraints

There is nothing wrong with totara timber. On the other hand there certainly are practical issues around coordination of collective supplies, timber grading and the availability of sufficient amounts of a dry and "ready-to-use" product. Chris Kennedy and I have started a company (Podocarpus Ltd.) which aims to address that situation.

On a broader level the Northland Totara Working Group has identified the following problems:

1. There is little market-awareness or demand for totara timber. Its use for general purposes has been overtaken by the introduction of aluminium joinery, new materials and treated timbers.

2. When a request is made for totara timber, it can be hard to locate because there is no functioning supply chain. This is a chicken-and-egg dilemma.

3. There are perceived and actual legal impediments. The Forest Act requires management to be on a sustainable basis. The Resource Management Act also applies through District Plans. For many land-owners, dealing with these legal issues is major disincentive.

Absence of carbon-trading incentive

There has been much talk about realisation of some financial return for the many non-timber benefits, services and values that native forests provide. Emissions trading schemes could provide a real opportunity in this respect, but the current Scheme is an opportunity missed in the case of much of the young totara resource in Northland. The stands have considerable potential for sequestration of carbon, but in most cases their establishment pre-dates 1990. Consequently they are not eligible for carbon-trading benefits associated with Kyoto-compliant forest. Planted stands and more recent regeneration may be eligible, depending on their size. At this stage it seems that a timber market would be the most relevant revenue incentive.

Opportunities

The character of private farmland is directly affected by the nature of the land-use. Commodity markets are still the biggest drivers and shapers of land-use and change (PCE 2004). A previous Parliamentary

Commissioner for the Environment, Dr. Morgan Williams, challenged us to find ways of using markets to change and shape our farms 'for good' (PCE, 2004). If we want to see more native trees on our farms, then I suggest we need to do more than just reduce legal impediments and disincentives. Management of native trees for various purposes should be an attractive business activity.

I contend that the development of a totara timber market could be an effective incentive for large-scale proliferation of totara trees on private land.

To summarise, totara has the following remarkable attributes:

- it regenerates naturally;
- it is resistant to grazing stock;
- it has an acceptable growth rate;
- it has high-quality timber;
- it responds well to silviculture;
- there is a large regional resource in Northland;
- some merchantable-sized trees already exist;
- it offers continuity of supply; and
- there is excellent potential for sustainable management of the resource.

These attributes underpin a case for promotion of the productive use of totara on farmland. This would be a practical, painless and appropriate way to integrate more native trees into our pastoral production landscapes. Utilisation of the potential offered by totara is a challenge for collective consideration.

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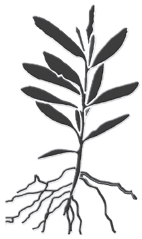

Selling aspiration

Jon Dronfield

About the Author

***Jon** is Resource Manager for New Zealand Sustainable Forest Products, overseeing management and production from 7000 ha of indigenous beech forest. He has worked with Timberlands West Coast and Forever Beech and remains committed to the principles of sustainable utilisation of timber resources through the application of continuous-cover forestry.*

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I was recently asked to present a lecture to a marketing class at the University of Canterbury School of Forestry. My initial reaction was: "Why are you asking me - I don't know anything about marketing?" Eventually I agreed and found it a very worth while experience, because it forced me to sit down and evaluate what we are actually trying to achieve with the processing and sale of our beech resource. What I realised was that we have an incredibly valuable asset in our indigenous timber resource. But what form does this value take?

When we sell our iconic native timber species we are selling product uniqueness; we are selling the certification of forest management and production chains; we are selling the environment and saving the world. We are selling health benefits, lifestyle, happiness and good appearance. We are appealing to taste, ethics and snobbery. In short we are selling aspiration.

The first question we should ask when attempting to manage our indigenous forest resources for multiple use, including sustainable timber harvest, is: "Why bother?" Can we accept the fact that the wood is required by society and that its production can be reconciled with environmental sustainability? If we can rationally take all opinions into consideration and still answer in the affirmative, there is a moral obligation to proceed with caution. Eco-colonialism in developed and developing societies, coupled with burgeoning middle-class affluence, creates a demand that is putting intolerable pressure on world natural forest resources. A mature, self-sustaining community must find ways to produce what it wishes to use.

Low-intensity selection harvesting is a common feature of beech forest management today. The government decision dictating cessation of harvesting on Crown land was predicated by the timely release of a forest growth model which showed that trees don't regenerate after harvest (or, by implication, after natural catastrophic disturbance). As a forester I found this misinformation particularly galling.

Trees don't lie. Ecosystems don't lie. Our challenge is to manage them with honesty and integrity and always to put the forest first.

In discussing the potential of the indigenous forest sector I will use some highly subjective calculations. Anyone can do a similar exercise and draw their own conclusions. At the end of the day, argument about the numbers is arguing semantics. Clearly, a healthy industry offers a great deal to our national wealth. It has been estimated that there are 1.4 million ha of privately-owned indigenous forest in New Zealand. Most of this area probably supports regenerating manuka. If we assume that 200 000 ha (14%) could be made productive under existing regulations, we could have a national resource producing 200 000 m^3 of high-value sawlogs per annum. At a conservative 40% conversion to timber, this represents 80 000 m^3 of sawn timber per annum. At an average price of $1400/$m^3$ the value of this would be $1.12 billion/yr. It is worth noting that the value multipliers for joinery and furniture is eight times higher.

I want to talk briefly about my vision for the beech resource. First a bold statement. New Zealand contributes insignificant amounts of product to

FIGURE 1: Development of red beech seedlings six years after harvest of the overstorey.

international markets. Global demand is so great that we are faced with the exciting challenge of how to market our small resources to achieve the highest returns and maximum exposure. I believe that we could adopt a different strategy for our timbers which would incorporate values far beyond those achieved from timber sales. We need to go beyond the sale of logs and sawmilling commodities. We should aim to link our stories and our unique New Zealand design with specific inherent timber characteristics and market them together to the affluent nations. I use the example of state-of-the-art German 3-D veneering which allows the faultless forming of previously unachievable designs. By this process, a piece of utility veneer worth $2.50 is transformed into a product worth $94.00. Most of the value is associated with the "design" aspect of the product.

Exquisite designs by David Trubridge and Kevin Webby showcase red beech wood at its best. Their pieces are functional and take maximum advantage of the inherent characteristics of the wood. Although they account for only small volumes of product, they are iconic works of art, used, seen and admired in Milan and New York.

Engineered flooring is a larger-scale example of a product that is hugely exciting for the beech industry. It is multi-strip, multi-layer flooring that has a thin layer of valuable timber laminated onto a cross-banded softwood backing. Thin-sawing and platen-drying of flooring lamella have circumvented difficulties associated with the drying and processing of solid timber and have opened up markets for beechwood. The European Union (EU) consumed 114 million m^2 of engineered wooden flooring in 2006. This was not solid wood, parquet or imitation vinyl flooring - just engineered wooden flooring. Laid out, it would cover 1100 ha. If we achieved our estimate of 80 000 m^3 of timber and converted it to engineered flooring we could produce 9 million m^2 and satisfy 7% of the EU demand, which is only one third of the global consumption. Finding pathways to appropriately-sized markets where "niche" is defined by scale rather than value, is the key to success.

Many barriers still exist. Problems associated with the fragmented resource base can be overcome, because a high-value product can withstand longer lead distances and high harvest costs. It must be recognised that multiple landowners will have multiple aspirations and must be approached as unique individuals. Skills can be developed if an industry requires them. We may have a legal mandate to manage forests for timber but we must ensure that our social mandate is unblemished. I wrote the following when advertising for a graduate forester:

"… you should have a deep respect of the natural world. It is our hard-won privilege to be able to manage indigenous forests for timber production. It is not a right. We have to prove ourselves to the owners and public every day and more so to ourselves and to the forest."

All the respondents identified with the sentiment. This may be our fledgling industry but we have responsibility for its maintenance and expansion. Development and protection of the reputation of native species is critical. If we are successful in gaining a market share and recognition for red beech we must guard against inferior quality products.

The Forever Beech company has been purchased by a New York investment family, and a new organisation, New Zealand Sustainable Forest Products, has been established to commercialise the work done to date. This has involved investment in a sawmill site and in state-of-the-art drying and processing equipment. It will enable full utilisation of the resource and will double the number of productive forest holdings. By March 2010 we should be employing more than 30 people. This investment depended on the existence of a forest resource secured under forestry rights and sustainable management plans. The safe and regulated operating environment was a factor, but the key to understanding the investment was the vision. The shrewd people in New York can see the value in sustainable forest management aimed at the manufacture of top quality items. They know that there is a good story behind the product.

The Northland Totara initiative is providing a fantastic opportunity. We need to find ways to bring it to the commercial starting line. Here are a few obvious suggestions for the Group:

- you need to quantify resources;
- you need to find appropriate models for collective management of forests;
- you need to understand the key constraints associated with second-growth timber. In today's world it is possible to engineer superior characteristics into timber by reconstitution, impregnation, pressurisation, thermal modification and other processes. Or you can grow better trees. There is a need for the development of specific silvicultural prescriptions aimed at a more homogenous product. Heartwood content is a function of age, site, stocking rate and crown manipulation among other things. It can be maximised; and
- you need to understand that the biggest challenge is how to encourage investment in silviculture. The mainstay will probably be the tried-and-true farm forestry practice of pruning a few trees when time permits and writing the effort off as exercise. I draw attention to the fact that under the Government Afforestation Grants Scheme, up to $1900/ha is available for planting radiata pine on dry East Coast hills in order to mitigate climate change. The irony of creating a huge carbon sink with higher-than-average risk of catastrophic fire should not be overlooked. Can this scheme be modified to include the thinning of 30-year-old totara re-growth? Of course not. But it might be wise to note that the Chilean Government is leading a drive for thinning and pruning up to 4 million ha of privately-owned regenerating beech forest.

Lastly, statistics posted on the NZWOOD website (www.nzwood.co.nz) are very heartening. This site sustained 700 visits/day in August. An unknown but probably major proportion of the queries would have come from architects, specifiers and home builders. "Totara" was among the top ten words searched for, along with "rimu" and "matai". This is evidence of current interest in specification and use of indigenous timbers. Naturally-durable, non-treated timber will always command a premium.

Thinning and pruning of totara-dominant naturally regenerating forest in Northland

David Bergin and Mark Kimberley

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***David** has worked for more than 30 years on establishment, growth and management of indigenous tree species for multiple benefits and is currently contributing to the Diverse Forests Programme at Scion. As a Tāne's Tree Trustee he assists with dissemination of scientific knowledge about New Zealand's native plant species.*

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Introduction

Totara is one of the most widely-distributed indigenous softwood timber trees in New Zealand. Its wood qualities are highly valued for traditional and contemporary use (Bergin, 2003). Most of the supply of old-growth totara suitable for timber production is now exhausted, and there is wide interest in further establishment of the species for market and non-market benefits (e.g. NZ Forest Research Institute, 1997).

Stands of totara are found in many pastoral areas throughout New Zealand (Wardle, 1974). Most are the result of natural regeneration following the clearing of forest, and their age ranges between 50 and 120 years. Seedlings germinating in pasture can develop into pure stands or form a major component of scrub mixtures containing kanuka, manuka and gorse. Totara regenerates readily on steep hill slopes subject to moderate grazing pressure (Bergin, 2001). It is relatively unpalatable to farm stock and often becomes a problem for landowners wishing to maintain pasture. On steep hill slopes with a nearby seed source, small stands of saplings develop within 20 years if the site is not heavily grazed or cleared regularly. An investigation of the development of naturally-regenerating totara-dominant stands in indigenous scrub and forest on farmland in Northland has indicated that poles and semi-mature trees emerge when natural thinning occurs with age (Bergin, 2001). Silvicultural treatment (thinning) is therefore expected to improve tree growth rate in natural stands.

The Northland Totara Working Group is examining the potential of naturally-regenerating totara stands for commercial management. Large areas of totara have developed to pole stage on farmland in many parts of Northland. One objective of the Working Group is the evaluation of growth responses to thinning and pruning in these stands. This report describes the establishment of a series of sample plots set up to measure responses, and summarises results obtained in the first two years after silvicultural treatment.

Establishments of sample plots

Selection of stands

Sites representative of totara-dominant regenerating forest were selected in the Whangarei, Kaeo/Okaihau and Herekino districts (Figure 1). At each site, one or more totara-dominant stand types were identified by age, stocking and site characteristics. In mid-2007, 38 permanent sample plots (PSPs) were established in three regional clusters, using methods recommended by Ellis and Hayes (1997). At least two plots were established in each stand, one plot being left as an untreated control, and the others receiving thinning and pruning treatment.

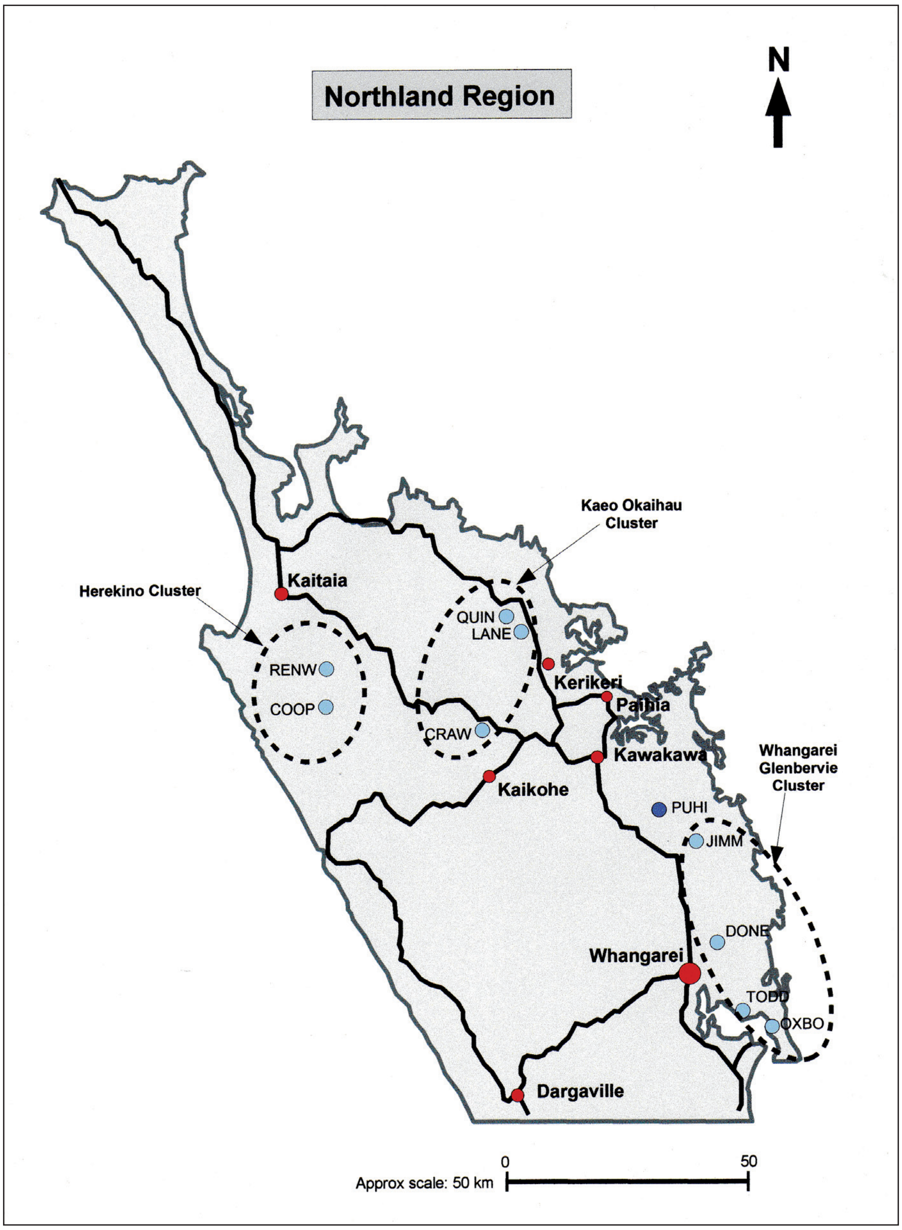

FIGURE 1: Location of the three clusters of sample plots used to evaluate the effects of silvicultural treatment in totara-dominant stands in Northland.

Silvicultural treatment

Treated plots were thinned from densities of more than 6000 stems/ha to stocking rates of 700-2000 stems/ha, Figure 2. The degree of density reduction was determined by natural variation in stem frequency, species composition and tree size. Average tree diameter ranged between 10 and 18 cm and tree height between 8 and 15 m. Thinning removed 15-60% of the basal area. Where stands contained a high proportion of other species, these were removed in preference to totara. Branches 2 - 8 m above ground level were pruned from residual trees. Multiple leaders and larger steep-angled branches were also removed. Height of pruning was determined by tree size, the aim being to retain at least one third of the green crown.

Measurement and data analysis

Trees in all plots were measured prior to treatment in mid-2007, in mid-2008 and in mid-2009. Diameters (DBH - 1.4 m above ground level) of live and dead tree stems within the plot were recorded by species. Heights of a subsample of trees in each plot were measured using standard procedures (Ellis & Hayes, 1997).

FIGURE 2: Naturally-regenerating totara-dominant pole stand in the non-thinned control plot TODD 5 at 2300 stems per ha (above) and in the adjacent thinned plot TODD 6 at 1600 stems per ha (below).

Plot stocking rates (stems greater than DBH 5 cm) were calculated for each measurement date. A height-diameter function was fitted to the data for each plot, enabling heights of all trees to be estimated. Because no individual tree volume function has been developed for pole totara, the function for pole rimu (Ellis, 1979) was used to derive stem volume for each tree using measured DBH and estimated height. Mean height, DBH and per hectare basal area and volume were then estimated. Volume and DBH increments over the two year period since silvicultural treatment were calculated for the growing component (trees live at both measurements) and the mortality component (trees that died between measurements). An estimate of net volume increment was then derived for each stand.

The effect of thinning and pruning treatment on growth increment was tested using two-way analysis of variance with factors for site and treatment. Mean diameter increment was expected to increase after treatment as a result of the removal of suppressed, slower-growing trees. In order to determine whether growth rates of residual trees had increased, an analysis of covariance using initial DBH as a covariate was also performed. This effectively adjusted growth rates to a common initial DBH across both thinned and unthinned plots.

Growth performance during the two years following treatment

Stocking rate, stem diameter and height

Mean stocking rate varied between 1000 and 5500 stems/ha in unthinned control plots and between 650 and more than 2200 stems/ha in thinned plots. Despite natural stand variability, most of the thinned plots had a lower stem density than the corresponding unthinned control plots. Mean stem diameter in 2009 was 9 - 22 cm in thinned plots and 9 - 19 cm in control plots. Mean height varied across all plots between 7 and 16 m.

Diameter increment

Mean annual diameter increment varied between 0.06 and 0.20 cm in control plots. Silvicultural treatment resulted in an increase in diameter growth at all sites. Considerable variation was observed between sites. This would have been attributable to such factors as soil fertility, degree of exposure, and intensity of thinning.

Analysis of covariance showed that after accounting for the stem selection effect, diameter growth of residual trees showed a statistically significant increase due to silvicultural treatment in each of the following two years (Figure 3). Diameter increments in thinned plots were on average 2.5 times greater than in control plots. Growth rate in the second year following silviculture was greater than in the first year, especially in thinned plots, and may be related to overall better growing conditions in the second year.

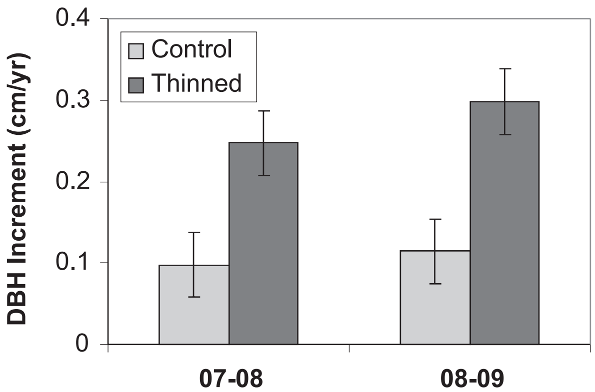

FIGURE 3: Mean annual diameter increment in unthinned and thinned stands of naturally-regenerating totara in Northland during the first and second years after treatment. Means have been adjusted to a common initial DBH value for thinned and control plots in order to eliminate thinning selection effects. Vertical bars show standard errors.

Volume increment

Mean annual volume increment during the first and second years after thinning and pruning is shown in Figure 4. There was a significant increase in net volume increment (5 - 6 m^3/ha/yr) in each of the two years following treatment. A decrease in net volume in control plots during the first year reflected a high mortality rate which was three times as great as that in thinned plots. During the second year a 2 m^3/ha/yr average increase in net volume in control plots was significantly lower than the increase in thinned plots. There have been few windthrow losses in thinned stands.

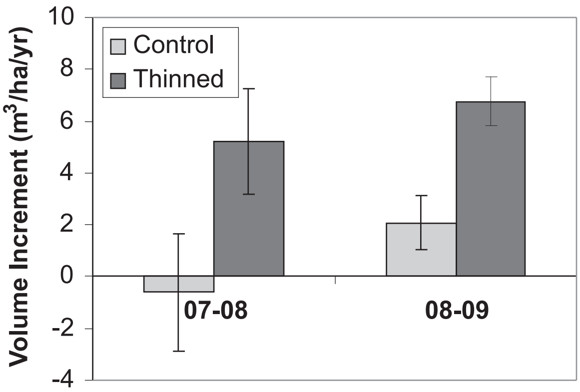

FIGURE 4: Annual volume increment in unthinned and thinned stands of naturally-regenerating totara in Northland during the first and second year after treatment. Vertical bars show standard errors.

For the first two years after treatment, the periodic mean annual volume increment of growing trees was almost 7 m^3/ha in thinned plots and 4 m^3/ha in control plots (Figure 5), this difference being statistically significant. Mortality rates in control plots suggest that the natural stands were at their maximum density and likely to be at the -3/2 thinning line (Weller, 1987). The combined effects of reduced mortality and increased growth rates resulted in a highly significant increase in net volume response to treatment, even though thinned plots contain fewer stems. It is estimated that thinned and pruned totara pole stands are producing 5 m^3/ha/yr more timber than unthinned stands.

Futher research

Because plots receiving relatively light thinning showed a lower growth response than the corresponding controls, and negligible windthrow has occurred in intensively-thinned stands, further thinning in the slow-growing, lightly-thinned stands should be considered.

Site factors that may influence totara productivity should be investigated. Fertiliser treatment might be worthwhile in slow-growing stands.

If one of the objectives of managing naturally-regenerating stands of totara on farmland is the development of a sustainable timber resource, comparison of wood quality in managed and untreated farm-grown stands will be necessary. Quantification of local knowledge about uses and characteristics of farm-grown totara in Northland would be a useful first step.

Conclusions

Two years after thinning and pruning treatment was carried out in a series of totara-dominated pole stands in Northland, mean diameter growth rates of residual trees increased 2 - 4 fold. Mortality over this period was three times greater in control plots than in thinned stands. Thinned stands have produced 5 m^3/ha/yr more stem volume than unthinned stands.

Growth responses were apparent during both first and second years following thinning. A high degree of between-stand variability is likely to be related to a combination of factors including thinning intensity and site characteristics. A conservative approach to thinning intensity proved to be unnecessary, since loss of trees through windthrow in thinned plots has been negligible.

Acknowledgements

Ongoing support for this project from the Northland Totara Working Group and landowners Paul Quinlan, Doug Lane, Allan Crawford, Jim Mackey, Todd Hamilton, Noel Donelley, Willie Oxborrow, Richard Renwick and the late Brian Cooper is gratefully appreciated. Owen Lewis and Michael Bergin carried out the pruning and thinning. Helen Moodie, NZ Landcare Trust, as Convenor of the Northland Totara Working Group, has provided valuable support throughout.

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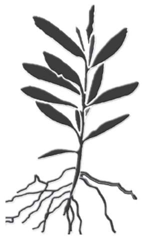

Forests Act issues likely to arise at the Conference

Alan Griffiths

About the Author

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There are two main issues for indigenous forestry: sawmill controls and sustainable management.

Sawmill Controls

Single trees and small groups of trees
Milling is only permitted under a Personal Use approval or a valid minor provision e.g. public work, mining (though this is limited).

Manuka/kanuka chipping
These species may be chipped under minor provisions – e.g. clearance for mining (again limited).

Of particular importance for the Northland Totara project is that regenerating forest is not differentiated from old growth forest under the Act.

Export of live trees
This is raised as an issue since live tree export is only permitted from planted indigenous forest.

Action/progress

- The Minister of Forestry has been approached on a number of these issues by private individuals.
- The Ministry of Agriculture and Forestry (MAF) has reviewed these issues in conjunction with key definitions and clauses in the Forests Act.
- MAF is reporting back to the Minister as to how these issues may be accommodated in the Forests Act without compromising the sustainable forest management (SFM) provisions, which are the principal component and reflect the Act's purpose: **"*to promote the sustainable forest management of indigenous forest land*".**

This is raised as an issue since live tree export is only permitted from planted indigenous forest.

Sustainable management

SFM Plans for regenerated and regenerating indigenous forest land
A planning template for "simple" forest associations should contain the following elements:

- a description of the land;
- a description of the forested areas;
- a map showing forest types and a record of any previous logging;
- ownership and contact details;
- Resource Management Act (RMA) requirements (District and Region);
- term of the plan (> 50 years);
- forest Inventory:
  - species to be harvested
  - volume to be harvested
  - inventory to justify the harvest;

- management details, including re-establishment of harvested species;

- Protection measures:
  - pests, stock, fire
  - measures for retention and enhancement of flora and fauna, soil and water quality; and

- prescriptions relevant to species groups.

The following issues relating to the Forestry Act's requirements for SFM plans have been raised over a period of time:

Forest description - simple but developing.

Natural values - limited but increasing.

Resource statement - fluid and growing

Allowable harvest - small but growing

Silvicultural management - desirable and profitable

Protection - future implications for stock management.

Forest replacement or succession - species preference (in decreasing order):

Totara→matai →rimu →miro.

Key messages for those preparing SFM Plans

- Objectives need a clearly-defined starting point and some vision of the endpoint.

- Baselines for monitoring change are required.

- Flexible management is vital.

- Reviews and modification will be required from time to time.

An iwi perspective on indigenous forestry

Wiremu Puke

About the Author

***Wiremu** is a Hamilton-based Consultant. He belongs to Ngaii Wairere, Tainui.*

I would like to show you a taonga that I carved with stone tools from pohutukawa, a kotiate (short hand-club) based on one taken by James Cook to England and now in the British Museum. It is presented to the Maori Rugby Player of the Year in the Waikato.

I am part of an organisation, Nga Manatoto o Kirikiriroa, started in 1995 and comprising six major Waikato hapu. It has come up with a number of initiatives dealing with Resource Management Act issues. These have a lot of community support. Mostly we are concerned with restoration and revival of traditional landmarks, especially areas of kahikatea bush, important for the hunting of native pigeons. Along with komako or bellbirds, pigeons were very common prior to the 1840s. Kahikatea was common around Hamilton in the past but now very little is left. It was a crime that so much kahikatea was removed.

We need to convince the Hamilton City Council that investing money in some of our initiatives is very important. We believe that these initiatives represent proactive ways to recover history. Having bush in the city will help increase property values. By using locally-sourced seed we can reconstruct the landscape and also the whakapapa of the local hapu. We would like to see local herbs peculiar to this area re-instated.

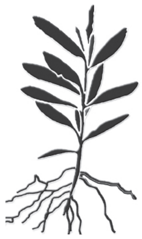
One of first things we did was to replant many of the gully systems in Hamilton City. This was done in conjunction with Professor Bruce Clarkson of Waikato University. We began by extracting information from the historical records. There is a special expression – whenua taonga – whereby a chief sets aside a forest block for a particular reason, perhaps to build a canoe, a pataka or palisade carvings for a pa. The land is set aside to provide appropriate types of trees for the future. As a carver myself, I am often hamstrung by the lack of suitable timber such as totara, which is needed to keep our carving traditions alive. I use stone tools - greenstone adze, greenstone chisel, and a flat grinding stone called a hoanga. These give me a sense of appreciation of the efforts of my ancestors who used stone tools to create such beautiful taonga.

Trees are often tribal landmarks in their own right. Misshapen trees or trees with unusual form often have special powers of tapu. There is a pa called Miropiko, which means "crooked miro tree". This was a special tree where pigeon were snared. Look at some of the Maori Land Court minutes - there are a lot of messages in the old names and records about possible uses of different areas for re-planting native forests. You will often read how significant certain ngahere were for the hunting of birds. Kahikatea berries (koroi), which I often ate as a child, were a very important food collected around the first week of February. We also had tawa and hinau which required a very involved process of steaming in an umu. With the advent of the supermarket many of those customs have disappeared.

We are recovering some of that knowledge and have created a special garden, Te Parapara, in Hamilton. Here we grow the food sources known as para (king fern), aruhe (fern root), different varieties of kumara, pikopiko (fern shoots), and tawhara.

The importance of planting is highlighted in a submission I made to the Council to re-instate kowhai along the banks of the Waikato River. Early accounts from George Angus in 1844 described the Waikato River as being bathed in yellow and gold. There was a local custom of wearing bunches of kowhai flowers tied to the earlobe. Flowering of the kowhai is an environmental indicator for timing the planting of kumara, just as it is an indicator for the gathering of kina on the coast. That is a sacred time of the year, marking the transition of the seasons and preparation for the planting of crops. The Council has committed $25,000 a year for the planting of kowhai along the banks of the river. The vision is the creation of a corridor of yellow kowhai right through the city. This is now bringing back large numbers of tui; and the kaka has been seen again. It has been proposed that the Hamilton provincial holiday should be separated from that of Auckland so that it can be based on the flowering time of the kowhai - spring. The kowhai has become quite an iconic flower in this area.

With assistance from the Council, school children now plant trees every June. Six hundred trees were planted this last year at Te Papanui (Jubilee Bush). It is important for children to have a major role in replanting as this gives them a sense of ownership – and a sense of connection with Papatuanuku. Finally, the custom of rahui has been adopted by Council Garden Staff to enable plants to rejuvenate and recover.



Summary of comments following Workshop 1: Productive use of native species.

Helen Moodie

This first Workshop sought to explore further ideas about requirements for development of a native tree industry. Participants were asked to consider the following questions:

Using totara and beech as examples of species that have already stimulated interest in management for timber production and other purposes:

1. ***What are the key obstacles to productive use of native species?***
2. ***What are some suggested actions?***

Responses

Obstacles	Suggested actions
Public perception that native trees should not be used for commercial production. Perception that we would be "mining" the resource. Myth that production and conservation cannot co-exist. Overall cost and the lack of infrastructure for processing of products. Long rotations for indigenous tree species compared with short rotation of governments. Most people do not think ahead for more than a few years.	Provide continuous assurance about sustainability of production. Educate the public about non-timber uses of native trees. Convince local councils, government, universities, general public about the need for more productive indigenous forests. Encourage media profiles of the "good news" aspects. Showcase sustainable indigenous forestry. Demonstrate the value of farm forestry using indigenous species. Profile certification of sustainable indigenous forestry management and supply. Promote indigenous forestry as a sustainable green activity. Emphasise co-benefits (e.g. biodiversity). Utilise EnviroSchools – start with the young people. Influence city dwellers – create urban plots. Promote the long term perspective (create a legacy). Develop an industry body for media, marketing, information sharing. Lobby all MPs, local government Councillors.

Obstacles	Suggested actions
Lack of research/ knowledge about: good establishment practice wood quality non-wood values market trends. Lack of information in the public arena. Poor understanding about the many reasons for encouraging indigenous forestry.	Encourage people to seek professional advice. Revisit the archive – summarise and republish previous work. Develop a mechanism supporting the uptake of information. Dedicated website (Tāne's Tree Trust?, NZ Farm Forestry Association?). Encourage tertiary research/post graduate studies. Educate people about the time period required for different tree species to reach maturity (it is not always hundreds of years). Improve information-transfer to the public at large. Implement good market research.
Lack of volume - not enough to create a viable market.	Make an inventory of supply/long-term projections. Develop robust growth models for indigenous species. Set targets for new planting. Link suppliers together to make long-term supply agreements. Promote the financial opportunities that are available to landowners. Carry out market research and development. Develop robust grading systems, quality control and certification. Expand the scope of the Afforestation Grant Scheme to allocation of money for silvicultural intervention in the naturally regenerating resource.
Legislation is a disincentive.	Lobby all MPs, local government Councillors. Develop a national policy statement for indigenous forestry. Organise site visits to demonstrate good examples. Talk to the enemy – get them on board. Facilitate action in policy areas.

Obstacles	Suggested actions
Cost of establishment, low financial viability. Lack of sawmilling technology. Physical challenges. Other competing values (e.g. biodiversity).	These issues were discussed but no conclusions were drawn

Introduction to Workshop 2: Establishing natives economically

Helen Percy

About the Author

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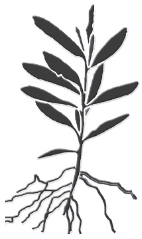
The theme of this workshop is the development of methods for cost-effective, large-scale planting of native species – which still elude us. The workshop will address current work on this issue, identify options for successful establishment, and highlight areas in which progress can be made.

The Sustainable Farming Fund is supporting this Conference because it aims to provide opportunities for learning from the past in order to move into the future. In many instances the information and knowledge already exists, so it is a matter of adapting and updating rather than re-inventing the wheel. There are gaps in our knowledge and more work is needed, so it is important to identify these gaps and prioritise them. What we want to do in this workshop is to examine questions about the establishment of native trees and how this can be done more economically.

Four speakers will set the scene and share experience on the following topics:

1. Nursery methods for raising native tree seedlings
2. Survival and growth of transplanted seedlings
3. Production and use of open-ground (bare-rooted) stock
4. Results of a recent survey of nursery and establishment practice relating to native trees.

After these presentations we will divide into four groups to explore specific questions around the establishment of indigenous tree species; to examine some of the practical and economic answers; and to identify specific hindrances to progress in this area.



Reducing costs associated with establishment of native plants in the Lake Taupo Catchment

Philip Smith

About the Author

***Philip** is General Manager of the Taupo Native Plant Nursery. He has been involved in large-scale production of native plants for 22 years. Current interests include new plant production methods and mycorrhizal associations with native plants.*

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Introduction

Seedling costs and variability in plant size and quality are currently major impediments to large-scale indigenous forestry. The project described here seeks to develop and refine techniques developed during previous work on the large-scale production of native tree and shrub species. The aim is to drive down the cost of nursery-raised seedlings and to improve plant quality.

The project currently in progress at the Taupo Native Plant Nursery builds on work undertaken by the former NZ Forest Research Institute in the 1960-80s, in particular the results of trials carried out by Jaap van Dorsser. It also expands the approach taken in a project managed by Cimino Cole in which three methods for raising and establishing a limited selection of shrub hardwoods were compared.

The project aims to:

- select a range of native shrub and tree species appropriate for planting in the Lake Taupo catchment and propagate them as open-ground plants (Years 1 and 2). We are currently at the Year 1 stage;

- compare the nursery performance, plant quality and relative cost of native species raised as bare-root (open-ground) transplants and in various container types (Years 1 and 2);

- establish demonstration trials comparing the performance of bare-rooted and container-grown plants at two site types typical of areas being retired for revegetation in the Taupo catchment (Years 2 and 3);

- establish demonstration trials comparing the performance of bare-rooted and container-grown plants at two site types typical of areas being retired for revegetation in the Taupo catchment (Years 2 and 3);

- disseminate the findings regionally and nationally by running field-based workshops and by the production of user-friendly guidelines (Year 3).

The project is not intended to "reinvent the wheel". It seeks to demonstrate that robust plants can be raised economically for large-scale revegetation projects and the restoration of native forest. It will:

- consolidate previous work, using scientifically-sound trials;

- refine the open-ground indigenous plant nursery techniques already in use at the Taupo Native Plant Nursery;

- establish demonstration trials, using locally-sourced and locally-raised native trees and shrubs for large-scale establishment and management of native forest cover in the Lake Taupo Catchment.

Trials in the nursery involve the raising of plants native to the Lake Taupo region. These include toetoe and harakeke, the shrub hardwoods karamu, manuka, koromiko and kohuhu, and the conifers totara, kahikatea and rimu. Toetoe and harakeke will require one year in the nursery; conifer and hardwood seedlings up to two years. Locally-collected seed has been germinated using standard techniques and a minimum of 500 seedlings have been prepared for lining-out into tractor-formed nursery beds. Every species is also raised in selected container types and sizes for comparison of a range of factors including growth rate, root system form and quality, the cost of production, and the cost of establishment in the field.

Most of the nursery techniques for weed control, fertiliser treatment and irrigation have been developed already, but opportunities exist for further refinements relating to local soil and climate conditions. Records kept during the nursery phase include assessments of plant growth, health, and root development, and an account of time and resources required for each combination of raising method and species.

Seedlings of each species/raising method combination will be planted at two sites in the Lake Taupo catchment area in order to compare establishment performance in the field. Treatment combinations will be fully replicated and arranged in a Randomised Complete Block design to allow statistical analysis of performance data.

Advantages of bare-rooted open-ground plants

Two major advantages of open-ground plants are lower cost and improved plant physiology. Growing plants in the open ground is also more environmentally sensitive. It leaves a smaller carbon footprint per plant produced.

Cost

The cost of nursery plant production has risen dramatically during the past twenty years.

- *Labour costs:* these can account for more than half of the total, have risen by more than 60% during the last decade.
- *Materials:* Costs of planter bags and soil-less media (bark/peat and pumice) have increased more than 100% in the past 15 years.
- *"Sustenance":* The costs of fertiliser and water have risen by approximately 200% in the past ten years and will continue to increase.
- *Pest and disease control:* Costs have risen, although the plant production industry is trying to reduce the level of chemical application by more environmentally-friendly practices such as Integrated Pest Management.
- *Freight*: Often forgotten in calculations, freight costs incurred in transport to the planting site can average 25% of the total. Costs related to petrochemical consumption and wages have doubled in the past 10 years.

The present average cost of a container-grown plant varies from approximately $2.95 for basic PB3-grade revegetation species (e.g. manuka, pittosporum, harakeke) to $5.00 for PB3-grade podocarp tree species (e.g. rimu, matai). Initial results from the current project indicate that high-quality open-ground plants can be supplied at less than half these prices. Preliminary extrapolations from current computer models indicate that we could in fact supply plants for a 1000 ha revegetation project at $0.50 - 1.00/unit. This would be a 75% reduction in current plant costs.

Planting costs for bare-rooted plants are comparable to those for exotic forestry species, whereas planting costs for container-grown plants range between $1.00 and $2.50/unit for a comparable PB3-grade plant.

Plant physiology

Advantages in terms of plant form and function observed for open-ground plants in comparison with container-grown plants can be listed as follows:

- open-ground plants usually have a good root structure which can be inspected both prior to, and during dispatch. Container-grown plants are very susceptible to the root-circling and root-balling often seen in plants in the market place. Plants are often left too long in the containers. Plastic bag culture produces particularly poor root systems;
- the root systems generally have greater mass and more fibrous root development than container-grown plants. Root fibre is an important factor in the setting of initial growth rates;
- roots are conditioned to growth in a "living" soil environment. Plants raised in soil-less media have to adapt to natural soil conditions during establishment in the field, and this adds to the stress of adjustment to a new environment.
- in general the plant mass above ground is larger. Leaf area is greater, and increased photosynthetic capability stimulates growth during the establishment phase. It is important for the plant to grow as rapidly as possible so that it can overcome competition from weeds.

Larger plants with better developed roots have increased ability to survive moderate amounts of animal browsing;

- leaf cuticle thickness is noticeably thicker in open-ground plants. This confers a greater degree of disease resistance. We have noted that koromiko is more resistant to downy mildew when raised as open ground grown plants, and
- mycorrhizal activity is greatly enhanced in open-ground plants. This improves resistance to heat stress and pathogen attack.

Problems associated with the raising of open-ground plants are as follows:

- there is a much narrower time period for planting. We currently recommend planting between late May and early September. Many large-scale revegetation projects find difficulty in adhering to a planned time schedule. Late planting exposes plants to the effects of greater water stress and wind experienced after September. Late spring rain cannot be relied upon;
- bare-rooted plants have a limited “shelf life”. Except for harakeke, which can be left unplanted for two weeks or more, they should be planted within two days of lifting. They should be protected from sun and wind. Modern stress guards e.g. root gels and anti-transpirant sprays can reduce the level of transplanting shock to a certain extent;
- the available species range is limited. We are working to extend the number of species that can be supplied as open-ground stock; and
- Capital start-up costs for large-scale open-ground production is prohibitive for small operations. Necessary implements range in price from $50,000 for an under-cutter to $70,000 for the tractor to power the implements. Good quality flat land is also required.

Overview of practice at the Taupo Native Plant Nursery

Seed collection and processing

This is done according to procedures that most plant nurseries would follow. Seed is collected from all over New Zealand and from some offshore islands. It is catalogued, processed and stored either in peat or (dry) in a cool store at 4 ± 1 ºC.

Sowing

Seed is sown in seed trays for later pricking-out into plug trays, or sown manually or by machine directly into plug trays. Plug trays usually have 30 - 60 mL cavities.

Planting bed preparation

Normally we carry out a soil test to get an indication of current soil fertility. Results are used as a guide for fertiliser application.

Transplanting to open ground beds

At this stage we transplant manually. We are investigating the use of mechanical planters designed for the vegetable industry.

Plant conditioning

A number of important steps are performed according to schedule:

- undercutting - cutting and conditioning of tap roots;
- lateral pruning - cutting lateral root growth *down* the rows;
- box cutting - cutting lateral root growth *between* rows;
- topping - to maintain the desired root/shoot ratio; and
- wrenching - to increase the amount of root fibre (root conditioning).

Pest and disease management

In the current project we have needed very little pest and disease control for open-ground plants.

Lifting

The plants receive a final wrench and anti-transpirant sprays are applied if required. Roots are dipped manually into a root-gel solution before the plants are transferred to forestry planting boxes.

Further research

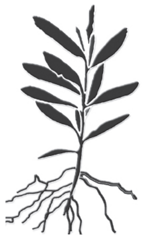
As this project proceeds, we have identified areas in which further research is required:

- species selection. We would like to expand the current species range;

- mycorrhizal effects in the nursery and after planting in the field;
- mechanisation of planting in the nursery and at the field site; and
- pelletising seed of native species.

Acknowledgments

To Jaap van Dorsser for his wisdom and encouragement. We would not have made progress without his input. To the Lake Taupo Protection Trust for funding, without which the project could not proceed. To Tānes Tree Trust, in particular David Bergin and Ian Barton who manage the science and oversee the project. To Herwi Scheltus, Department of Conservation, whose advice has been invaluable, and finally to the Staff of the Taupo Native Plant Nursery who carry out the nursery work for this project.



Options for successful establishments of natives

Jaap van Dorsser

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***Jaap** is now retired after managing the Forest Research Institute Experimental Nursery for 35 years. He has also been a forest nursery consultant in New Zealand and Australia. His interests include farm forestry and native forest and riparian rehabilitation.*

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Introduction

When taking on a project of any sort you have two options:

Option 1. You allow poor planning, management slop and poor execution to ruin your results; or

Option 2. You do everything well and on time.

The seasons don't wait.

Six components contribute to the successful establishment of forest tree species, native or exotic: These can be summarised as follows:

Planning and site preparation

Planning must be done in advance. Site preparation usually involves fencing, weed spraying and animal control. It may have to start two years in advance of planting. Machinery may be required.

Order planting stock in advance. Giving the nursery plenty of time ensures that the species you want will be available and that the quality will be satisfactory.

Nursery Production

Open-ground production

For large scale afforestation with native species, open-ground (bare-root) production is cheaper than the raising of trees in containers. Methods for cost-effective large-scale open-ground raising of native species were developed at the NZ Forest Research Institute in the late 1950s and early1960s. Many thousands of plants were grown and used in native forest rehabilitation.

To produce 1- and 2-year-old native planting stock, the preferred method is to sow seed in plug trays during winter. Plug trays can be treated with a copper compound such as copper hydroxide. This inhibits the development of curling and tangled roots, and also has a fungicidal function. It facilitates the process of de-plugging by avoiding root damage.

Seedlings are transferred into pre-formed and pre-dibbled outdoor nursery beds in the spring. From then on the trees are "grown off the tractor seat" using methods developed for exotic species such as eucalypts and Douglas-fir.

Container growing

The horticultural approach of single-plant culture is the prevailing method used for raising native tree planting stock in New Zealand.

In recent years some nurseries have installed cavity tray-filling and precision-sowing equipment. This eliminates the need for pricking-out, a labour-intensive procedure which often results in tap root distortion. Cavity trays produce plug-grown plants which are then transferred into larger containers.

The inside of plug trays and containers may be treated with a copper compound such as copper hydroxide in order to improve the quality of the root systems. This treatment inhibits the development of curling and tangled roots, and also has a fungicidal function.

It is especially useful for species subject to root rot problems. It facilitates removal of the plant from the container without root damage.

De-bagging

When plants are grown in planter bags the quality of their root systems cannot be readily assessed. Root deformities remain hidden until time of planting in the field, when they are not easy to rectify. For this reason, when using container-raised plants I prefer to de-bag them up to a week prior to planting. The roots are disentangled, trimmed, dipped in water and then placed in white forestry plastic bags. They must be kept wet - forgetting them at this stage is **not an option.**

One advantage of early de-bagging is that root system quality can be checked and remedied prior to planting. Another benefit is that it makes the establishment of a mixed species plantation much easier.

Transport

Robust container-grown trees are bulky and heavy. The shifting of these plants from nursery to planting site, and on the planting site itself, is costly in terms of transport and labour. Trees in white plastic bags are less bulky and lighter to handle.

Storage at the planting site

Bare-root plants must be kept cool, wet, and protected from sun, wind and frost. Laying bare-root plants out ahead of planting is **not an option.**

Planting

Bare root or de-bagged trees can be planted from autumn to spring - that is in the cooler and wetter parts of the year. Dig to loosen the planting spot, open up a hole wide enough and deep enough to dangle the root system in, plant deeply and firm the plant in well. Do not stuff the roots in the hole.

Water-in, if necessary and possible. Assistance from the local volunteer fire brigade is an option; they enjoy the practice!

Aftercare

Weed control is essential, especially in the first and second years. Weed development should be monitored and if necessary controlled in Year 3. Animal control is important, especially for broad leaved species which are particularly vulnerable to browsing. Use of animal repellents is an effective option.

Concluding remarks

This last winter we planted 3000 trees and shrubs at Ngongotaha. I expect every tree to survive and grow. If 60 of them died (2% of 3000), we would want to know what went wrong. Anything less than 98% success is **NOT AN OPTION.**

A survey of New Zealand experience in propagation and establishment of native forest species

Nick Ledgard and Heidi Dungey

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Abstract

A survey of larger native plant nurseries, also companies and individuals with experience in plant establishment, was undertaken in order to obtain information about growing and establishing indigenous forest species on farm and ex-farm grasslands. Forms were sent to 47 recipients, 24 in the North Island and 23 in the South Island.

The 60% response rate included 18 Nursery forms and 14 Establishment forms suitable for analysis. Returns were also received from four specialist seed sellers. Replies covered all aspects of native plant growing and establishment: preferred species; benefits and disadvantages of bare-rooted and container-grown seedlings; seedling quality; transport; planting; spacing; site preparation; pre- and post-planting weed and animal control; use of fertilisers, water and stakes; eco-sourcing; use of natural regeneration; use of nurse species; client knowledge; major establishment problems; suggestions for improving survival; overall cost; and opportunities.

Responses showed that a range of plant material was used, most of it grown in containers. There was a lack of consistency in specification of height, root collar diameter and shoot/root ratio suitable for different site types. It was commonly felt that plant survival in the field could be improved by better weed and animal (wild and domestic) control. Poor post-planting management was identified as the main cause of failure. The majority of respondents felt that there were opportunities for reducing plant costs if larger seedling orders were placed well in advance. Greater use of bare-rooted seedlings would reduce establishment costs, but for a number of reasons this option was not favoured by either nurseries or establishers. Costs of native forest plant restoration could be reduced by greater use of direct seed sowing and encouragement of natural regeneration, but these methods had not been explored by the majority of survey respondents.

Introduction

The New Zealand Government wishes to see more trees (either exotic or indigenous species) planted on ex-pasture “marginal” land, particularly on steep, erosion-prone sites considered to be unsuitable for other purposes. In late 2008, the Ministry of Agriculture and Forestry (MAF) asked Scion to produce an up-to-date report on matters relating to the establishment of indigenous forest on grassland in New Zealand.

Part of this project entailed a survey of practical experience obtained in propagating and establishing indigenous forest species on farmland. As time was limited, the nationwide survey was restricted to larger native plant nurseries and companies and individuals known to have considerable experience in native plant establishment.

Methods

Survey forms and recipients

Two survey forms were prepared, one for nurseries and one for native tree establishers. These were sent to 47 nursery managers and tree establishers; 24 in the North Island and 23 in the South Island. All recipients had agreed to take part in the survey.

The forms contained questions on 43 topics. Copies of the forms and a detailed account of the responses can be found in the main report (Davis et al., 2009). This paper summarises responses on major topics.

Results

Twenty-eight recipients (60%) returned a total of 19 Nursery forms and 15 Establishment forms. Three of the latter were from private/farmer planters. Additional returns in the form of sales catalogues were received from four specialist seed sellers.

Nursery responses

Eighteen of the forms returned were suitable for analysis.

Top ten indigenous forest species sold - see Table 1.

Bare-rooted (open-ground) plants

Open-ground plants can be produced for less than half the cost of containerised plants. No nurseries were currently growing regular crops of bare-rooted seedlings, although two had experience in that area. Reasons were: insufficient space; lack of equipment and people skills; native plants less tolerant of root-pruning/wrenching than exotic conifers; shorter selling season (cash-flow limiting); lack of demand from clients, inability of clients to handle and establish them properly – failure sometimes falsely attributed to nursery practice.

Container-grown seedlings

All nurseries grew and sold seedlings in a variety of containers. Four types were commonly used:

1. *Plugs:* Plastic trays with small 5-10 cm deep x 2-3 cm wide cavities. Mostly used for grasses and herbs. Few nurseries sold woody species in plugs for planting in the field;

TABLE 1: Top ten indigenous forest species sold.

Common name	Latin name	No. of nurseries and (% of total)
Flax	*Phormium tenax*	17 (94)
Cabbage tree	*Cordyline australis*	13 (72)
Kohuhu	*Pittosporum tenuifolium*	11 (61)
Manuka	*Leptospermum scoparium*	8 (44)
Kanuka	*Kunzea ericoides*	7 (39)
Mountain ribbonwood	*Plagianthus regius*	7 (39)
Toetoe	*Cortaderia richardii*	7 (39)
Karamu	*Coprosma robusta*	6 (33)
Narrow-leaved lacebark	*Hoheria angustifolia*	6 (33)
Broadleaf	*Griselinia littoralis*	4 (22)
Mingimingi	*Coprosma propinqua*	4 (22)

2. *Root trainers*: Light plastic re-usable “cards” or “booklets” composed of 4 - 6 cells with ribbed sides to encourage straight root growth. Held in trays containing 10 - 12 cards, which are kept off the ground so that roots at the base are “air-pruned”. Common types are: Tinus (20 x 5 x 5 cm); and Hilson (15 x 4 x 4 cm). These are mostly used for shrubs and smaller grades of trees and are commonly used for planting out in the field;

3. *Hard plastic pots*: Capacity ranges between 1 and 4+ litres. Types most used were: Olive pots (14 x 6 cm and 17 x 8 cm); RX90s (90 mm pots); BCC81s; Lannen 35s; Hico V150s and Hico 35Fs. These are suitable for plantable shrubs and trees; and

4. *Soft polythene planter bags*: Commonly known as PBs, these range in size from PB3/4 to PB5+, with numerals referring to capacity in pints. Size used most commonly for plantable shrubs was PB2; for trees PB3 to PB5.

For logistical reasons, most nurseries used one or two types of container – usually root trainers and hard plastic pots for medium-grade plantable seedlings and PBs for larger grades.

Container-grown stock was preferred to bare-rooted stock for the following reasons: ease of holding in the nursery; greater flexibility in grading large and small seedlings; more suitable for fine-rooted native plants; better tolerance of handling, storage and planting by clients; longer season for sales and planting; ability to lay out species mixtures prior to planting; greater likelihood of establishment success for the average client.

About half of the nurseries tried to grow seedlings to target specifications such as height and root/shoot ratio. Four (22%) included root collar diameter in specifications.

Plant cost

Prices for the same grade of stock were very competitive between nurseries. The average lower-end price for bulk-produced shrubs and smaller trees in root trainers and hard plastic pots was $1.75/unit. Larger trees in PB2s were $2.25. Bulk-produced, bare-rooted stock could be produced for $0.80. This method may not be suitable for all native species.

Asked whether an increase in demand for native plants would result in supply deficiencies, 34% did not anticipate problems in meeting demand while 66% expected problems in obtaining enough seed, especially if ecosourced.

A total of 56% maintained that their prices were as low as they could be and 44% commented that price reduction would depend on larger orders with longer lead-in times (forward ordering – “no price reduction for spec. sales”). Two respondents replied that prices could be reduced if smaller plants were supplied, but this would require a high standard of preparation: “smart use of smaller plugs with excellent weed and rabbit control – the forestry approach”. One commented that cheaper plants could mean poorer quality. Other interesting comments concerned use of biodegradable pots to be planted with the seedling; “large scale production of bare-rooted stock”; and “creative use of exotics” – presumably as a nurse crop.

Customer knowledge and success in establishment

Nurseries were asked for their impressions of customer knowledge about species choice, quality and establishment. Replies indicated that 65% (range 15-100%) of clients did their own planting, and that less than 20% ordered stock more than one year before the intended planting date. Exceptions were the few clients placing regular large orders who can make up a large proportion of sales (in one case, 70%).

The majority of clients, especially smaller ones, had little knowledge about the need for matching species to site or the importance of weed and animal control. All nurseries offered advice, often supported by excellent written material, and most clients sought such assistance. There were often reports of variable plant survival, a major reason being poor post-planting maintenance (weed and animal control). Less frequently reported were damage from herbicides, frost or drought, shallow planting and use of small plants on harsh sites.

When asked how seedling sales might be increased and how to get more trees established on grasslands, 56% replied that there should be financial incentives in the form of direct grants or tax/rates relief. Improved education and awareness was mentioned by 33%, another 17% adding that greater establishment success would attract more planting. Some wondered how prospective planters might be informed, suggesting that written material and field-days were mainly accessed by the “converted”. Two respondents (11%) felt that regulation would not work, and could have the opposite effect. Three (17%) commented that there needed to be more “acting as one spoke” from the likes of Federated Farmers and Fonterra who use images of native planting to portray a “clean, green image”.

Establishment responses

Fifteen native plant establishers responded to the survey and fourteen forms were suitable for analysis.

Numbers of seedlings planted

Twelve respondents (86%) gave approximate numbers of seedlings planted annually as 500 - 500 000. The total number planted by all respondents was between 592 500 and 813 500.

Bare-root vs container-grown seedlings

All respondents used container-grown stock for shrubs and trees. Most establishers could not access bare-rooted seedlings, even if they had wanted them.

Eco-sourcing

A majority (86%) of respondents considered that ecosourcing was either “very important” or “important”. Three (21%) commented that it was not easy to obtain sufficient numbers of ecosourced plants of some species.

Seedling-quality specifications

All respondents felt that seedling quality was important. When asked for desirable features, seven (50%) gave actual figures, mostly for minimum shoot height (25 - 50 cm, depending on species). Three (21%) also gave root collar dimensions (5 - 10 mm, depending on species). Most relied on seedling appearance (“sturdy”; “well developed root systems”; “height to root ratio important”; “height and age”; “not too tall”) or nursery advice.

Eleven respondents (79%) agreed that root-binding in pots or bags could be a problem. Nine (64%) resorted to cutting or pruning parts of the root system, some noting that this added cost to the planting operation. Two (14%) would not buy, or would return, root-bound stock. Another two thought that under-formed roots (a result of late potting-up) were more of a problem.

Transport of nursery stock

The question was related to plant stress. Most respondents (79%) tried to use closed-canopy vehicles. One nursery used special plastic bins for transporting seedlings which had been removed from containers and placed in large plastic bags. Five (36%) ensured that seedlings were well-watered prior to transport. One commented “no need [to take extra care] – we grow hardy plants in an exposed nursery”. Another stated that “driving at average speed (with seedlings in an open trailer) is no different from being on a windy site”.

Site preparation

The most common (86%) pre-planting site preparation practice on grassland sites was spot-spraying. The remaining respondents (14%) advocated heavy grazing before planting. Four (29%) mentioned ripping if soil was compacted or if an underground hard pan was present.

Plant spacing

Spacing ranged from 0.5 m (40 000 plants/ha) to 4.0 m (625/ha). A majority of respondents (71%) planted shrubs at 1.0-5.0 m spacing (10 000 - 4444/ha); trees at 2.0-2.5 m (2500 - 1600/ha). Rapid canopy closure (for soil retention, weed suppression and carbon storage) was a major aim.

Planting time

Time of planting depended on location of planting site. Spring was favoured by southern respondents and those planting inland or on cooler sites. Autumn was preferred for warmer and coastal sites:

- Tauranga: “May”;
- Cambridge: “May is the best month; September where frosts exceed -5 °C”;
- Taranaki: “May to September”;
- Wellington: “June-October”;
- Marlborough: “May/June for coastal sites, October for inland coastal sites”;
- West Coast: “Any month except January or February”;
- North Canterbury: “August for open sites, winter for sheltered sites”;
- Queenstown: “August on dry north- and west-facing slopes, but generally September-November”; and
- Coastal Southland: “Winter for some coastal sites, September-November if frosts are an issue”. “For PB2s or larger, autumn is best”.

One respondent commented that plant quality affects planting time.

Planting tools

All respondents used planting spades but six (43%) mentioned mattocks/grubbers and motorised augers.

Planting depth

Five respondents (36%) recommended burial to a level 1 - 5 cm above the root collar, while two respondents recommended planting “to root collar depth only” in wet sites. The remaining 64% planted to root collar depth, one stating “to same level as in pot – very important”, and another that planting depth varied with species.

Weed control

This was considered to be of vital importance. All carried out pre- and post-planting weed control with chemical herbicides. Most (78%) also weeded by hand or used hand-tools (spades, grubbers), or motorised tools (mainly weedeaters and scrub-bars). Use of tools was restricted by time and cost. One respondent mentioned greater use of physical methods due to damage resulting from use of chemicals.

Most respondents (79%), expressed interest in using mulches (woodchips, bark, carpet, wool, plastic mats), but commented that they were not suitable for large areas, and incurred extra expense. Two (14%) did not use mulches for weed control. One replied that “sprayed, dead rank grass makes an excellent mulch”.

Time-span for weed control

All considered weed control following planting to be essential for long-term success. Most felt that control should be maintained for at least two years, but due to costs involved this was usually left to the owner of the trees. Two “own-land” planters controlled weeds for up to four years, one stating that shelterbelt areas were sprayed with herbicide three times a year.

Animal control

Next to weed control, animal control (domestic and wild) was considered to be most important. Animal control, especially fencing to exclude domestic stock, was left to the landowner. One respondent stated “I insist on fully-fenced sites before I plant natives”. Rabbits and hares were the wild animals most frequently mentioned. Six respondents (43%) used plastic sleeves to protect seedlings, and three (21%) used repellents (although they “do not last long”). One thought that “effective hunting or poisoning is preferable”.

Fertiliser treatment

Six respondents (43%) did not use fertiliser when planting (one of them for “water quality” reasons). The remainder placed slow-release fertiliser pellets/tablets at the bottom of the planting hole.

Watering

Nine establishers (64%) did not water after planting. The remainder used water if readily available or when post-planting conditions were extremely dry. One commented “should not be needed if weed control good”.

Staking

Most (64%) did not use stakes, one commenting that “we prefer sail pruning or topping in order to stabilise plants”. Others only used them to mark plant locations. Bamboo was the preferred material for stakes.

Follow-up maintenance

All respondents acknowledged that this was very important. Most felt that poor weed and animal control were the main reasons for establishment failure. All offered advice to clients on follow-up maintenance, and all but two offered the service of follow-up weed control. Many commented that clients often intended to do maintenance work themselves. Three farmer respondents carried out weed and animal control in their own plantings for 4 - 5 years.

Survival

All but one respondent expected survival rates to be 80 - 100%. Two replies stated that survival could be as low as 30 - 50%.

Nurse species

Eight respondents (57%) sometimes planted non-target species to shelter establishing trees and shrubs. Nurse species mentioned were *Coprosma robusta, C. rigida, C. crassifolia, C. virescens*, kanuka, tree lucerne (tagasaste) and gorse (not actually planted). Gaps of 1 - 5 years between planting of nurse and target species were mentioned, also the need for managing nurse species by pruning back or removal. One respondent who did not use nurses commented that “close-spaced kanuka can completely suppress natural successions”; another that “initial selection of appropriate species means that there should be no need for nurse species”.

Major establishment problems

Eight respondents (57%) mentioned inadequate weed control as a major cause of seedling failure. Of the 43% citing lack of domestic and/or animal control, many commented that owners often failed to carry out post-planting maintenance. Blame was not always attributed to owners (“contractors not always reliable to do things on time”). Solutions offered were: better fencing (“too much use of a single hot wire”); use of larger seedlings (soon grow above weeds and can “absorb” browse damage); better quality control auditing; effective chemicals; readily-available guidelines; more training for operators; planting at the right time of the year. Other reasons for failure were weather extremes (29%) and selection of plants by price rather than quality.

Retirement of land from grazing to promote natural regeneration

Five establishers (43%) had experience with retired grassland. The most frequent comments were that there must be a seed source nearby and that weed and pest control must be effective. Although “no grazing” was recommended by most, two respondents felt that there was room for strategic grazing by sheep.

Establishment costs

Establishment costs were calculated, using the assumption that establishment operations incorporated efficiencies of scale associated with large numbers of plants. They are presented in detail in the full MAF report (Davis et al., 2009).

In summary, results of the survey showed that natural regeneration was by far the cheapest method for establishing native species ($4039/ha). The next cheapest was broadcast-sowing for kanuka ($8873/ha) and manuka ($10,310/ha), but not karamu ($22,550) or totara ($25,060) due to the high cost of seed. Manual planting was the most expensive method ($15,479/ha for bare-root stock; $24,144/ha for root trainer stock; $27,000/ha for PB2 container stock). Comparable costs for establishment of radiata pine were lower than for native plants due to lower seed and seedling price and higher survival rates. Costs were close to those derived by Douglas et al. (2007): $13,955 - $23,535/ha for spaced planting and $4780 - $14,300 for direct sowing.

Opportunities for overall cost reduction

A range of responses included those (36%) who felt that seedlings were already too cheap (“nurseries have to survive”). On the other hand, 21% felt that establishment of native plants could be cheaper if larger nursery orders were placed well in advance, or if smaller plants were used (this would require better site preparation, weed and pest control). Use of mechanical aids such as planting machines and motorised augers was suggested by four respondents (29%). Other opportunities mentioned were better planning and standardisation of growing and establishment processes; more research; and use of biodegradable pots.

Conclusions

All the nurseries and establishers felt that they were producing seedlings and establishing them as well as they could. If orders to nurseries could be: (a) placed well in advance, preferably at least one year before planting; and (b) placed for large numbers of plants, discounts could be offered. In the field, plant survival could be improved by better control of weeds and animals (wild and domestic) for at least two years.

A range of planting stock was used, most produced in containers. There was a lack of consistency in relating specifications (height, root collar diameter and shoot/root ratio) to site conditions.

Greater use of bare-rooted seedlings would reduce establishment costs, but most nurseries and establishers preferred container-grown material for a range of reasons.

Native forest restoration costs could be reduced by greater use of direct seed sowing and the encouragement of natural regeneration. These two techniques had not been explored by the majority of survey respondents.

The survey showed that the cause of native plant establishment on grassland is well served by a number of keen and knowledgeable nurseries and establishers who report successful operations and try to keep costs as low as possible. If larger areas of grassland are to be restored to native forest plant cover, more certainty about the reliability of establishment practices will be needed. A wider range of growing and establishment techniques (e.g. direct seed sowing - Douglas et al., 2007) deserves attention.

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Comparisons between open-ground and container-raised indigenous shrubs in nursery and field trials

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Introduction

Pastoral property holders are experiencing increasing pressure for restoration of degraded and marginal land. Requirements include the integration of indigenous biodiversity into productive landscapes in order to improve opportunities for environmental sustainability, and the establishment of indigenous trees to meet a range of objectives including sustainable timber production.

A considerable proportion of the pastoral land in New Zealand, particularly riparian and marginal steep hill country, could be retired and dedicated to plantations of indigenous species. This would improve environmental outcomes, particularly for waterways. It would also provide sustainable management opportunities for indigenous forestry to be integrated into agricultural land use (e.g. PCE, 2002). Revegetation with indigenous species requires a major increase in commitment and the use of cost-effective establishment techniques. At 1.5 x 1.5 m spacing, and allowing for replacements, conversion of only 1% of New Zealand's 13.5 million ha of pasture to indigenous plantations would involve the raising and establishment of 630 million plants.

Revegetation using wide plant spacing will involve weed control over many subsequent years. Often this is not carried out, and the result can be total failure (e.g. Pardy et al., 1992; Beveridge & Bergin, 1999). Closer spacing can provide canopy cover within two years, but costs associated with use of standard lines of container-grown stock are high. Bergin & Gea (2007) estimated that more than $40,000/ha would be required for a density of 10 000 plants/ha).

Price is likely to be a major factor influencing choice of species for revegetation purposes. Indigenous plants are usually raised in containers, and cost $1.50–5.00 each. In contrast, open-ground techniques are used to raise many exotic tree species, and the cost per plant is less than $1.00. Plant quality may also be an issue. It is difficult to assess the condition of root systems in container-grown stock, and tree failure within two decades has been attributed to root malformation associated with early confinement in containers (J. van Dorsser, pers. comm.).

Major factors responsible for the high cost of establishing indigenous species include the cost of planting and the cost of maintenance. Depending on plant size and spacing, up to eight years of maintenance may be required to protect plants from competition by weeds such as kikuyu or blackberry. A useful measure of economic effectiveness could be the cost of achievement of permanent weed suppression through continuous canopy development.

Building on previous research on techniques for raising indigenous tree and shrub species, the project described here was undertaken in order to compare the performance of container-grown and open-ground plants in nursery and field trials.

Background

Between 1960 and the early 1980s, techniques for large-scale low-cost production of bare-rooted indigenous plants were developed at the Forest Research Institute by Jaap van Dorsser (e.g. Forest Research Institute, 1980a; 1988). These techniques were based on methods used for a wide range of exotic conifer and hardwood species by forest nurseries throughout the country.

The open-ground method involves highly-mechanised production systems to raise and condition seedlings in readiness for planting. Young seedlings are lined out in 90 cm-wide nursery beds prepared by tractor cultivation. Over several months preceding lifting, reciprocal undercutters are used to root-prune and wrench the plants in order to stimulate the formation of fine root systems near the base of the plant (Figure 1). When old enough, the well-conditioned plants are easy to lift. Roots are inspected and trimmed before transport to the field site. Plants with poorly-developed fibrous or distorted roots are rejected.

All indigenous tree and shrub species used in revegetation programmes can be raised by the open-ground method. In spite of this, few nurseries, including the largest native plant nurseries in the country, have adopted open-ground techniques for indigenous plants. This is largely due to the piecemeal approach and lack of planning associated with most indigenous revegetation programmes. Nurseries are forced to produce small numbers of a wide range of species in the hope that orders will be forthcoming.

Container-grown plants are easier to handle in small numbers and this method is favoured by small community-based nurseries. If necessary, plants can be retained from one year to the next by potting-on. A wide range of containers is available, and there is often debate about the suitability of root trainers, polythene planter bags or plastic pots for different species and planting programmes. Variation in type and size of containers means that costs are also variable.

There is continuing concern about the quality of indigenous planting stock, especially the condition of root systems of container-grown plants (e.g. Davis & Meurk, 2001; Bergin & Gea, 2007). A small number of forest nurseries including Appletons Tree Nursery, Nelson (Appletons, 2006), and Ngongotaha Nursery, Rotorua, produce a limited range of indigenous species using the open-ground methods applied to exotic forest trees. Taupo Native Plant Nursery uses open-ground techniques for a small proportion of its output but is looking to increase both the range of species and numbers of plants produced using open-ground methods (Philip Smith, Manager, Taupo Native Plant Nursery, pers. comm.).

FIGURE 1: Jaap van Dorsser, former Manager of the Forest Research Institute Nursery, Rotorua, demonstrating to a workshop the importance of well-conditioned root systems. *Photograph: Michael Bergin*.

Despite research into methods for raising and planting indigenous trees and shrubs (e.g. Forest Research Institute 1980a; 1980b), information about the relative performance of open-ground and container-grown plants has been based on personal observations rather than objective experimental trials (Bergin & Gea, 2007). Friends of the Mahurangi, acting in accordance with the Mahurangi Action Plan for revegetation of a large area of a North Auckland catchment, eventually decided that scientifically-designed trials were needed to determine the best methods for propagating native plants. With the assistance of former Forest Service scientists, they made a successful application to the Ministry of Agriculture and Forestry Sustainable Farming Fund and are now engaged in trial work comparing the performance of container-grown and open-ground indigenous plants for revegetation purposes.

Methods

After some preliminary work in North Auckland, a trial was conducted at the Taupo Native Plant Nursery, selected for its open-ground capability and also considerable experience in growing native species.

Emphasis was placed on the likelihood of successful plant establishment after transfer to a field site. It was recognised that the cost-effectiveness of establishing indigenous species involves more than the price of the plants. The real measure of success in a revegetation project is the early development of a continuous canopy that suppresses weed growth. Effective canopy development requires a high plant survival rate, rapid initial height growth, and a spreading crown form to maximise canopy cover soon after planting in order to reduce the requirement for weed control.

Nursery trial

Three nursery treatments were compared in terms of their effect on the size and health of plants prepared for revegetation projects. Seed was germinated in seed trays and pricked out into propagation cells. Within 2-3 months of germination, individual seedlings were transferred into either:

- open-ground nursery beds;
- PB3 polythene planter bags (larger-sized containers or pots);
- Hilson-sized root trainers (small containers).

The open-ground method was largely based on that developed by the New Zealand Forest Research Institute in the 1960-1980s. PB3-sized planter bags and Hilson-sized root trainers are the most commonly-used container types for indigenous species.

Plants of the following six indigenous species were raised by each of the three methods:

- harakeke (flax) (*Phormium tenax*)
- toetoe (*Cortaderia fulvida*)
- ti kouka (cabbage tree) (*Cordyline australis*)
- koromiko (*Hebe stricta*)
- manuka (*Leptospermum scoparium*)
- karamu (*Coprosma robusta*)

Most of the seed was collected in the Mahurangi district; some in the greater Auckland region.

At least 50 individual plants in each of the 18 treatments were examined nine months after seed sowing and within two months of transfer to the field for planting. Height, root collar diameter and crown spread (length x breadth) were measured, and plant vigour and health were assessed. Height of the monocotyledons harakeke, toetoe and ti kouka was taken to be the maximum length of leaves when gently pulled into a vertical position. Within species, a plant vigour and health score was allocated according to the following scale:

1. Very unthrifty (few or no leaves, only just alive).
2. Unthrifty (some defoliation, poor foliage colour, weak shoot growth).
3. Average (moderate health and vigour).
4. Good (minor leaf damage, otherwise good growth).
5. Excellent (robust plant with healthy foliage and shoot growth).

Roots of a small sample of each species were visually examined and briefly described. Representative plants of each species/nursery treatment were photographed for comparison of shoot and root development.

The cost of raising each species in containers was derived from the standard nursery pricelist for indigenous shrub hardwoods and monocots raised in large quantities at the Taupo Native Plant Nursery. Costs associated with the raising of open-ground plants were estimated by experienced nurserymen.

Field trial

Three sites were selected for determination of the effect of nursery treatment on growth of the six species when transplanted into different environments. All were on land north of Auckland that had been recently retired from pastoral farming:

1. A gently-sloping riparian area at Mahurangi (Figure 2).
2. A flat river terrace near Silverdale.
3. A steep, exposed hillside near Silverdale.

Handling, transport and planting

Plants lifted from the open-ground beds were transported immediately to the field sites in white corrugated plastic planter boxes each containing 20-40 plants (Figure 2). Plants in the larger PB3 containers were transported in plastic trays (eight containers per tray); those in the smaller root trainer containers in wire

FIGURE 2: The Mahurangi site, recently mowed and spot-sprayed with herbicide in readiness for planting. Open-ground nursery stock was transported in white corrugated plastic planter boxes (foreground). *Photograph: Michael Bergin.*

baskets each containing 60 plants. Approximate space requirements on the deck of a truck were calculated for each type of planting stock.

When seedlings were approximately 11 months old, three 10-plant rows of each of the 18 treatment/species combinations were laid out at each site in a fully-randomised and replicated design. Approximately four months after planting, chemical and mechanical methods were used to release the plants from weed competition. After this the need for releasing was considered to be minimal. Plants were inspected regularly to record any mortality or damage and its cause, so that timely maintenance could be carried out.

Almost a year after planting, survival, height, canopy spread and vigour were assessed, using the methods and criteria described for the nursery trial.

Results

Nursery trial

Shoot development

Nine months after seed sowing, canopy spread of the open-ground stock of most species was greater than that grown in large containers (PB3 bags), which in turn was greater than that of plants in small containers (Hilson root trainers) (Figure 3a). Only harakeke had a similar plant spread in all nursery treatments. The root collar diameter of open-ground plants was on average twice that of plants in PB3 containers and three times that of plants in Hilson root trainers (Figure 3b). Height growth was greater for harakeke and toetoe in root trainers but lower in the same nursery treatment for most of the other species (Figure 3c). All species had an average plant vigour score close to 5.

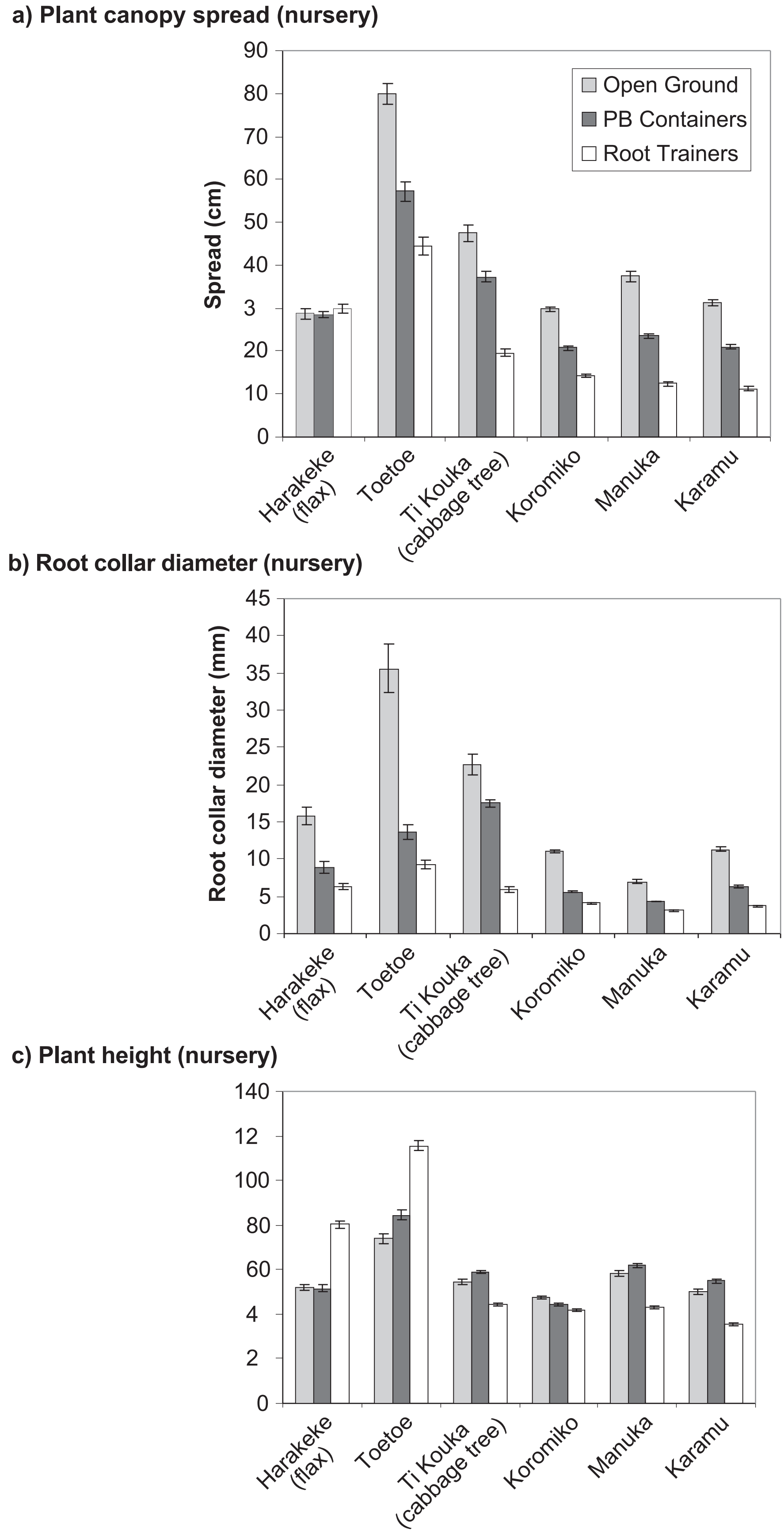

FIGURE 3: Effect of three plant-raising methods on: (a) canopy spread; (b) root collar diameter; and (c) height of plants after nine months in the nursery. Columns show means and standard errors for each species.

FIGURE 4: Toetoe (top), manuka (middle) and karamu (lower) plants raised for nine months in the larger PB3 containers (left); in open-ground nursery beds (centre); and in smaller Hilson root trainers (right). *Photograph: Jonathan Barran*.

Open-ground plants had better-developed shoot growth than plants grown in containers (Figure 4). This was probably related to available soil volume (nutrient source) and space for canopy expansion. Nursery area allocated to each plant in this trial would have been 400 cm^2 in open-ground beds; 225 cm^2 in PB3 containers and 25 cm^2 in Hilson root trainers. Plants raised in root trainers were particularly spindly.

Root development

All species grown in the PB3 containers displayed distortion known as root circling, some to a pronounced degree. Root development in the smaller root trainers was clearly restricted although vertical ridges in these containers prevent root circling. Open-ground plants had an abundance of unconfined roots that could be trimmed into a shape suitable for planting.

Plant cost

Estimated cost per plant for each nursery-raising method was:

- Open-ground $1.50 (provisional; small-scale experimental experience only);
- Large PB3 containers $2.50;
- Hilson root trainers $1.25.

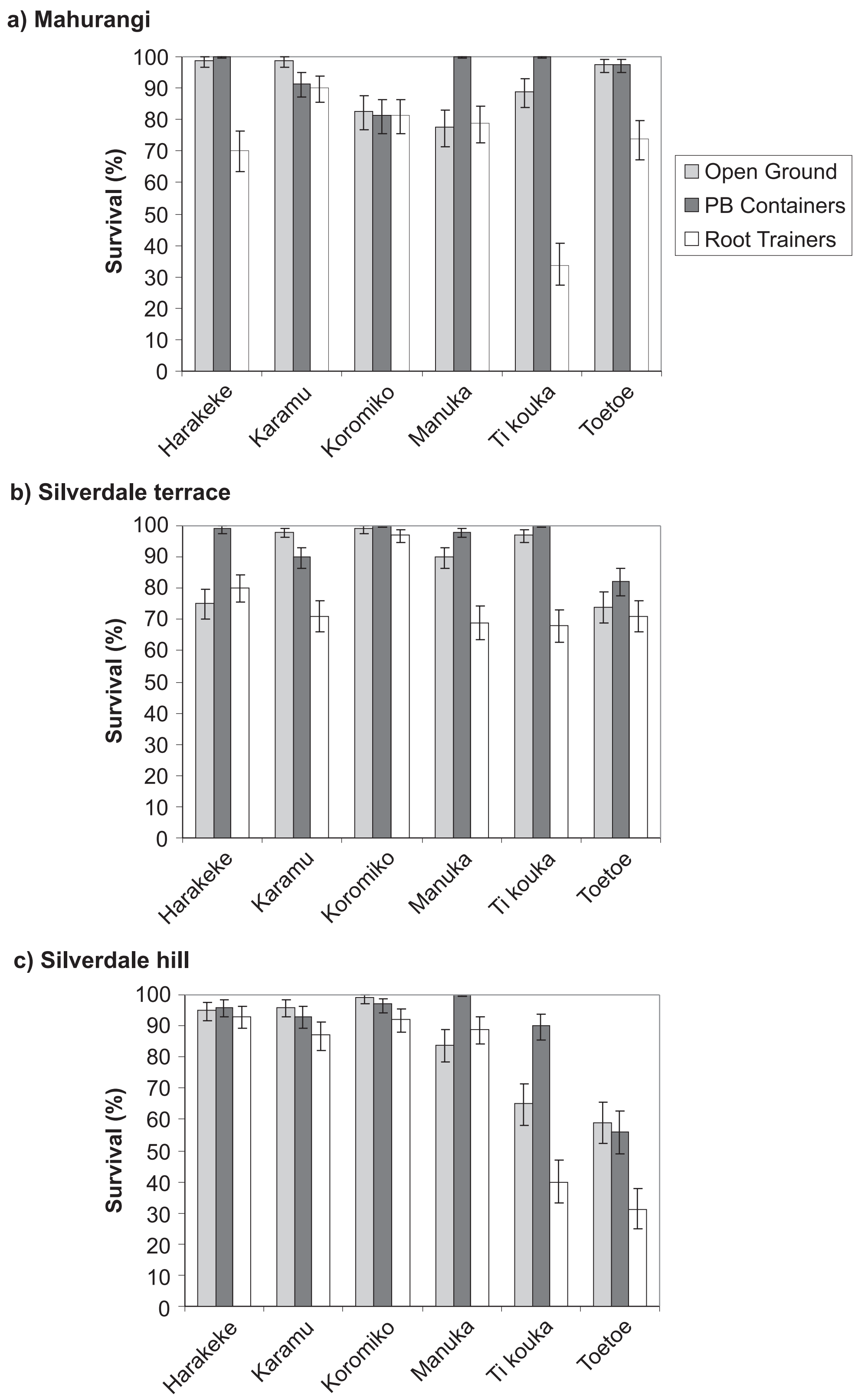

FIGURE 5: Effect of three nursery plant-raising methods on survival, 11 months after transfer to three field sites. Columns show means and standard errors.

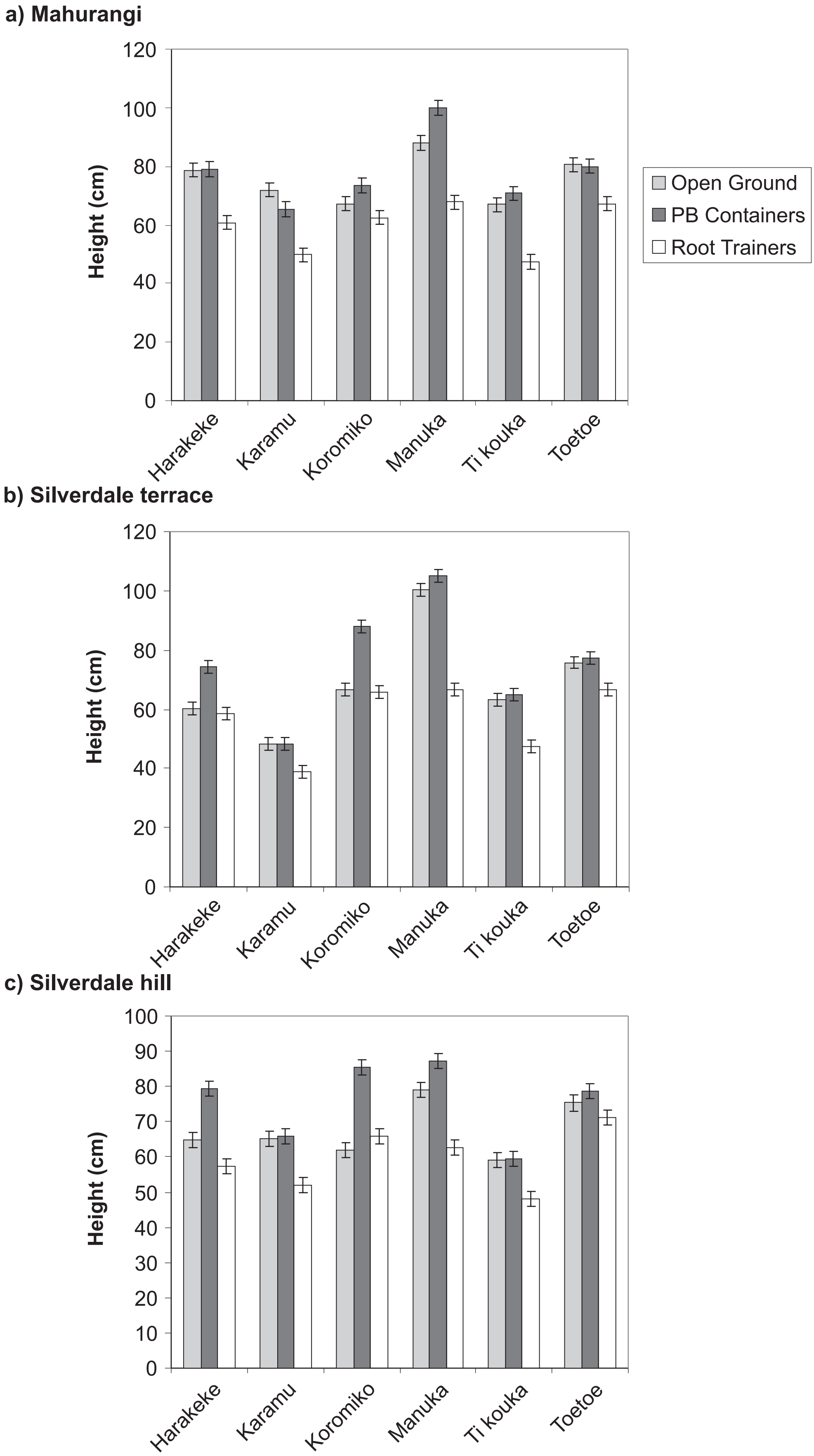

FIGURE 6: Effect of three nursery plant-raising methods on plant height, 11 months after transfer to three field sites. Columns show means and standard errors.

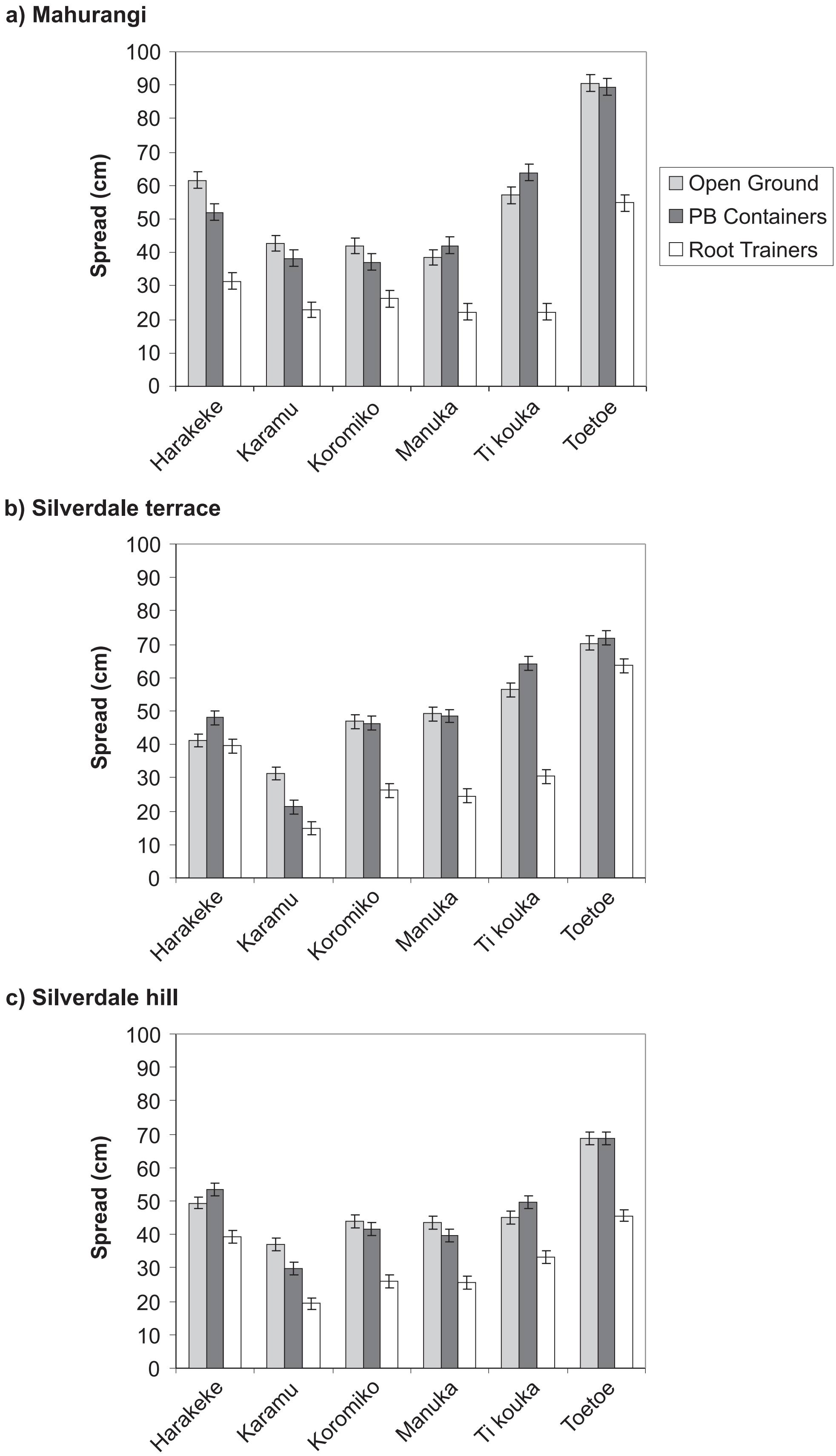

FIGURE 7: Effect of three nursery plant-raising methods on canopy spread, 11 months after transfer to three field sites. Columns show means and standard errors.

Field trial

Handling and transport

Stacking of planter boxes and use of trolleys with multiple shelves allowed the following numbers of plants to be transported per m^2 of truck deck space:

- Open-ground (3 layers x 8 boxes x 20-40 plants) – 480-960.
- PB3 containers (2 layers x 60 plants) – 120.
- Hilson root trainers (2 layers x 6 baskets x 60 plants) – 720.

Open-ground and root trainer plants occupied similar amounts of space. Costs of handling, storage and transport were therefore also similar. In contrast, plants raised in the larger PB3 containers occupied four times as much space and transfer to the field sites was therefore more expensive.

At the planting site, handling and placement of open-ground stock was found to be easiest. Container-grown plants were heavier due to the potting mix adhering to the roots. Extra time was required for removal from the container.

Survival

Across the three trial sites, plants raised in PB3 containers had the best overall survival rate after 11 months in the field, 15 of the 18 species/site combinations showing less than 10% mortality. Comparable values were 11/18 for open-ground plants and 6/18 for root trainer plants (Figure 5).

Plant height

After 11 months in the field, plants raised in PB3 containers tended to be tallest (Figure 6). Root trainer plants were often shorter than those raised by other methods. Plant height overall was greater at Mahurangi than at either of the Silverdale sites. Browsing by rabbits may have accounted for poor height growth of karamu at the Silverdale terrace site.

Canopy spread

Plants of all species raised in root trainers had poorest canopy development at all sites (Figure 7). Only minor canopy spread differences were observed between plants raised in PB3 containers and those raised by the open-ground method.

Conclusions

- Early establishment performance (survival rate) of indigenous tree species was similar for plants raised in large containers (PB3 size) and in open-ground nursery beds. Higher mortality rates and slower growth can be expected in plants raised in small containers (Hilson root trainers).
- Height growth was often greater in plants raised in PB3 containers than in those raised in open-ground beds.
- Canopy spread of open-ground plants was similar or greater than that of PB3 plants.
- The cost of plants grown in PB3 containers was twice that of plants grown in Hilson root trainers. Provisional estimates of cost for production of open-ground plants suggest that they are cheaper than PB3 plants.
- Plants grown in the smaller root trainers or as open-ground plants were easier to handle and transport to the field sites than those in large containers.
- Handling and placement at the field site was easiest with open-ground stock.

Further work

Time-and-motion studies will be needed for accurate estimation of costs associated with use of open-ground stock or container-grown plants in revegetation projects. The price differential between large-container stock (currently $2.50/plant) and open-ground stock (provisional estimate $1.50) is likely to increase when indigenous seedlings are produced on a larger scale.

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The place of native trees in the New Zealand forestry landscape

Clive Lilley

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Introduction

Today I wish to focus on the Ministry of Agriculture and Forestry's role in implementing government policies on forestry; achievements to date; and challenges for Tāne's Tree Trust, for the sector and for MAF. Let's start with a quick overview of what MAF should be doing. Government policy on sustainable management of indigenous forests on private land has been stable since Part 3A of the Forests Act was introduced in 1993. Harvesting of indigenous timber in Crown forests has been phased out and harvesting on private lands permitted subject to the provisions of the Forests Act.

At present, 49 approved Sustainable Forestry Management Plans relating to approximately 50 000 ha provide for the harvest of 80 000 m^3 of logs. In addition, more than 500 Sustainable Forest Management Permits have been approved. Each provides for a capped one-off harvest. Current production from these plans and permits represents approximately one third of the available volume. The Ministry estimates that about a third of the 1 000 000 ha of private indigenous forest in New Zealand has potential for sustainable management, so the amount of activity is nowhere near the possible maximum. This is due to competition from imported timbers and the general lack of demand for beech, the native species group which has the greatest potential volume for sustainable management. The slower-than-expected harvest rate represents an opportunity for the sector to look beyond forest management to marketing and product development. Jon Dronfield has described the opportunities recognised by Forever Beech.

Outside the area of forest currently considered to be sustainably managed, questions are being raised about the current Forests Act, which is putting brakes on legitimate harvesting. For example, restrictions placed on the management of single trees and groups of trees on grazed pasture could be restricting the sustainable harvesting of totara in Northland. Land owners argue that more flexible provisions would encourage the integration of forest and pastoral farm management.

Amendments to the Forests Act

The Ministry of Agriculture and Forestry is considering a number of minor amendments to the Act. Tāne's Tree Trust is making useful and productive contributions to expansion of the scope of indigenous forest management. The Trust supported new regulations enabling certificates to be issued for planted indigenous forests in order to provide surety for forest harvesting and milling. The Ministry also plays a role in indigenous forestry by sponsoring and administering the Indigenous Forestry Development Group, formed in 2006 under the chairmanship of Jim Anderton, the previous Minister of Forestry. In those days it was called the Indigenous Forestry Advisory Group. With the change of government the word "Advisory" has been replaced with the word "Development". The current chairman is David Carter, the present Minister of Forestry.

Activities of the Indigenous Forestry Development Group

The task of the Group is to be an advocate for the sector and to promote its initiatives. There have been a number of successes to date. Information about indigenous timbers provided to the NZWOOD website has profiled the sector as a contributor of quality building materials. Since designers and architects are among the most frequent visitors to this website this contribution should help to raise awareness of the potential of indigenous timbers. The Group has also funded a sustainable farming project. It contributed to the review of the Timber Framing Building Code and will make a similar contribution for other timber- and wood-based products in the Building Code when these come up for review. These efforts will help to ensure consideration of indigenous timbers for use in New Zealand buildings.

I would like to note at this point that so far there has been little overlap or collaboration between this Group and Tāne's Tree Trust. I believe there is scope for the two bodies to work together to achieve common goals.

Carbon sequestration

You cannot talk about forestry these days without mentioning climate change. Three carbon storage schemes are designed to encourage the planting of new forests, both exotic and indigenous. For the first time these schemes provide a mechanism for land owners to obtain income from the non-timber values of their forests. Many consider this to be a huge step forward for forestry in New Zealand, and the Government believes it will lead to new investment in native and exotic forest establishment. The most widely-known of the three is the Emissions Trading Scheme (ETS), which has been in place for a little over a year. The ETS included the forestry sector from the outset. The other two schemes are the Permanent Forest Sinks Initiative (PFSI), which provides opportunity for land owners to earn revenue from the carbon sequestered in their forests, and the Afforestation Grant Scheme (AGS) which helps with the development of new forests. One of the Tāne's Tree Trust Newsletters describes these schemes very well.

You are all aware of the ability of indigenous species to sequester carbon. The relatively slow growth of these species makes for long periods of sequestration and, as Jan Wright pointed out, this provides food for thought. Market forces dictate that carbon prices will rise as polluters in more countries are forced to account for their emissions. The time may come when the value of sequestered carbon exceeds that of the timber content of a forest stand.

Here are some statistics arising from the post-1989 exotic forests legislation put in place by the previous Government. This came into effect in September last year and we are implementing it now, while also working on further policy options for Government at the same time as considering how to design new legislation that may result from the Climate Change Response Amendment Bill. So far, 165 ETS applications have been approved: 53% of these are in the 1-50 ha category; 14% in the 51-100 ha category; and 28% in the 101-500 ha category. This means that we have a total of approximately 49 200 ha in the post-1989 Scheme to date. While most of the forest area registered so far is exotic, indigenous forest can be established on eligible land to earn carbon credits. To date nearly 700 000 carbon credits, called "NZ units", have been transferred to forest owners.

Many forest owners are dissatisfied with the 3t/ha/yr estimate of carbon sequestration rate used for indigenous forest in the ETS. Jan Wright called it a very conservative estimate and said that this demonstrated an immature understanding of the situation. Let me make it clear that we always intended this to be an interim figure. We have now completed more detailed studies and have supplied the Government with sufficient data and justification for the use of rates that reflect carbon sequestration rates during the active growing phase of indigenous forest. So the three tonne figure is for the politicians to amend.

The Permanent Forest Sinks Initiative aims to create permanent forest sinks by restricting harvesting and by the use of covenants. It is particularly suited to the growing of indigenous forests or to forest reversion where timber production is not the only reason for establishment or maintenance. Twelve PFSI forests totalling 2814 ha have been registered. The credits given to PFSI applicants are called Assigned Amount Units (AAU). Another 19 applications covering a total of 4000 ha are being considered. Some 1470 ha of this area is reverting to native species. There has been strong endorsement of the Initiative by land owners who see reversion of land to indigenous forest, the ability to undertake future limited harvest, and the accrual of internationally-tradable carbon as positive outcomes. We have other informal applications for 2600 ha of reverting indigenous forest. So the PFSI is being considered by people with indigenous forestry in mind.

Under the Afforestation Grants Scheme, half of the fund is made available to regional councils and the other half to a public tender pool. I chair the public tender pool and oversee the regional council activities. Just now we are auditing some of these – to make sure that allocation of taxpayer money is justified. Of the 16 regional councils in New Zealand, 10 have signed a memorandum of understanding with MAF however only six are actively using the AGS.

Bids for an afforestation grant can be made through a regional council or through the tender process. Seventy percent of the public pool is allocated for species with high sequestration rates; the remaining 30% for species with low sequestration rates. Nearly

6800 ha have been bid for. These include 1370 ha of indigenous forest, 700 ha of which is reversion. As well as opportunities, these programmes bring responsibilities relating to cash grants and restrictions, liabilities and responsibilities relating to the carbon units. The Ministry has a compliance and audit function and people need to be educated about the new and technical aspects of the process and their rights and obligations. Our job is to understand this and translate it for the public.

Research and development

The Ministry of Agriculture and Forestry and Tāne's Tree Trust have achieved a lot in the R & D area recently. The Trust has sought grants of about $400,000 in order to achieve its goals. Sustainable Farming Fund (SFF) grants to the Trust have included money for sustainable forest planting, continuous-cover forestry, promotion of native trees on farms, and investigation of beech ecology and management. Other organisations have obtained funding for indigenous forestry programmes. For example the Maori Trustee and Farm Forestry have received support for research on the marketing of beech timber, due for completion next year.

My Directorate has also undertaken research projects to support Part 3A of the Forests Act and to assist forest owners. These include the development of growth models for indigenous species, the remeasurement of existing silvicultural trials and the testing of small-scale management systems. There are some challenges for the sector. Conventional economics are a poor measure of the overall value of our indigenous forests to New Zealanders. Although the sector still contributes less than 0.5% in value to the annual forest output, we know that it has a lot of potential for increase. The challenge is to meet the needs of future generations by looking beyond the short and medium term to gains that can be made in 50-100 years time. The sector can do more to promote planting, forest management and the marketing of indigenous timber products. It can take indigenous forestry to an even wider land management base, improve the image of indigenous species and products, demonstrate good forest management and develop products that have a marketable point of difference.

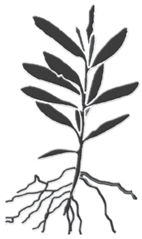
Creating a firm base for the indigenous forest industry

The indigenous forest industry needs a firm base, which is not there at the moment. The Ministry must administer the sustainable forestry provisions of the Forests Act responsibly, efficiently and in a timely manner and we are trying to improve our performance. The Trust needs to escalate the technology transfer process, and the sector at large needs to promote the planting of indigenous trees in a manner that provides for a more diversified forest landscape. There is room for more collaboration between the Indigenous Forest Development Group and Tāne's Tree Trust. I will put it to the Minister that TTT be invited to send a representative to the twice-yearly meeting of the Group. At present you are missing out on something there.

The second Select Committee

Finally, I would like to make a point about the second Select Committee. It is not my place to comment on policy but I am allowed to express a personal opinion. This year there have been two Select Committees on carbon issues. As we heard from Jan Wright the recent one produced five minority reports that went back to the Government. She said that the Bill would be debated in the House under urgency, clause by clause. That worries me, because the ETS is a technical and complex scheme and we will have to trust the understanding of our politicians. Normally you have legislation and you then apply rules for its administration. This did not happen with the previous Government - they wanted to have the ETS approved by 1 July 2008, before the Ministry and the Select Committee had commented on the form of the legislation. So people were trying to design the system before decisions were made, and everything was done rapidly in order to meet the deadline. Once the Bill was enacted, the Ministry was unable to inform the public because of the General Election. The new Government came in and a new Select Committee was appointed to come up with it's findings within six months. This means that there has been a huge lack of public education. People such as yourselves have not been properly informed. While debating a Bill clause-by-clause, Members can introduce supplementary order papers with only 24 hours notice. These can be used to change a word, a phrase or a whole chapter. So we will have a situation in the House in which a lengthy Bill is debated by people who may know little about it. Any Member will be able to change or amend complex carbon trading issues at will.

In broad terms, the whole idea with our domestic scheme is that it should be neutral with respect to the international scheme. This ensures that the taxpayer will not have huge deficits to make good when international auditors examine our national figures. The law of unintended consequences says that the Bill will go through in urgency. I can only hope that it is properly understood in the House and that, when it comes to us to implement it, we shall be able to take it to you in an understandable form.



Summary of comments following Workshop 2: Establishing natives economically

The purpose of the second Workshop was to examine past and present work on establishment of native species, and to indicate gaps in our knowledge and practice. Participants were asked to consider the following questions:

1. ***Based on the Workshop presentations and your own experience, what are some good ideas for establishing native species economically?***

2. ***What is currently preventing people who want to plant natives from establishing them successfully?***

3. ***What specific action could be taken to address the issues raised in Question 2?***

Summary of responses to Question 1

Topic	Ideas
Seed.	Improve the ecosourcing of seed. Improve seed supplies.
Plant quality.	Use larger-grade plants (less releasing, less trouble from animal pests.) Streamline shipping and handling. Select genetically-superior genotypes for planting. Choose plant size appropriate for site.
Plant species.	Start with one or two species – concentrate on these rather than spreading effort too thinly. Select best species for the site. Map the placing of seedlings during planting for later identification. Allow natural regeneration.
Nursery quality.	Use high-quality medium for raising plants. Exercise quality control at the pricking-out stage. Create good relationship with nursery staff. Harden off seedlings in the nursery to improve survival in the field. Don't plant seedlings that are too small. Introduce planting stock standards.
Timing.	Plant at the correct time of year. Adjust time of planting to site latitude.

Topic	Ideas
Preparation of planting site.	Use nurse crops. Use exotic nurse crops (including lucerne). Use close spacing of plants (weed control). Prepare ground two years prior to planting. Plan ahead for site preparation – every failed plant is a cost to be borne against a successful one.
Weed control.	Monitor weed development for five years or more. Control weeds over whole site. Use specific herbicides. Use mulches.
Ecology of planting.	Investigate the characteristics of regeneration. The role of nurse plants needs to be better understood.
Pest and animal control.	Stock exclusion – fencing.
Perception of value.	"$3.50 planted is good value".
Volunteer labour.	Make use of the community – schools, iwi, sports teams. Do more yourself – e.g. sourcing of seed, propagation etc.
Planning.	Understand the purpose or goal. Plan entire project including costs. Ensure good site access. Only plant what you can maintain.
Knowledge.	Communicate with the experts. Go to people who have already established indigenous species. Have equity partners (e.g. government). Don't use volunteers.
Economies of scale.	Use bare-rooted seedlings. Purchase bulk orders in advance – team up on purchase.
Regeneration.	Encourage birds. Choose a site close to a natural seed source for natural regeneration.
Open-ground planting.	Use direct-seeding methods. Sow manuka/ kanuka directly into pumice soil. Use bare-rooted seedlings. Develop new "no nurse crop" practice for some species.
Incentives to increased planting.	Lobby government for tax rebates.

Summary of responses to Questions 2 and 3

Barriers to economic establishment practice	Suggested actions
Getting widespread community buy-in [for restoration planting] e.g. from farmers.	Education – schools, wananga. Use “bribery” e.g. food, events etc. to encourage involvement. Involve marae, schools, local sports teams. Lead by example.
Lack of support and usable information.	Provide support systems/networking opportunities to inspire enthusiasm. Produce an “idiots guide” or manual. Assist with identification of pest weeds. Provide more information about good planting techniques. Set up a “one-stop shop” for information (site and species selection, pest control etc.). Distribute information using posters in areas likely to be frequented by prospective native forest growers e.g. RD1 stores, nurseries.
Perceived high costs/lack of returns.	Lobby legislators – insist on subsidies. Develop value standards – look at intrinsic value of native trees on properties. Utilise community schemes etc. to cut labour costs. Provide incentives through rebates, tax re-scheduling etc. Place advance orders for large-scale plant requirements. Value the non-timber benefits that natives confer on the environment. Use the carbon trading scheme to provide short-term cash and funding for research. Obtain funding through the Afforestation Grants Scheme and Carbon Credits. Increase the use of cheaper technology (requires education of landowners). Develop cost-effective strategies for establishment using filler species. Recognise biodiversity benefits as part of schemes like AGS. Perform better cost/benefit analyses.
Lack of young people in the horticulture/forestry industry.	Pay more for trees (nursery industry currently at rock bottom). Make the industry more attractive.
Plant and animal pests.	Education (especially for urban population).
Absence of a business case. Failure to treat project as a business. Failure to plan. Lack of purpose and uncertainty about outcomes.	Develop a business case. Collect available species data. Target a 70 year growth cycle. Undertake sustainable economic analyses. Prepare a business plan. Ensure nationwide publicity.
Lack of success stories.	Increase media awareness Encourage membership of Tāne’s Tree Trust.

Barriers to economic establishment practice	Suggested actions
The "*Pinus radiata*" mentality.	Overcome this by valuing ecosystem benefits as well as carbon sequestration.
Lack of knowledge by public.	Develop website/blog that is updated regularly. Develop case study e.g. for use in publicity such as the television programme Country Wide
Current perception as "Long term radiata".	Place more value on ecosystem benefits. Promote continuous cover.
Poor advice from nurseries/ consultants.	Form an independent body to oversee nursery accreditation. Adopt standards for planting stock (as in Australia).
Poor understanding of what constitutes "good practice".	Better training systems.
Research on native species doesn't reflect experience. Lack of understanding about planting site characteristics.	Encourage research on storage and treatment of seed. More research on site/species relationships. Better information transfer.

Other barriers (no identified solutions)

- Lack of scale/too diverse (especially when compared to exotic forestry).
- Lack of seed for large scale direct-seeding projects.
- Increasing incentive for planting of exotic species.
- Ignorance of long-term benefits (compared to upfront costs).
- Time-poor society – there are easier things to do.
- Over-use of herbicide (e.g. on rank grass).
- Lack of inter-generational planting (e.g. Europe).
- Poor leadership from central or regional government.
- Need for better understanding of environmental outcomes.
- Inability to envisage long-term outcomes e.g. 70 years.

Introduction to Workshop 3: Ecosourcing

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About the Author

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Introduction

Interpretation of the term "ecosourcing" and the way in which it is applied to the planting of native trees and shrubs varies greatly from region to region and between organisations. For some it is an important guiding doctrine; for others it is a hindrance to the planting of native vegetation.

The objective of this Workshop, one that will be pursued by Tāne's Tree Trust after this Conference, is the examination of current ecosourcing policy and practice. We will attempt to answer the following questions:

- Is ecosourcing being applied consistently across the country?
- Is current ecosourcing policy based on sound science?
- Is there any evidence that ecosourcing is working - i.e. are we safeguarding the genetic integrity of natural plant populations?
- Is it appropriate to have one generic ecosourcing policy that applies to all plant species in all locations?
- Is current ecosourcing policy practical and affordable?
- Can ecosourcing accommodate the use of selective breeding methods for productive purposes?

If the answer to any of the above questions is "No", we need to start a process of refinement. We may even need to develop a new set of guidelines for practitioners that meet the necessary ecosourcing criteria.

Origins and history of ecosourcing

The word "ecosourcing", a uniquely New Zealand term, is 20 years old. It was invented over a cup of coffee at the Taupo Native Plant Nursery in 1989 as a way of describing the concept of genetic integrity of plant material to purchasers of native plants. Ecosourcing describes the practice of propagating and planting indigenous plant material that has been derived from a local provenance, i.e. a population of naturally occurring vegetation growing close to the planting site. This practice has been encouraged because it contributes to retention of the genetic integrity of local populations. Introduction of plant material from other provenances is regarded as genetic pollution.

The internationally-accepted and applied concept of genetic integrity has older origins. Here in New Zealand it was probably Dr. Eric Godley who, in the early 1970s, first introduced the idea of genetic pollution. His rule was: "plant natives reared from locally collected seed only". There is some evidence that the concept was understood and put into practice earlier. Revegetation of the area around the Aratiatia Dam and power station near Taupo during the 1960s was accomplished with plant material that was mainly sourced from local provenances.

Ecosourcing today

The concept is known today. Recommendations relating to ecosourcing can be found in almost every set of vegetation restoration guidelines, especially those produced by local councils. They can even be found as rules in some District Plans e.g. those of the Rodney District Council.

There is little doubt that ecosourcing, when applied on a broad scale, increases the likelihood of survival. Locally-sourced plant material will generally survive better than stock sourced from a considerable distance.

The way in which the practice of ecosourcing is applied has a direct influence on the cost of native plant production and the availability of plants. The issue of greatest concern, expressed by many practitioners, is not so much the validity of the concept of retaining genetic integrity, but rather the scale and strictness with which it should be applied in practice. Questions often asked are:

- how far away is "too far away" for seed collection, and should one rule apply to all species?
- should ecosourcing be applied with the same rigidity in all landscapes?

A wide range of recommendations and policies exists about distance between source and planting site, and where ecosourcing should be enforced:

- Godley (1972) recommended sourcing "from the same patch of bush".
- Wilcox and Ledgard (1983) recommended that Ecological Districts should be used to define suitable seed collection areas (there are 260 Ecological Districts in NZ).
- Lands & Survey and Department of Conservation policy in the 1980s and early 1990s stated that Scenic Reserve plantings should be sourced within 1 km.
- Wright and Cameron (1990) maintained that even small amenity plantings around buildings (e.g. information centres and toilet blocks) should be derived from local plant stock.
- The Rodney District Council Plan rules that all riparian revegetation must contain native plants sourced from within the Ecological District.
- Manukau City has a three-stage approach: (i) Selection from the site itself; (ii) Selection within the same catchment; (iii) Selection from the Ecological District.
- Marlborough District Council has developed ecosourcing zones. These reflect the small and fragmented character of many plant populations.

Internationally and here in New Zealand botanists are debating the subject of genetic integrity, especially in terms of distance between source and planting site. Until recently, very little research has been carried out to substantiate policies regarding suitable collection distances.

Collection of seed within the same Ecological District is recommended in many regions of New Zealand. Questions can be asked about this procedure:

- is there good scientific research to support the policy?
- does this approach contribute to protection of the genetic integrity of our native plant populations?
- is a single generic policy applicable to all species in all locations?

New Zealanders have a history of moving plants around the country.

- Maori have shifted species such as cabbage tree and karaka for cultural purposes.
- Gardeners, tree enthusiasts and foresters have continually shifted species: kauri can be found growing in Dunedin and Stewart Island; Central North Island rimu has been established in Westland.
- Roadside and early restoration project areas contain plants that were not sourced locally.

Have we already caused irreversible damage? Does this mean that adherence to a strict ecosourcing policy is a waste of time? What ecological damage has been caused, and what harm will be done if we don't ecosource?

Since pre-human times, much of New Zealand's lowland forest has become fragmented and genetically isolated. This is a result of geographic separation and the loss of dispersal agents. It could be argued that ecosourcing, as applied today, is sustaining a narrower level of genetic diversity than would have occurred under a natural system. Is there a reasonable case for supporting increased genetic mixing between plant populations to restore greater population resilience?

Our Australian neighbours may be showing us the way. They are utilising DNA finger-printing technology to determine the degree to which plant populations can be genetically differentiated. Species are being grouped into three broad provenance classes: narrow, local and regional, to guide decisions about appropriate sourcing zones.

The way forward

To make headway on this subject in New Zealand we need to:

1. Develop a better understanding about the extent of genetic mixing within and between plant populations. Chrissen Gemmill will deal with some aspects of this in her paper.

2. Decide why and where the maintenance of genetic integrity is important. Philip Simpson's paper will assist our thinking here.

3. Consider how the selection and development of native plant provenances for productive purposes can be achieved without compromising the future resilience of natural plant populations. Heidi Dungey addresses this in her paper.

4. Develop a set of practical and well-founded guidelines for ecosourcing/seed collection. This is a challenge for Tāne's Tree Trust over the next year.

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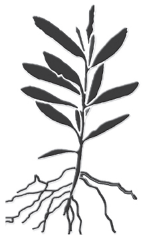

Why I believe in ecosourcing

Philip Simpson

About the Author

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Introduction

As I left home to come to this meeting, my last e-mail message contained "Ecosourcing News", forwarded by the Tasman District Council. It was about rangiora, a species unlikely to be planted anywhere. I recalled that years ago I had seen the very large-leaved northern form of rangiora planted in a bush reserve somewhere in Wellington or the South Island. It was totally out of place among the smaller, sturdier plants of the southern population. Rangiora has a cultural history and a natural diversity of its own – a good species to be using as an example in a talk about ecosourcing. Whoever would have thought that the local District Council would be interested? But they are. They will be in trouble if they don't follow the Resource Management Act and look after natural resources. These include native plants, and the genetic character of the landscape.

If you could see the DNA of the landscape in technicolour, what would it look like? It would be a complex pattern for every species. Lancewood, for instance, is a common and widespread species that I have looked at closely many times and asked myself "Is that *Pseudopanax ferox*? Oh no, it's just a very small-leaved *P. crassifolium*." If you mapped lancewood locally you would find it in riparian strips, on lower middle and upper slopes, on ridge lines and in gullies. You would see groves of young saplings coming through the bracken and, travelling north to south, you would see a change in leaf shape, size and toothiness. If we had the eyes to penetrate the chemistry, we would detect physiological differences in the leaves, roots and seeds, variations that adapt the species for life in its particular location. Of the millions of lancewood seeds produced, we see only a tiny fraction as established plants – those that were adapted and fit from the day that the first root struck the soil. Survival depends on this adaptation. And if we were to paint the DNA variations, we would see a kaleidoscopic effect. But we can't, and that's why we don't understand the intricate pattern of variability that every species needs to rely on to survive in a diverse world.

I have a vision of a restored world, where natural ecology includes the human species and its activities in a balanced and mutually–healthy way. This is not the case at present. While some of us struggle to protect what remains, and to bring back ecosystems and species that have been locally endangered, others are seeking fresh ground to cultivate. It is difficult to imagine a balance between nature and culture in the near or even the distant future, but we need a vision to help us to clarify directions and effort. Ecological restoration is such a vision, and the genetic foundation of it is a vital underlying component.

Restoration ecology is an important subject. It acknowledges the importance of linkage between natural areas, the understanding of ecological pattern in functional terms, and the need for integration of natural and cultural landscapes. In New Zealand, processes of restoration are seen in the largely natural mountainous hinterland, the widespread regeneration of scrub and bush in the hills, and the work of hundreds of restoration groups. Nature must inevitably do much of the work, but people are needed in the lowlands, which are the rarest and richest of our ecosystems. It is here that active management of replanting is needed.

It is here that the genetic principle of ecosourcing is most important.

The science behind ecosourcing

There is no single reason for the local sourcing of plant material, but a suite of inter-related factors offer a powerful argument in its favour. There are also valid reasons for being sceptical, because not all species are the same and strict adherence may not be necessary in all parts of the country. There is a social element to it, much like our support of a local rugby team, the tribal identity of iwi, or simply a personal sense of place. Ecosourcing imposes restraint, and to some the need for planning and delay is annoying and perhaps costly.

It is important, especially for those who have to implement a policy, that the theory behind ecosourcing is founded on scientifically-derived knowledge. In 1992 I published a review of the science behind ecosourcing (Simpson, 1992). Much has happened since then, and there is a need for a new review. The revolution in the science of genetics during the last two decades has produced evidence that strongly supports the need for ecosourcing.

Climatic gradients

Except for social reasons, ecosourcing would not be necessary if plants and ecosystems were not genetically variable. Appreciation of this variability lies at the centre of the issue. We used to think of New Zealand as a single ecological entity. A native plant was a native plant, and it was OK to plant pohutukawa wherever it might grow. This attitude demonstrates blindness to one of the most wonderful aspects of New Zealand nature: it varies from north to south, from east to west and from low to high country. These variations reflect differences in climate, especially temperature and rainfall, which in turn influence soil fertility and, to some extent, land form. Within this variation there is a more intricate source of variability related to geology, which again is reflected in soil characteristics. If you look at the broad north-south climate pattern, several very important boundaries coincide with the distribution of species. A northern forest ecosystem extends south to about Latitude 38ºS. Here a number of characteristic species reach their southern limits: kauri, puriri, pohutukawa, taraire and many others. South of this latitude, seedlings of these species seldom establish naturally, even if mature plants survive quite happily. The distribution pattern is probably the result of a complex set of factors, but I think the most important one is simply seedling vulnerability. Every plant was at one time only a day old, and what happened during that day, or shortly thereafter, was the most important set of events in its existence. There is another important north-south boundary around Nelson, Latitude 42ºS. Here, the climate pattern differs from that in most of the country, the west being milder than the east. Another set of forest species reaches its southern limit in the north of the South Island: tawa, titoki, rewarewa, northern rata, kawakawa, and rangiora, for example.

These patterns show that New Zealand forests are not all the same. Understanding why involves complex science and you can be sure that there is an underlying genetic component that we need to work with, not against.

Widespread species

Most New Zealand plant species have a limited distribution, but many are widespread. The major podocarps, totara, rimu and kahikatea, occur nation-wide as do many common understorey trees such as fuchsia, broadleaf, marbleleaf, mapou and mahoe. Some forest-edge shrubs like karamu, manuka and koromiko (South Island: *Hebe salicifolia*; North Island: *H. stricta*) are also ubiquitous. These species confer a characteristic feel to the bush. But if you could suddenly jump from one part of New Zealand to another, nearly all of them would look slightly different. Leaf shape and size are the most noticeably variable features. So, even widespread species have become adapted to local conditions including, temperature, rainfall, soil type and site history. Isolation can lead to “genetic drift”, whereby a species changes slowly because it has a relatively limited breeding range. Island species are especially noted for this slow change which eventually results in the development of island endemics. Well before this stage is reached, plants exhibit slight differences from those in the adjacent mainland population.

For many years, Landcare Research has recorded the leaf and habit characteristics of cabbage tree plants raised from seed collected throughout the country and planted together in a number of locations. A north-to-south and a lowland-to-montane increase in adaptation to cold was noted. When cabbage trees were exported to Britain, only those sourced from the south survived – this was our first experiment with ecosourcing! An east-west change in leaf structure reflects a response to drought, something that Maori weavers have known for a long time. Studies of many widespread species have revealed similar patterns of diversity reflecting adaptation to local temperature, rainfall and soil conditions. The ease of DNA analysis offers a relatively simple way to determine the genetic basis of this diversity.

One of the most obvious indicators of variability in New Zealand plants is the number of cultivars available in the horticultural trade for species such as manuka, kohuhu, ramarama, kowhai, harakeke and many more. Many of these cultivars are genetic oddities representing chance mutations with little adaptive value. They should not be used in restoration projects. Cultivars often revert gradually to their ancestral condition.

Soil and geology

Some plant species grow on a wide range of soil types. An example is lowland totara, which is found on coastal sands, river valley alluvium, pumice soils, and hill-slope clay. Good drainage and high fertility seem to be important, but this is not always the case. More probably, totara has become genetically adapted to local conditions. This will be true of many, if not all, widespread forest species. Some 19 species of endomycorrhizal root fungi have been identified in rata and pohutukawa, and mycotrophy may be another factor contributing to the ability of trees to survive in different soils. Plant genetics will influence relationships with symbiotic fungi.

New Zealand has a large number of edaphic endemic species - species that are adapted to and/or tolerant of soils derived from specific rock types. Local and unique suites of species are associated with northwest Nelson limestone (Mt Arthur), dolomite (Mt Burnett) and serpentine (Cobb, Dun Mountain) soils, and similar adaptation occurs throughout New Zealand. These endemic species are an extreme example of the general fact that, over many generations, plants become adapted to the local chemical environment.

Centres of Diversity

New Zealand has a number of species-rich areas. Examples are northwest Nelson, inland Marlborough, central Otago, Fiordland and the North. Some of these places are refuges from former events. Glaciation, for instance, caused local extinction over large areas of New Zealand. Species that did not migrate had to succumb. There is evidence that survival of southern rata in northwest Nelson was due to unique DNA combinations. After the last ice retreat, this population was able to spread over most of the South Island. In the long term its uniqueness would be confounded if “foreign” southern rata genes were allowed into the area. Genetic sanctity is an important issue for restoration in such places because species richness is the product of unique circumstances.

Every part of New Zealand is distinctive for one reason or another. We should not be seduced by richness itself. Paucity of species, or the absence of certain species, also confers uniqueness. Why is northern rata absent from the Marlborough Sounds? It is the natural pattern of ecosystems and species location that deserves our attention.

Climatic and geological history

The end of the last major ice advance occurred about 20 000 years ago. Since then species have been migrating from centres of survival into places with a climate that can support them. The process is not yet complete for all species. Beech (*Nothofagus*) for instance has a very complex distribution pattern that results from post-glacial recovery and/or responses to subsequent climatic and geological events. Whatever the reason for its absence, I would need very good reasons for supporting its reintroduction into beech-free areas. Understanding our natural history gives us a blueprint for survival and quality.

Speciation and hybridisation

The Ice Age was a time of extinction, and it probably brought species into closer proximity. Since then they have been spreading into old habitats. But things have changed. Plant-animal relationships have changed; soils are being renewed and climatic patterns are different. These features have contributed to a new phase of genetic change. Twenty thousand years may not seem long, but for many species this period represents hundreds of generations in which new genetic combinations have emerged. Kohuhu for instance varies throughout the country. The differences might reflect population isolation due to the ice advances or subsequent genetic change. Whatever the reason, even this one species contributes a huge amount to the variety in our landscape.

One type of genetic diversification that underlies some of our genetic landscape is hybridisation. Botanists have sometimes looked upon hybrids as freaks lacking the purity of their parent species. They are often difficult to identify, and are frequently sterile. Hybridisation can be regarded as an adaptive process. Where two species occur side by side, hybrid formation might represent a spanning of the ecological boundaries of each parent species. Lowland totara and Halls totara, for instance, hybridise regularly in an altitudinal band. So do pohutukawa and northern rata. *Podocarpus waihoensis* is a hybrid species that combines the ecological preference of lowland totara (for alluvial river flats) with the temperature and soil moisture requirements (cool, wet) of needle-leaved totara (*P. acutifolius*) and is able to colonise post-glacial outwash in South Westland. I regard *P. waihoensis* as a new species, rather than a variety of *P. totara*, because it occupies a region outside the natural distribution area of *P. totara*. Some botanists think that black beech is a hybrid between mountain beech and red beech. Characterisation of DNA is changing attitudes to hybridisation, which is emerging as an important process in plant evolution. New Zealand is in a phase of active speciation by hybridisation. Our restoration activities should respect this process even if the story is incomplete at present.

There is a down side to hybridisation. Transfer of a plant from a distance could result in a phase of hybridisation producing local forms. Since many New Zealand species are local endemics this could lead to loss of rare species. This danger may be affecting local *Corokia* on volcanic "islands" in Taranaki.

The scale of ecosourcing

I take an extreme view of ecosourcing because I am trying to envisage ecosystems in which every individual plant is adapted to its own precise niche. For example, ridge-line lancewood would be genetically different from riparian lancewood. Sunny-slope plants would be derived from sunny-slope parents. We do not have the time or money to achieve this in restoration projects, so the approach has to be broader. A New Zealand-wide scale is only appropriate in special cases where, for instance, extinction will occur without human action of some sort. This is the case with the Three Kings *Tecomanthe speciosa* which was reduced to a single individual. The broad regions of plant distribution described earlier were recognised in the days of Leonard Cockayne, when several Floristic Provinces were identified throughout the country. This scale is useful, but too broad for some species. Pohutukawa for instance, has a distinct form at its south-western boundary in Taranaki. We need to respect such boundaries.

Ecological regions and districts have been mapped in an attempt to secure a representative sample of all natural ecosystems. The maps are a cornerstone of the so-called Protected Natural Areas (PNA) Programme. An "Ecological District" was defined as a geographical area with a recognisably distinct pattern of characteristic natural ecosystems, and an "Ecological Region" as a single, very distinctive Ecological District, or a group of adjacent Ecological Districts that have diverse but closely-related ecological components and relationships (Simpson, 1982). Eighty-two Ecological Regions and 235 Ecological Districts were recognised, the district scale being regarded as most appropriate for the PNA Programme.

From a habitat viewpoint, and therefore as a basis for selection of material for restoration purposes, an Ecological District can be a very large and diverse area. It has been selected by some as the scale at which ecosourcing should be carried out because it purports to represent a natural subdivision. This is an attempt to invoke the objective approach needed by local councils engaged in restoration work (e.g. in the Significant Natural Areas Programme). It also offers guidelines for public use. However, Ecological Districts were not mapped on the basis of plant genetics. Each species has a different degree of genetic variability. Some will show little variation over large areas, even over the whole country if they migrated rapidly from a single population. Some will have prominent ecotypes confined to habitat areas much smaller than those of the District. No scale is appropriate for all circumstances. Decisions should be based on plant characteristics and all available information about the species. We are gradually accumulating relevant knowledge, and ecologists are gaining an understanding of genetic variation. With DNA characterisation now readily achievable, the time has never been more favourable for increasing our objectivity.

Consequences of not ecosourcing

There are plenty of arguments against strict application of ecosourcing. Does it really matter? Haven't we mixed up the genetics of the world so much that ecosourcing is a trivial pursuit? Aren't humans part of nature anyway? Isn't it a good idea to introduce new genes to a population? Why not just get on and plant the forest? Isn't it a matter of attitude - feeling good about ourselves - rather than science?

Ecosourcing does have potential or actual positive consequences. If it is true that plants in their natural state become adapted for survival under local conditions, a restoration project in which these plants are used is more likely to succeed. Restoration is costly, time-consuming and involves hard work. Failure breeds contempt. Success breeds enthusiasm for more. We do not want our ecological restoration projects to fail.

Genes, when introduced, will spread into a natural population. There is nothing more certain than that pohutukawa genes from trees planted in car parks in the Abel Tasman and Kahurangi National Parks will be transferred to northern rata. I don't think that this will confer any advantage. There is such a thing as hybrid vigour (aggressiveness?), which could extinguish uncommon species confined to a narrow range of habitats. We do not want to be responsible for the extinction of a potentially-valuable resource. Knowledge underpins human activity and there is value in being able to distinguish between natural places/events and those modified by human influence. Without ecosourcing, future generations will misinterpret restored landscapes.

Conclusion

Ecosourcing is a genetic issue. The genetic characteristics of each species must be determined if the real nature of plant diversity is to be understood. Where this has been accomplished, the evidence is compelling. Most New Zealand plant species are genetically diverse because they occupy a diverse landscape. If we do not ecosource we will increase the irreversible human impact on our native flora.

Ecosourcing is also a social issue, a matter of attitude. How far do we go with it? I say, establish the principle first and then modify implementation according to species and need.

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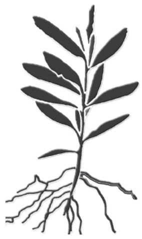

Are current restoration practices capturing the levels of genetic diversity of plants observed in the wild?

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Abstract

The use of locally-sourced seeds and plants is becoming common practice in a range of restoration projects because it is generally acknowledged that "local is best". Knowledge about genetic variation in natural and restored populations can contribute to the maximisation of genetic variability in *ex situ* collections and hence to the long-term evolutionary potential of plant populations. The goal of restoration genetics is the use of plants that reflect levels of genetic variation found in natural populations. This will help to ensure resilience to environmental change and disease and will limit genetic drift and inbreeding. Where possible, the promotion of natural levels of gene flow is also desirable. These factors should be considered when planning urban garden plantings.

We examined plants from the Waiwhakareke Natural Heritage Park, Hamilton, to see whether they were genetically similar to individuals sampled from nearby areas. Three species commonly used in restoration projects: kahikatea (pollen spread by wind and seed by birds), mahoe (pollen spread by biotic agents and seed by birds) and manuka (pollen spread by biotic agents and seed by wind) were assessed. In each case two DNA fingerprinting techniques (ISSR* and AFLP[†]) were used to examine *ex situ*, urban, and forest populations.

In general, the individuals planted at the Natural Heritage Park had genetic profiles that were similar to those of natural populations. No unique alleles (alternative gene forms) were detected. Levels of genetic variation in Waiwhakareke kahikatea were lower than those in urban and forest populations. In Waiwhakareke mahoe they were lower than those in the forest population but higher than levels in the urban sample.

* Inter-simple sequence repeat markers.

† Amplified fragment length polymorphism.

Contact the lead author Chrissen Gemmill for further information.

Planting indigenous forests for timber – a production perspective

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Abstract

Planted forest trees can grow at a faster rate than those in natural populations when knowledge of genetics is applied through breeding programmes. In New Zealand, tree selection and breeding programmes have been used to improve the characteristics of exotic forest trees planted for timber production. Indigenous forest tree species have rarely been considered for production forestry plantations. A major reason for this discrepancy is reluctance to interfere with "natural" genetic variation and the individuality of indigenous populations.

Scientific principles underlying the practices of tree breeding and ecosourcing are explained and the need for more information about genetic variability in indigenous tree populations is underlined. There appears to be little reason for supposing that indigenous tree species will not respond to breeding practice aimed at improvement of growth rate, form and wood quality.

Introduction

A major aim of plantation forestry is to increase production of timber and/or biomass. In New Zealand, radiata pine forests are a classic example of the plantation approach to timber production. The first field tests of imported radiata pine material were encouraging although form, branching and straightness were not satisfactory (Figure 1). Selection and breeding from well-tested individuals resulted in the improvement of form, stem diameter, and branching (Figure 2). Good nursery and establishment practice and silviculture (control of spacing, thinning, pruning, and fertiliser treatment) resulted in increased stem growth and reduction in branch size. Radiata pine forests became a source of wood and fibre for housing, paper, packaging and other important products.

Techniques developed and used in radiata pine forestry are applicable to other tree species. Why have they not been used for New Zealand native forest trees, especially those with known high-quality wood characteristics? The radiata pine example appears to conflict with an approach adopted for native forest restoration work. Seed for plantations of indigenous species often has to be obtained from local sources under a set of strict guidelines (Ferkins, 2005). This practice of ecosourcing has been adopted in part because local populations are thought to be better adapted to local conditions and also in order to preserve the distinctive genetic characteristics of plants growing in a specific region (e.g. ARC, 2010; New Zealand Plant Conservation Network, 2010).

Implications of the development of a genetically-improved productive indigenous tree resource are not well understood. This paper focuses on opportunities that exist for identifying indigenous trees with superior growth and form and applying plant breeding methods with the aim of improving attributes required for timber production. We also outline a way in which breeding methods could be applied to assist restoration planting.

Why should we bother with indigenous forest trees?

The timber of many of New Zealand's indigenous forest trees is highly valued for a range of end uses including furniture-making and carving. At present, most of this resource is located in Crown-owned conservation reserves. A limited supply of timber is available from sustainably-managed old-growth forests on private land. Interest in the planting and management of indigenous trees on previously-forested land is increasing.

FIGURE 1: Radiata pine offspring from a natural population on the island of Cedros, off the coast of Mexico. Note the irregular branches, forking and the lack of uniformity between trees.

What is tree breeding?

Tree breeding involves the testing and selection of individual trees that have superior measurable characteristics. Foresters are mainly interested in growth rate, form, and wood quality.

Crosses are made between individuals exhibiting the desired trait. The average value for the trait among progeny from crosses between selected parents will be superior to the average value among the original tested population. White et al. (2007) give an excellent account of the options available to forest geneticists. These techniques do not involve any direct manipulation of DNA.

Application of breeding techniques to indigenous forest trees

Tree breeding principles are applicable to indigenous forest species. In Australia and New Caledonia similar species have been used in breeding and selection

FIGURE 2: A radiata pine plantation after one generation of selection. These trees are the offspring of trees selected from natural population tests in New Zealand. Note the improved form, small branches and uniformity of the stand.

programmes (Figures 3 & 4). Differences in strategy for dioecious species (those with female and male components on different trees) can be accommodated. So what is the hold up?

In world forestry circles, the rotation length for radiata pine is regarded as unusually short. There is a widely-held belief that growth of indigenous forest trees is too slow, and that a forest would need to be at least 100-200 years old before timber would be available. Steward and McKinley (2005) have demonstrated that high-quality timber can be obtained from kauri in less than 70 years. This is mostly sapwood, which is not suitable for outdoor use, but is ideal for many other purposes. Preliminary sawing studies of farm-grown totara logs indicate that there may be a reasonably high proportion of heartwood in relatively young trees (Figure 5; Cown et al., 2009).

Another stumbling block is current legislation, set in place to preserve indigenous forest remnants for future generations. Although Part 3A of the 1949 Forests Act allows sustainable management and utilisation of indigenous forests, this is tightly regulated (MAF, 2010). No clear distinction is made between natural and planted forests grown for carbon sequestration (MAF, 2010). They must have been established after 1 January 1990 by seed sowing and planting methods. There is little incentive for planting indigenous tree species for timber, as they must be managed and harvested according to strict MAF guidelines. This imposes an additional transaction cost on landowners.

Rotations of 50+ years are common in Europe. Kauri logs tested for wood quality (Steward & McKinley, 2005) were from wild unimproved trees which had received little silvicultural treatment. What effects would the application of breeding, selection and silviculture produce?

We need to define the potential of some of our indigenous forest trees, answering questions such as "Where do they grow best?" "What is the wood like?" "What is the potential for genetic improvement of the species?"

FIGURE 3: Selected individuals of the Australian native hoop pine in Queensland. This species is related to New Zealand kauri and is grown in plantations for timber. A breeding programme has resulted in increased growth rates and shorter rotation lengths without any deleterious effect on wood quality.

FIGURE 4: *Agathis moorei*, a native of New Caledonia, grown in plantations for timber. Seed for this plantation was obtained from genetically-improved material.

Breeding versus ecosourcing

Ecosourcing is the practice of propagating plants from material that has been collected locally or at least within the same Ecological District or Region as the planting site. New Zealand has been divided into 85 Ecological Regions and 268 Ecological Districts according to the geological, topographical, climatic and biological features and processes that produce characteristic landscapes and biological communities (Biological Resources Centre, 1983). An Ecological Region comprises a group of adjacent Ecological Districts which have diverse but closely-related ecological components and relationships.

FIGURE 5: An example of a farm-grown totara log. The darker wood in the centre is durable transition wood and heartwood; the lighter area towards the bark is sapwood.

Breeding involves the mixing of populations in order to produce outstanding individuals or groups of individuals suitable for a specific purpose. Selection of characteristics in indigenous trees from mixed populations for production purposes is not compatible with the concept of ecosourcing. The question then is "Where do we want to go?" Should opportunities for deriving benefits from selected and improved provenances of indigenous timber species (Bergin & Gea, 2005) be denied to landowners? Strict adherence to ecosourcing guidelines is not likely to increase timber productivity. It is usually the recombination of genetic characteristics from different populations that produces outstanding individuals as a result of release from local-population inbreeding. If indigenous forests are to provide an increase in the value of the land by sequestering carbon, reliance on ecosourced planting material is unlikely to realise the full potential offered by tree breeding.

Are ecosourcing rules based on well-researched information? It appears that many of them may not be. In fact the mixing of populations may assist long-term survival and conservation of some species.

An example of the complexities – planting kauri in Manukau.

New Zealand has a history of human modification of the extent and content of indigenous forest. This activity was greatest in the Auckland region, which covers the Manukau City area. It is likely that considerable areas of kauri forest once grew in Manukau. Natural kauri stands still exist in the Hunua and Bombay Ranges to the south, in Alfriston and Clevedon to the east, in the Waitakere Ranges to the west, and Greenhithe, Whenuapai and Orewa to the north. Kauri may not have been dominant in the forest. Some definitions of "kauri forest" relate to the presence of isolated kauri trees (one or less per ha) in a forest dominated by podocarps or broadleaved species. Kauri seed is dispersed by wind. In the absence of storms, it is rarely carried more than 20-100 m from the parent tree. Individuals in small, isolated populations are therefore likely to be closely-related.

When planning to replant kauri in a Manukau City park, three approaches could be considered:

1. Strict adherence to ecosourcing guidelines would suggest collection of seed from naturally-occurring kauri trees in the same park, or within the immediate neighbourhood. This would maximise likelihood that planted trees would have the same characteristics as the historic population. If only one natural kauri tree is present in the park, and producing seed, where does the pollen come from? Pollen sources could be older planted kauri (origin unknown) in the same district, kauri outside the immediate district, or the tree itself. The first and second of these sources would dilute the local character of the new population, while the third possibility represents the worst-case scenario of inbreeding.
2. Plants could be raised from seed collected in the wider Auckland region. Kauri pollen is released in spring, around the time of the equinoctial gales. It is most likely that kauri trees in the Auckland region have shared pollen for millennia, and that they therefore share characteristics of the Manukau park kauri. This second approach would preserve any local regional variation in kauri but could "pollute" the character of the Manukau population.
3. Good quality kauri plants could be obtained from any available source. Human impacts on the quantity of kauri, and to some extent its quality (the best specimens were harvested) have been immense. Reinvigoration of kauri within the park and the wider Auckland kauri population could be achieved by bringing in "new" genetic material. Over time this option would have potential for suppressing the local genetic variation of kauri, if such variation exists.

The most obvious questions for a geneticist would be:

- What do we know about the gene flow between local Auckland populations?
- How does gene flow occur, does it occur locally or across a wider landscape?
- We certainly know that there are a lot of forest remnants, but are their characteristics distinctive enough for conservation to be justified?
- Is there any inbreeding?
- Are they genetically robust or should we intervene and intentionally introduce new material?
- Do they interact with kauri already planted?

Scientifically informed answers are needed.

Underlying scientific principles

Genetic structure of natural populations

In order to understand the potential for improvement of a tree characteristic, it is important that the genetic structure or architecture of the population should be understood. One way of investigating genetic makeup is to compare the characteristics of individuals collected from representative regions when they are grown together in a common environment (e.g. White et al., 2007). This type of "common garden" experiment often forms the basis for a breeding programme and is known as a provenance or progeny trial. Measurements made in the trial are analysed in order to determine the proportion of variation that is related to environmental influence and the proportion that is due to additive genetic effects and can be passed to the next generation. To date indigenous timber tree provenance trials have only been conducted with beech (Wilcox & Ledgard, 1983) and totara (Bergin & Kimberley 1992; Bergin et al., 2008).

Molecular biology techniques can be used to examine variation in a natural population. Ideally, material should be taken from a common garden experiment so that differences can be attributed to genetic variability, rather than site influences. A large number of studies have been based on this technique (e.g. Baradat et al., 1995; Lee et al., 1998; Lowe, 2005; Vendramin et al., 1995). Results supply information about the basis of variation that can be used to develop a robust species management plan. This would be particularly useful in the case of kauri, where existing populations are only isolated remnants of the former forest (Figure 6). These residual stands (0.6% of the original forest cover) in some cases may possess the worst timber-production attributes of the species (e.g. poor form), since they are derived from populations of trees that have already been logged. This means that any remaining trees are likely to have been initially rejected for harvest.

Small populations with a limited distribution are more likely to suffer from the effects of inbreeding, or reduced variability, than large populations. Inbreeding is known to reduce the number of rare alleles in a population due to an increase in homozygosity. This is a problem if the rare alleles are important, for example in controlling disease resistance. This concept is well understood in tree breeding (White et al., 2007).

Understanding the genetics of totara

A totara provenance trial was established at the Tapapakanga Regional Park, southeast of Auckland, by Scion in 1985 (Bergin & Kimberley, 1992). Seed was collected from 42 geographically separate populations of totara (provenances) representing distribution of the species throughout the country. Trial assessments at age 6 and 11 years revealed differences between

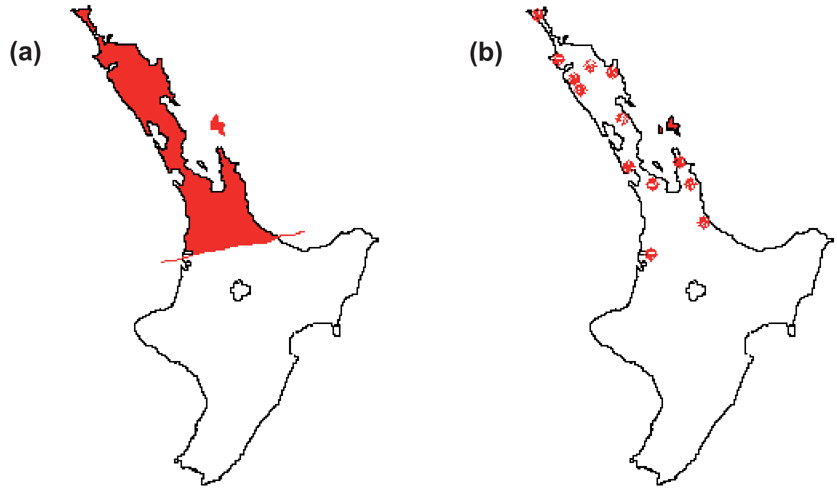

FIGURE 6: (a) Distribution of kauri before European settlement; (b) Current distribution of remnant kauri populations (G. Steward, unpublished data).

provenances in growth rate, form and survival (Bergin, 2001). A more recent assessment (V. Alderson-Wallace et al., unpublished data) showed that provenances exhibiting the best form and growth rate at age 6 and 11 were still superior at age 21.

A DNA-marker study based on 180 individual totara trees from the same trial at Tapapakanga Regional Park demonstrated genetic differences related to the geographic separation of their seed sources (T. E. Richardson et al., unpublished data). This information will form a basis for future genetic improvement of totara.

Gene flow

Once the underlying genetic structure is known, gene flow can be investigated. Gene flow takes place through the transfer of genes between populations. In practical terms, this usually takes place through movement of pollen, seed and/or fruit. Ideally, planted forests, should be managed in order to minimise detrimental effects on the genetics of surrounding natural populations. The large amount of literature on this topic has been reviewed by Potts et al. (2003). Gene flow may result in the extinction of a population. It can also increase genetic variability in an inbred population to a level that ensures long-term viability (Potts et al., 2003).

Gene flow is a natural process in tree populations able to produce and disseminate pollen and/or seed. In New Zealand, seed dispersal by birds also promotes gene flow (Kelly et al., 2010). When populations become isolated, no gene flow occurs and differences can develop. In long-lived tree species these differences take a long time to become apparent. Gene flow from planted forests or trees can be identified through DNA-fingerprinting of material from planted individuals and comparison with material from adjacent natural forest. Information on gene flow and genetic similarity/differences between populations would undoubtedly assist species management.

A way forward

The process of gene flow should be investigated for each species of interest in order to determine the extent and area over which it occurs naturally. If gene flow is substantial, the mixing of populations is unlikely to have serious consequences. The genetic architecture of each species should also be studied. If genetic differences between populations are small, there is no reason why they should be treated separately. Genetic information would allow informed decisions to be made about the sourcing of seed for plantings and the management of existing populations to ensure survival of the species.

Potts et al. (2003) suggested a framework for assessing the risk of “genetic pollution” from pollen produced in planted eucalypt forests. Key elements are pre- and post-mating barriers to reproduction, such as reduced pollen viability, flowering times, the reproductive fitness of any embryos and offspring, presence or absence of dispersal agents (e.g. birds/insects), and site conditions. Similar assessments are needed for planted indigenous forests in New Zealand.

Implementation is the next challenge. Future Forests Research, a partnership between the forest industry and Scion, has initiated studies on a “Diversified Species” theme (FFR 2010). In conjunction with Massey University and Dr Peter Lockhart of the Allan Wilson Centre for Molecular Ecology and Evolution, a PhD student will be recruited during 2010 to investigate the population genetics of totara. The Scion Te Aroturuki process will be used to ensure involvement of the tangata whenua. There is also an intention for selected totara trees to be planted at two sites in order to establish a future resource. Selections will be made according to iwi requirements. Totara may be the first species to be planted or managed in production forests derived from material selected through a breeding programme.

Conclusions

There is no doubt that genetic improvements can be made to indigenous tree material intended for use in planted forests. At present the extent to which growth rates, form and wood quality could be improved is unknown. There is a need for the genetic basis of ecosourcing to be clarified for key forestry species in order to develop more robust knowledge-based guidelines for implementation.

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Summary of comments following Workshop 3: Ecosourcing

As part of of the "Ecosourcing" Workshop, Conference participants were asked to consider and discuss the following questions:

1. ***Are current ecosourcing policies and practice***
   a. scientifically valid?
   In other words, are current policies and practice actually sustaining natural plant provenances as nature would have done?

   b. practical and affordable?
2. ***How important is ecosourcing compared with other aspects of revegetation?***
3. ***What aspects of revegetation are more important than ecosourcing?***
4. ***What new rules/guidelines could be developed to improve ecological outcomes without incurring great cost or confusion?***
5. ***How do we accommodate the desire for selective breeding for productive purposes while adhering to a policy of protection of natural genetic diversity in our indigenous plant populations?***

Answers to Questions 1 - 3 were grouped under three headings and can be summarised as follows:

Question 1a: Are current ecosourcing policies and practice scientifically valid?

Yes	7
No	44
Don't know	36

Question 1b: Are current ecosourcing policies practical and affordable?

Yes	20
No	41
Don't know	21

Question 2: How important is ecosourcing compared with other aspects of revegetation?

Most important	27
(Intermediate)	13
Not so important	33
(Intermediate)	6
Irrelevant	10

Answers to Questions 3 - 5 took the form of ideas and comments:

Question 3: What aspects of revegetation are more important than ecosourcing?

- Species selection.
- Natural regeneration.
- A holistic approach.
- Plant survival.
- Local situation – geography and climate.
- People.
- Need for maintenance.
- What is happening on neighbouring property.
- Choosing plants that are appropriate for the site.
- Asking why the plants are not there in the first place.
- Ability to obtain good-quality stock
- The impact of climate change – importance of encouraging migration.

Question 4: What new rules/guidelines could be developed to improve ecological outcomes without incurring great cost or confusion?

Ideas

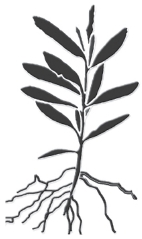
- Select seed from similar habitat.
- Representative sample (10+ plants).
- Mandatory recording of collection site.
- Create gene/seed banks.
- Establish stocks of cuttings.

Comments

- We need a national policy on provision of diversity in genetic material.
- Ecosourcing is based on false assumptions – it goes against the principles of evolution.
- Ecological Districts are an irrelevant and unnecessary overlay to seed collection.
- The definition of seed collection is too restrictive.
- We need seed collection guidelines – these should be included in the Tāne's Tree Trust Handbook.There is a problem with determining historical presence vs actual presence today. If you have to go outside the Ecological District to get plant material, then you should.
- Better education of nurseries is needed to encourage application of the principles of ecosourcing.
- Nurseries should be rewarded for efforts to record the origin of material.
- Plant stock should have an eco-standard that guarantees ecosourcing. Currently ecosourcing is based on trust.
- Do we need to intervene and manipulate species distribution in order to take the effects of climate change into account?
- Don't create rules. Guidelines are more valuable and effective.
- Develop a list of appropriate species according to latitude and altitude.
- Apply ecological knowledge in the absence of genetic certainty.
- We need more robust scientific evidence.
- Do more research before we mess things up.
- Keep the rules for rare/threatened species.
- The degree to which ecosourcing should be applied depends on the site. There should be less concern about roadsides than about sites of ecological importance.
- Suitability of seed-collection zones should be related to the normal extent/distance of pollen and seed dispersal of individual species.
- Iwi sould be consulted before species are moved around the country.
- Take a pragmatic approach to seed.
- Get on with it.

Question 5: How do we accommodate the desire for selective breeding for productive purposes while adhering to a policy of protection of natural genetic diversity in our indigenous plant populations?

- Underpin decision-making with science – genetic and ecological.
- Keep the larger ecological/biodiversity picture in mind.
- It is being done in the horticultural industry all the time.
- Multiple productive purposes (including extracts) must be specified.
- We have no choice if we are serious about production from native species.
- Don't place limits on locations where natives are grown for commercial purposes.
- Don't confuse growing wood with genetic diversity.
- There will be no effect on species with a restricted natural range.
- Cultural implications should also be considered before moving species/provenances around the country.



Introduction to Workshop 4: Research

Andrew McEwen

About the Author

***Andrew** is President of the New Zealand Institute of Forestry and undertakes some forestry consulting. He has worked for more than 45 years on general forestry, forest research and privatisation of the former State Forests. He is a Trustee of the Tāne's Tree Trust.*

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The objective of this workshop is to try to find answers to the following questions:

- What do we know about indigenous forestry establishment and management?
- What don't we know?
- What should we know?
- How do we get there?

Building on the results of a workshop held in Christchurch in March 2007, we need to ask:

- Are the research needs identified in 2007 still relevant?
- Do we need a group to update/produce a strategy for indigenous forests?
- Is the Christchurch proposal still relevant?
- If not, then what?

The objective of the Christchurch workshop was "To identify research needs for indigenous forest establishment and management and consider the formulation of a research strategy and advisory group". Nearly 50 people attended that workshop, but only about 10 of them are present today. More than 50% of those in Christchurch were based in the South Island. This Conference is dominated by North Islanders, particularly people from the northern half of the North Island. Accordingly we can expect differences between what you see as the most important species/research and what the Christchurch participants considered to be necessary.

The Christchurch workshop produced a long list of research needs in some order of priority. It also proposed the establishment of a body to coordinate research needs for indigenous forestry, emphasising the need for commercial production. This new body was not to be restricted to research needs – there was general agreement that it should also produce and implement a general strategy for indigenous forestry.

Although steps were taken to try to establish the proposed body, nothing has happened. This Conference will review what was proposed and decide whether the structure and objectives set out at Christchurch are still relevant. If they are not, then what, if anything, should replace them?

Delegates will be asked about research priorities and the need or otherwise for a body to coordinate research and look at strategy for indigenous forests. In particular they should think about:

- Who will be responsible for whatever is proposed?
- Why should they do it on behalf of others?
- Who will provide the funding?
- What will happen when the current enthusiasts move on? It's all very well being an enthusiast for native trees on your property, but will your children take over from you? Will the next owner feel the same way?

- Until we build up and guarantee a long-term supply of timber of a particular species, how are we going to encourage the development of processing and marketing mechanisms?

This Workshop will include presentations from three speakers. Tom Richardson will give an overview of current activities at Scion; Bruce Burns will share his ideas about research on indigenous forestry; and Diana Whiting will explain the Government's approach to strategic investment in indigenous forestry. We shall then break into groups for consideration of major questions, and there will be a report-back session before final discussion with a panel of speakers.

An overview of Scion research on indigenous forest species

Tom Richardson

About the Author

***Tom** is the former Chief Executive Officer of Scion. Tom’s scientific background is in genetics. He established the genomics research group at Scion and a spin-out company “SignaGen”, which provided high-throughput DNA testing to the NZ ag-bio sector. His experience as a scientist, new business developer and science innovation sector leader has led to frequent assignments on advisory boards, external review panels and international delegations.*

Introduction

In the field of indigenous forestry Scion is currently focussing on four major aspects:

- evaluating the establishment and management of selected indigenous timber species, particularly kauri and totara;
- researching the propagation, establishment and management of a wide range of indigenous tree and shrub species to meet multiple objectives;
- dissemination of information to a wide range of end users including landowner, iwi and land managing agencies; and
- exploring future opportunities and identifying additional priority research areas.

Kauri

Research focus on kauri has recently changed from management and development of second-growth stands to investigation of the characteristics and productivity of young plantations. Growth rates of trees planted at different densities, and trees of different ages and size classes are being measured to assist the development of robust models for prediction of height, diameter, basal area and volume increment. Many of these stands were planted outside the current natural range of the species, and the effect of local site variables is also being studied. Work involved in development of these models will complement results of earlier investigations into wood quality which indicated that the wood of young fast-grown kauri has attributes similar to those of old-growth heartwood. Modelling has already identified gaps in our knowledge about factors influencing early establishment and research plantings are being made to evaluate early predictions.

The effect of a recently-isolated fungus, *Phytophthora* Taxon Agathis (PTA) has been a major concern. Disease symptoms were first identified on Great Barrier Island in the 1970s, and are now found in forests in Northland and Auckland. Scion, together with Landcare Research and Plant and Food Research, is part of the Kauri Dieback Joint Agency Response (KDJAR) Group. Margaret Dick, a scientist in our Forest Protection Team, is a member of the KDJAR Technical Advisory Group and is assisting with more precise identification of the fungus and with determination of its effect on kauri. The Group is developing a method for detecting the presence of PTA in soil and is drafting a protocol for surveyors to follow when determining the distribution of PTA in Northland, Auckland and the Waikato (Coromandel). A new molecular technique allowing the rapid detection of PTA in wood is also being tested.

Totara

As we have heard earlier in this conference, a considerable amount of work is being done on the establishment of sample plots throughout the range of naturally-regenerating stands of totara on pastoral land in Northland. Preliminary data indicate an increase of 5 m^3/ha/yr in stem volume in thinned and pruned stands within two years of treatment. Further assessments of annual growth rates will help in the refinement of silvicultural regimes for this resource.

Continuing collaborative work with the Northland Totara Working Group will be directed towards examination of the wood quality characteristics of naturally-regenerating totara and exploration of opportunities for utilisation of the timber in high value products such as furniture. Preliminary studies indicate that, in addition to natural durability, the wood of young totara regenerating on farmland has many of the properties of timber from old-growth stands. These include amenability to machining and suitability for traditional carving. Further wood studies will be an important step in development of a sustainable specialty timber market for the resource.

At present the focus is on regenerating totara in Northland, but the work is likely to have national application. The aim is to provide management options that will benefit landowners wherever totara is regenerating on farmland.

Propagation, establishment and management

Research on reduction of the cost of nursery propagation of indigenous species and on successful establishment in the field is being expanded. Large areas of riparian land and steep hill country need to be retired from pastoral farming. Establishment of indigenous vegetation on these sites will improve environmental outcomes, particularly for waterways. A recent review completed by Scion for the Ministry of Agriculture and Forestry has drawn attention to the high cost of planting indigenous trees and shrubs and our lack of knowledge about methods and costs of establishment and about potential benefits in terms of carbon storage (Davis et al. 2009).

Several current projects seek to quantify and compare plant development, root system quality and the cost of production of selected indigenous shrub and tree species raised in different types of containers and as bare-root transplants. Because costs associated with planting are likely to be prohibitive for large-scale re-afforestation programmes, other options such as direct seeding and the encouragement of natural regeneration are being explored.

Dissemination of information

Scion assists with the production of high-quality publications providing advice on planting and management of indigenous trees. Bulletins and handbooks are produced for practitioners as well as formal papers for research journals. Some of this information transfer is done in collaboration with Tāne's Tree Trust. Recent published outputs include:

- the Indigenous Tree Bulletin series – information about totara, kauri, management of indigenous trees, pohutukawa, and farming with natives;
- a further publication in the Indigenous Tree Bulletin Series –information about the ecology, establishment, growth and management of beech;
- a review of up-to-date knowledge about kauri (Steward & Beveridge, 2010);
- information about provenance variation in totara (Bergin et al., 2008); and
- the Tāne's Tree Trust Technical Handbook – planting and management of native trees, officially launched at this Conference.

Future opportunities

A major concern for New Zealand is the management of marginal hill country pastoral farmland, large areas of which are either under-utilised or not used at all. Much of this land was once covered with indigenous forest and is therefore well-suited to the growth requirements of indigenous tree species. The value of indigenous tree plantations in terms of timber production, non-timber products and ecosystem benefits could repay a considerable amount of research effort:

- growing indigenous trees for carbon sequestration;
- genetics of indigenous tree species – diversity, tree improvement, ecological variability;
- site selection for indigenous tree plantations;
- management of indigenous trees to maximise growth responses;
- biosecurity – management of pests and diseases;
- utilisation of tree stands and tree components for both timber and non-timber benefits; and
- evaluation of end uses and markets for potential products.

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A strategic approach: current thinking about investment in indigenous forestry

Diana Whiting

About the Author

***Diana** is Senior Investment Manager, Primary Sector, for the Foundation for Research, Science and Technology. She manages government on-farm strategic research investment in the forestry, horticulture and arable sectors. She has played a leading role in research management at the University of Auckland, and was an applied scientist with HortResearch.*

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My brief is to give an overview of the current position of the New Zealand science innovation system. A lot of it is in a state of flux, with an unprecedented number of reviews in progress and restructuring pending as we prepare for changes in the second year of this National-led Government.

The likelihood of change creates uncertainty about the level of funding available for investment and the way that the Foundation for Research, Science and Technology (FRST) may operate in the future. Possible changes include:

- the Crown Research Institute (CRI) Taskforce Review - due in December 2009;
- the Business Assistance Review;
- the future role of the Ministry of Research, Science and Technology (MoRST);
- output expense restructuring – how we look at the investment landscape and manage it.

The Foundation has recently undergone major restructuring. The MoRST and NZ Trade and Enterprise CEOs have indicated that they are resigning. This triggers a government review. The form and scale of most of this activity will be known by the end of December 2009.

I will attempt to outline current thinking about where indigenous forestry sits in this rapidly-developing picture. The current Government is putting strong emphasis on science and innovation as economic drivers. This approach is led by the Ministers of Finance and Economic Development, and parallel work streams are to be completed by the end of 2009 for implementation in the 2010 Budget.

The Government has stated its goal and its top high-level priorities. The biological, high-technology, energy, and minerals industries align with the economic growth agenda. Prioritisation of economic outcomes will be driven by the quality of science, the scale of the opportunity and the pathway to effective progress through research, development and commercialisation. Alongside these economic drivers are vital areas such as the environment, climate change, health, and societal research. The Government wants a new investment structure and the Foundation has already restructured to align with sectors. Wider changes are envisaged.

Two other initiatives in the fields of research, science and technology (RS&T) are:

1. examination of ways in which the CRIs can operate more effectively to answer sector questions; and
2. looking at ways in which business investment in research and development can be increased. How can businesses be encouraged to engage in innovation? How can universities and CRIs reach out to businesses more effectively and earlier?

Recommendations on these initiatives are due by the end of 2009. The Ministry's job is to set out strategic principles for science investments and priorities which support the Government's growth agenda. These must ensure that New Zealand gets maximum benefit from its investment in RS&T. Total government RS&T expenditure in New Zealand is 0.51 percent of GDP. The allocation is tight. There must be overarching principles and clear objectives to ensure that spending is prioritised effectively.

The proposed Biological Economy domain ($165M) includes primary sector productivity and sustainability, and high-value food and biological products and processes. The Environment domain ($81M) includes understanding, knowledge and tools relating to sustainable management of the New Zealand environment. Of interest to people working in indigenous forestry, are land and freshwater resources, territorial ecosystems, climate, and atmosphere.

The Ministry has been seeking views on the following topics:

- the overall investment structure;
- the current weighting of funds within that structure;
- where emphasis should change, given Government goals;
- whether the proposed structure is sufficiently flexible to respond to new opportunities and challenges;
- whether the identified areas are of greatest priority for investment in strategic research platforms;
- how well the proposed strategic research platforms fit with the new investment structure;
- how the identified areas for strategic research platform investment should be ranked, and why.

Submissions closed yesterday and I hope you had your say.

The Foundation's role is implementation, monitoring and support of the Government agenda. Our investment tools support the RS&T objectives, they do not drive them. The intention is for investment tools to be driven by the priorities and economic outcomes.

I would like to talk about FRST's new structure so that you can see where the science system is heading and understand implications for your RS&T needs.

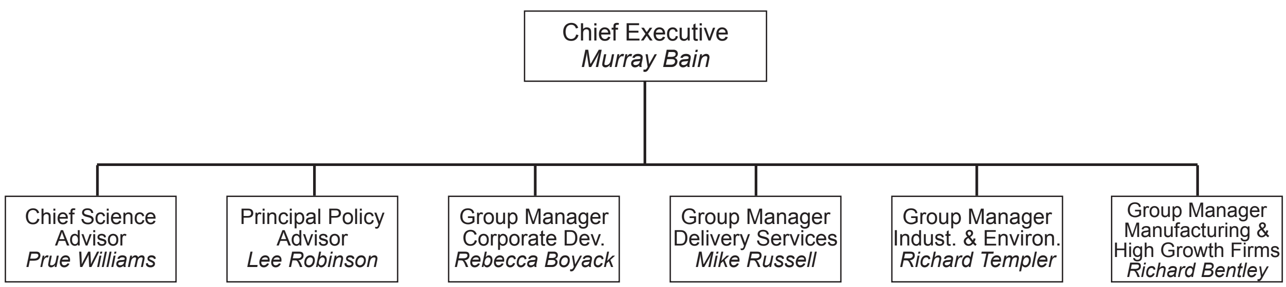
The six groups under the CEO are shown below. Three have responsibilities of particular interest to the forestry sector:

- Chief Science Advisor: input into sector strategies and the balance between basic and applied science.
- Industry and Environment Group: nationwide benefits of RS&T.
- Manufacturing & High Growth Firms Group: creation and growth of individual export companies.

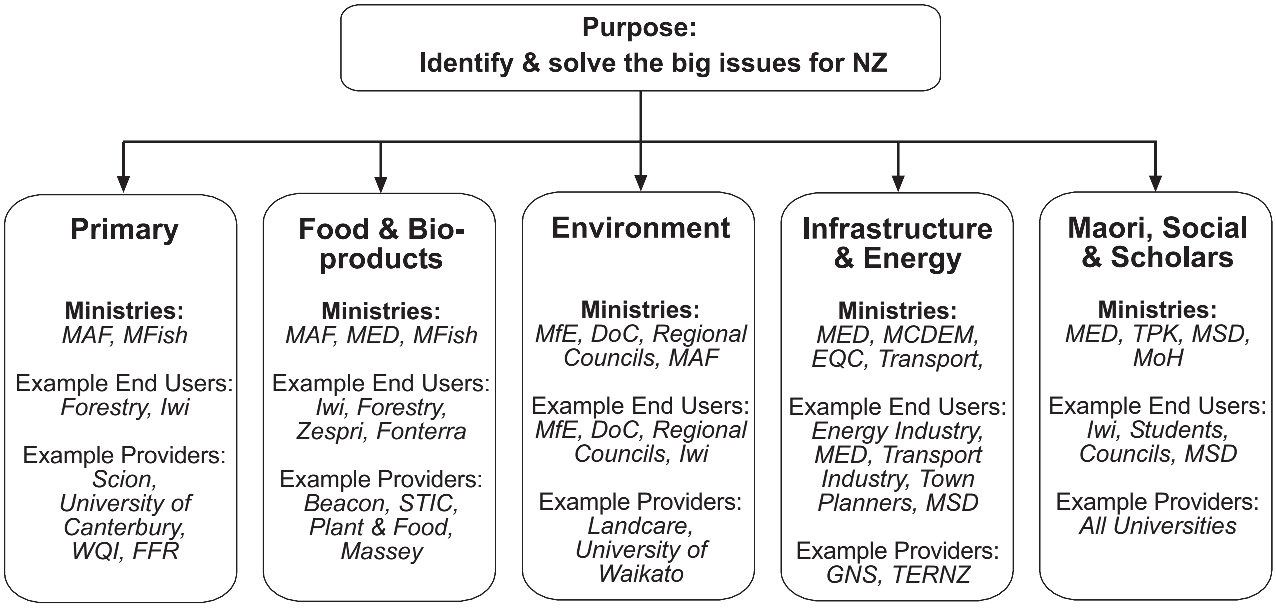
All feed into the Policy Group which has input into government initiatives via MoRST.

I want to draw your attention to the Industry and Environment Group, where most of the money lies. This has five sections. A Strategic Advisory Group will be appointed for each section and very shortly we will be developing investment strategies. The Maori Business and Innovation section now has its first director. Restructuring has raised the importance of Maori interests and promotes Maori activity across all sections. This recognises that Maori success is New Zealand success and strategically important for economic growth.

The Maori emphasis is necessary in the forestry sector because Maori are major owners of land and resources. Maori entities will influence policy, partnership and investment opportunities across all investment areas, the emphasis being on *willing partnerships that are prepared to learn in different ways.*



Industry & Environment Group



Vision Matauranga

The vision is: *To unlock the innovation potential of Maori knowledge, resources and people to assist New Zealanders to create a better future.*

This will be achieved by:

- *Indigenous innovation:* contributing to economic growth through distinctive R&D.
- *Taiao (Environment):* achieving environmental sustainability through iwi and hapu relationships with land and sea.
- *Hauora/Oranga (Health & Well Being):* improving Maori health and social well-being.
- *Matauranga (Maori Knowledge):* exploring indigenous knowledge and RS&T.

We have started to implement these objectives by supporting tribal R&D strategies developed by the following organisations (all involved in forestry):

- Ngai Tahu (South Island);
- Ngati Porou (East Coast);
- Ngati Awa (Bay of Plenty);
- Ngaitai Iwi (Bay of Plenty);
- Te Whanau a Apanui (East Coast).

We are also in discussion with:

- Tainui (Waikato);
- Te Arawa (Rotorua);
- Tuhoe (Urewera National Park);
- Tuwharetoa (Taupo);
- Maori-in-Business - e.g. Tuaropaki Trust, Central North Island (Geothermal energy, Agriculture, Forestry, Horticulture, Communcations);
- SME Maori Enterprises: e.g. Nga Whenua Oranga Trust, Rotorua (looking at land use to develop traditional and contemporary Maori products as well as main-stream products).

Advice for Tāne’s Tree Trust

Strategic partnership with Maori was an area identified as a gap in 2007. The Foundation can help you with this. When choosing a strategic partner, ask the questions: Who do you know? Where are they? What are your shared values? Why should iwi be interested in you? Do you represent current indigenous forest owners? Do you have political/science sector knowledge and networks that would be useful to them?

Tāne’s Tree Trust will find it worthwhile to expand recent efforts to serve Maori, given the high Maori ownership of forestry land as a result of post-Treaty settlements and their expressed interest in indigenous forestry.

Reece Moors, the new Section Director, is a useful contact. He has developed effective networks and will be happy to provide introductions, facilitate engagement, and give advice on strategy and priorities.

Strategic funding is going to be driven by New Zealand's needs rather than the needs of individual institutions. The change is from a supply-driven to a demand-driven approach. This will result in sector empowerment based on user leadership, influence and investment.

Your role is highlighted in bold italic on the right hand side of the table below. The term "users" rather than "end–users" is used to emphasise the supply chain approach. We are looking for input and investment from stakeholders at all stages between production and market. Users, research providers and their partners will identify and shape the activity, thus empowering the end-user.

Investment tools

These will support, rather than drive government objectives. The intention is for investment to be driven by priorities and outcomes. The Foundation's tools are:

- fellowships for individual researchers (TechNZ capability/ scholarship funding);
- investigator-initiated research (Marsden Fund) - referred to in the proposed structure as "Top talent" ($55M);
- science-led contestable funding for smaller projects and larger programmes (basic science);
- long-term strategic research platforms - increased emphasis with changed criteria. A potential platform is "Forestry production - higher value wood products". The platforms must have:
  - strategic relevance to government and/or strategic goals;
  - research that is significant in scope, size and duration - $10M p.a. up to 10 years;
  - co-funded partnerships with users (e.g. research consortia such as Beacon Pathway's Post-Kyoto Homes and the Solid Wood Initiative; 50/50 FRST/industry funded);
  - commercial support (e.g. Pre-Seed Accelerator Fund);
  - technology transfer (e.g. Envirolink);
  - company-led R&D with export focus (e.g. TechNZ).

The Foundation currently has two contracts in the area of indigenous forestry:

1. The Diverse Forests contract, managed by Future Forests Research with Scion as the research provider. Last year this contract won $1.6M for five years directed towards indigenous species (a four-fold increase in this area).
2. Landcare holds an ecosystems-based Indigenous Forestry contract for $450,000 for three years focussed on southern species.

To grow this investment you will need to realise economic growth in the areas of:

- species diversification;
- selective breeding;
- improved silviculture;

The Shift - Our Challenge

Supply Driven	to	Demand Driven
Research providers leading R & D projects	⇨	***Users leading*** their research agenda supported by research providers
Portfolios inform investment signals (eg: RfP's) direct investment priorities	⇨	***Users*** groups and other sector stakeholders ***inform and influence*** sector investment strategies and signals
Research providers "consult with end user groups	⇨	***Users invest*** their knowlwdge and resources into the innovation system
Research providers have the capabilitiy and intellectual property	⇨	***Users and research providers together*** build and share new capability and new intellectual property

- defined and improved wood properties;
- other products – fibre and extracts;
- carbon economy;
- environmental services.

You must develop your business case around export-based sustainable production. It is not yet clear where environmental services such as biodiversity, erosion control etc. fit into the new system.

To summarise, you need to:

1. develop a national RS&T strategy with input from key stakeholders (including Maori) that has clear priorities. Know what you want as a subsector group - FRST will be asking.

2. develop partnerships and get your priorities heard by ministries, regional government, users throughout the value chain and research providers. It is suggested that you co-ordinate your research providers. Although you are small, make sure you get the biggest "bang for your buck".

If you want to influence and drive government investment, you will have to put your money where your mouth is and demonstrate your own investment in the research. Direct participation in the project will

Research on indigenous forestry

Bruce Burns

About the Author

***Bruce** is a senior lecturer in ecology at the University of Auckland. He is currently President of the New Zealand Ecological Society and is a Trustee of Tāne's Tree Trust. His research interests include the forest ecology of indigenous forests and particularly kauri.*

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Introduction

The goal of this workshop is to consider gaps in our knowledge relating to the establishment and management of native trees, and to define a research strategy for improving future activity. Useful, high quality research results are reliable (the goal of the scientific method), generalisable (can be applied to many circumstances), and accessible. When developing a research strategy for indigenous forests managed for production purposes, delivery of these qualities must be included.

I want to consider first the amount of research that has been carried out on indigenous forestry over the last few decades, and its focus. I suggest that if it had been meeting the needs of this group, the present workshop would not have been necessary. What does this tell us about topics that have been neglected? Secondly I want to suggest some areas of research that would repay future research investment.

Survey of research publications

In order to gain a perspective on past indigenous forest research, I compiled a list of relevant scientific articles published since 1980, using the Web of Science online database and the following keywords:

> New Zealand; forest; silviculture; native; tree; regeneration; wood; timber; growth; *Agathis australis*; *Dacrydium cupressinum*; *Beilschmiedia tawa*; *Podocarpus totara*; *Nothofagus* spp.

The tree species chosen had been identified at the 2007 Christchurch workshop on Research Needs for Indigenous Forest Establishment and Management as having most management potential. The list of articles developed from the search was reduced by removal of those dealing with topics not directly related to production forestry, such as dendrochronology, forest wildlife, stream biology, and natural extracts.

The result was a final list of 211 papers. Although it may not have been completely comprehensive, I'm confident that it did identify most of the relevant research papers completed and that it provided a representative sample of the topics covered. The papers were grouped into five-year publishing periods to show fluctuations in research activity. The address of the senior author and the topic of each paper were noted.

An average of 35 papers on indigenous forestry-related topics has been published in each five-year period during the last 30 years. Fewer were produced in the 1980s, but output has remained relatively constant since then (Figure 1).

The number of papers with senior authors living overseas stayed relatively constant at 9% for most of the time period considered but rose to 39% during the last five years. Most of the topics were related to ecology or tree physiology. Only nine were on forest management, with seven on wood properties/utilisation, and one on native forest plantations.

This analysis indicates that there has been substantial active research on New Zealand indigenous forests

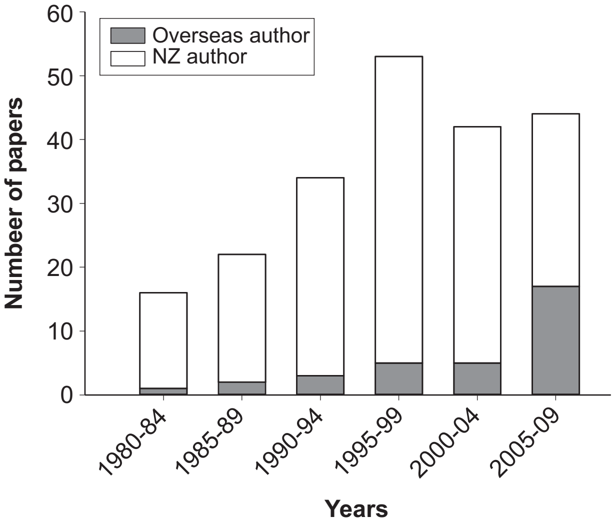

FIGURE 1: Number of papers published on New Zealand indigenous forests and forestry 1980-2009.

over the last few decades. It also suggests that no research has been undertaken on establishment and management of native trees in plantations or other production forestry settings. This is a gap in New Zealand's research portfolio.

The sudden upsurge in overseas senior authors during the last five years is difficult to interpret. It suggests that New Zealand forests are increasingly of interest internationally, but may also suggest that research capability in this area within New Zealand is declining.

Suggestions for the focus of future research

1. *Assessment of the silvicultural potential of a wider range of native tree species.*

At present we are considering only a few native tree species for plantation or productive purposes. I suggest that many more woody species in the New Zealand flora could be investigated as productive species. Some of these are listed in Table 1.

2. *Improvement of initial growth and survival rates of planted native trees.*

Survival and growth of native tree seedlings are known to be variable and can be poor on many sites. Growth rates usually improve once plants have become established. Research on ways to shorten the establishment phase could focus on:

- the selection of material for planting (genetic and phenotypic characteristics);
- site treatments facilitating root development (probably a key limiting factor for some species e.g. kauri);
- reduction of competition from pasture grasses and weeds;
- temporary use of companion species that could facilitate growth (e.g. nitrogen-fixing legumes, shade plants).

TABLE 1: New Zealand native conifers and angiosperms known or suspected to have plantation potential.

Conifers	**Angiosperms**
Kauri (*Agathis australis*)	Red beech (*Nothofagus fusca*)
Totara (*Podocarpus totara*)	Silver beech (*Nothofagus menziesii*)
Rimu (*Dacrydium cupressinum*)	Black beech (*Nothofagus solandri*)
Kahikatea (*Dacrycarpus dacrydioides*)	Puriri (*Vitex lucens*)
Hall's totara (*Podocarpus hallii*)	Rewarewa (*Knightia excelsa*)
Matai (*Prumnopitys taxifolia*)	Mangeao (*Litsea calicaris*)
Miro (*Prumnopitys ferruginea*)	Pohutukawa (*Metrosideros excelsa*)
Tanekaha (*Phyllocladus trichomanoides*)	Kohekohe (*Dysoxylum spectabile*)
Monoao (*Monoao colensoi*)	Hinau (*Elaeocarpus dentatus*)
	Tawa (*Beilschmiedia tawa*)
	Black maire (*Nestegis cunninghamii*)
	Kanuka (*Kunzea ericoides*)
	Whau (*Entelea arborescens*)

3. *Improvement of management methods for planted indigenous forest.*

Research on post-establishment management should include:

- the control of specific pests and diseases of indigenous trees, e.g. puriri moth (*Aenetus virescens*) and kauri dieback (*Phytophthora* "taxon Agathis"). Research on kauri dieback is urgently required. This could be a major threat. It is more widespread than originally thought, and there is currently no known cure (Beever et al., 2009);

- the role of mycorrhizal relationships in native species;

- the possibility of negative effects resulting from removal of dead wood from indigenous forests. Dead wood forms a habitat for many organisms and the consequences of its removal should be considered (Richardson et al., 2009);

- consideration of species mixtures including combinations of exotic and indigenous species.

4. *Development of appropriate harvesting systems.*

Indigenous plantation forests of the future are likely to contain species mixtures. They may be managed under requirements for maintaining forest cover for carbon accounting purposes. Development of harvesting systems designed for regular removal of smaller amounts of timber will be needed. The continuous-cover system described by Barton (2008) is a good starting point.

5. *Improvement of the social and economic viability of indigenous plantations.*

Research should be directed towards the identification of appropriate social and economic incentives for landowners considering indigenous plantation forestry. In particular there is a need for identification of ways in which growers might benefit from non-timber values and pre-harvest opportunities. The processing and marketing of native timber products also needs attention. Some existing markets (e.g. Bigsby et al., 2003) could be expanded.

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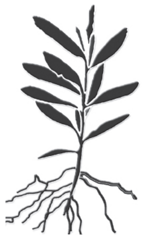


Summary of comments following Workshop 4: Research

The four Breakout Groups were asked to consider the following questions:

1. ***Are there any major omissions from the list of research needs developed at Christchurch and are the priorities identified then still relevant?***

2. ***Is there still a need for a group "to coordinate the assessment of research needs for indigenous forestry and to produce and implement a more general strategy for indigenous forests"?***

3. ***If there is still a need, are there any changes that you would make to the general structure and funding of the group?***

4. ***Is there any alternative that you wish to propose?***

Summary of comments

Question 1: Are there any major omissions from the list of research needs developed at Christchurch and are the priorities identified then still relevant?

Which species should research concentrate on?

Christchurch priority ranking was: (1) Beech; (2) Totara; (3) Kauri; (4) Rimu.

Rankings from the present Workshop were:

Breakout Group 1	Breakout Group 2	Breakout Group 3	Breakout Group 4
(1) Totara (2) Mixed species/Manuka (continuous cover) (3) Beech *Others* Kauri Rimu Rewarewa	(1) Totara (2) Kauri (3) Beech (4) Puriri	(1) Kauri (2) Totara (3) Rimu (4) Tawa (5) Puriri (6) Beech *Others* Tanekaha (regionally important) Black Maire	(1) Kauri *Others* Hall's totara Tawa Puriri Pohutukawa Kahikatea (instead of rimu) Species for carbon (kanuka/manuka)

The lower ranking of beech by groups in this Workshop probably reflects the predominance of North Island participants.

What are the most important research categories?

Christchurch priority ranking of the top ten major research categories was:

(1) Harvesting.
(2) Maori perspective.
(3) Management.
(4) Utilisation.
(5) Regeneration.
(6) Wood properties.
(7) Silviculture.
(8) Biodiversity.
(9) Technology transfer.
(10) Economics.

Other major research categories in the Christchurch list were:

- Markets.
- Forecasting (growth, yield, quality).
- Protection.
- Establishment.
- Choice of species.
- Species and site selection.
- Seed; seed sources.
- Nursery/propagation.
- Genetics & breeding.
- Legislation/regulation/ local government rules.
- Farm forestry perspective.
- Research perspective.
- Government perspective.
- Other perspectives.
- Soil and water.
- Recreation/landscape.
- Climate change/carbon.

Christchurch identified 101 research sub-categories. The five ranked most highly for importance were:

1. Adopting alternative harvesting techniques.

2. Role of nurse crops.
   Improved regeneration.

*Importation of illegal timber.
   *Public perception of indigenous timber and its values.
   *Need to combine/co-ordinate provisions from both the Resource Management Act (RMA) and Forests Act.

3. Drying stability of beech (and other species).
   New harvesting technology.
   Non-wood economic benefits.
   Collating existing growth and yield data.
   Forest management systems.
   Forest restoration.
   Timber stand improvement.
   Restoring cultural harvest to indigenous forests.
   *Better coordination of the indigenous sector.

*Training courses in indigenous forestry.
   *Analysis of District Plans to ensure consistency.
   *Sorting out issues raised in Tāne's Tree Trust (TTT) workshops (profiting from biodiversity).
   Regeneration of seedlings/seed.
   Lowering harvesting costs.
   Allometric relationships (carbon).
   Old vs young wood properties.
   Planted vs natural forest properties.
   Effect of silviculture on wood

**Policy/strategy rather than research.*

Other topics suggested at Christchurch included:

- New sawmilling technology.
- Appreciation of cultural values.
- Protection of small plants (mainly during harvesting and silvicultural operations).
- Gene pool improvement.
- Impact of tending regimes on tree stability.

Participants in the current Workshop gave the following responses
(NB - Group 1 did not answer this part of Question 1):

Breakout Group 2	Breakout Group 3	Breakout Group 4
What topics other than those suggested at Christchurch should be on the list?		
• Business case/sustainability (social, economic, environmental, cultural). • Wood properties/ utilisation. • Silviculture/management.	• Genetics/breeding programmes. • Preharvest return opportunities. • FRST investment/exports/ how to frame needs. • Sequestration. • Climate change. • Marketing.	• Carbon sequestration. • Disease (e.g. kauri dieback). • Soil and water. • Establishment. • Species and site selection. • Markets. • Ecosourcing – regeneration. • Non-wood values.
What are the most important areas of research?		
Important but not ranked • Establishment. • Genetics (timber and biodiversity). • Utilisation. • Biodiversity. • Management. • Carbon sequestration. • Social. • Non timber values (e.g. biodiversity).	*Ranked in orderof importance* • Regeneration (natural and planted). • Silviculture. • Genetics/breeding. • Management. • Economics. • Biodiversity. • Technology transfer. • Pre-harvest return opportunities. • Utilisation. • Sequestration. • Marketing.	*Ranked in order of importance* • Carbon sequestration. • Species and site selection. • Economics. • Soil and water. • Biodiversity. • Management (whole package including silviculture). • Genetics. • Silviculture. • Establishment. • Harvesting (sustainably). • Utilisation. • Regeneration. • Wood properties. • Disease. • Markets. • Ecosourcing. • Non-wood values.

Questions 2, 3 and 4:

Christchurch proposed the establishment of a group "to coordinate the assessment of research needs for indigenous forestry and to produce and implement a more general strategy for indigenous forests". Present suggestions for structure and funding were as follows:

- Six members (one representative each from TTT, the New Zealand Farm Forestry Association (FFA), Maori indigenous forest owners, processors, plus two others).
- Close liaison with, but no direct representation from, Government, Crown Research Institutes (CRIs), professional bodies (e.g. the New Zealand Institute of Foresters; NZIF), local government bodies, Queen Elizabeth II Trust etc.
- Role – preparing terms of reference; seeking feedback; appointing bodies would need to endorse the terms of reference developed by the group.
- Definition and seeking of its own funding
- First task could be review, revision and up-dating of the 1999 "Strategy for New Zealand Indigenous Production Forests and Timber Industries".

Breakout groups in the Workshop were asked to consider the following questions:

- ***Is there a need for a group such as that proposed at Christchurch?***
- ***Is there any alternative that you wish to propose?***
- ***If you don't like the Christchurch proposal for a body to produce and implement a strategy for indigenous forests, then what do you propose?***

Breakout Group 1 responses:

- There should be a group.
- Rather than a new group, use Future Forests Research (Indigenous Section).

Breakout Group 2 responses:

- There should be a group.
- It should be formed under the Tāne's Tree Trust umbrella and bring in supporting stakeholders including Ministry of Agriculture and Forestry (MAF), Ministry of Research, Science and Technology (MoRST), Scion, Landcare Research, Universities and iwi.
- The task should be to develop indigenous tree research and development strategy.
- Future Forests Research (FFR) should be the vehicle for implementing strategy.

Breakout Group 3 responses:

- There should be a group. It could be the Ministerial Indigenous Advisory Committee. Features should include:
  - A wide range of partners (including CRIs and Universities).
  - Correspondence by e-mail.
  - A "champion".
  - Attention to the new Foundation for Research Science and Technology (FRST) framework.
  - Development of a wide-based strategy.
  - Reporting to the Ministerial group.
  - Engagement with major players not represented at this workshop (e.g. big timber producers, natural forest owners, big iwi).

Breakout Group 4 responses:

- There should be a coordinating group which reports back (not stated to whom). The structure should include:
  - Balance with the industry-driven $ perspective (i.e. not just economic value).
  - FRST perspective.
  - Environmental perspective.
  - Cover of more bases (e.g. MAF, Forestry, Ministry for the Environment (MfE)).

Discussion with panel of speakers

Andrew McEwen recorded his agreement with Russell Dale, CEO of Future Forests Research, prior to the workshop, that any strategy should cover a wider field than just research in order to have an appropriate framework. Development of the wider strategy is outside FFR's scope of operation.

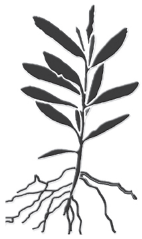
Tom Richardson noted that research strategy needs to be balanced, concentrating not only on species about which we have reasonable information, but also on work with species about which we know little. The trick is to get the balance right. There is also a need for research strategy to be linked with New Zealand's export strategy.

Andrew McEwen's concluding comments:
New Zealand's plantation forestry was developed over a period of 80 years with a great deal of government investment centred on one species. To make progress with indigenous species we need a well-financed, long-term view in order to more forward with confidence.

Conclusions

Andrew McEwen has provided the following concluding comments, taking into account both this and the Christchurch workshops:

- There is a need to develop a strategy for indigenous forests.
- Research strategy would be a component part. Trying to develop a stand-alone research strategy in the absence of a more comprehensive framework is likely to be less effective.
- Development of the strategy will need to involve a wide range of interested parties, but it may be more efficient to have a small project team. This team could prepare a framework document and seek input from a wider range of interested parties.
- The project team would be required to report to a body capable of action. This could be Tāne's Tree Trust or a steering group with representatives from interested parties.
- While the research part of the strategy may incorporate findings from the two workshops, it will need to be examined in the context of the wider strategy.



Report on the final Plenary Session: Towards a national strategy

Helen Ritchie

About the Author

Helen *is a specialist in agricultural and environmental management. She facilitates events, reviews research and writes resource material and reports. Formerly with Environment Waikato, she has assisted landcare groups in the Waikato region.*

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This session was used to identify strategic directions for advancing the productive use of native trees in New Zealand. Participants were encouraged to reflect on information shared during the Conference, and to suggest ways in which it could guide future activity in the indigenous forestry sector. The following question was put to participants:

What are some specific actions that groups or sectors can take that would make a difference to the productive use of native trees in New Zealand?

Responses

Suggestions were grouped according to linkages that participants could see between the ideas put forward. The following categories emerged:

1. Demonstration of effective models.
2. Preparation of a business case.
3. Communication/getting it out there.
4. Making the most of opportunities on farms/in the landscape.
5. Working inclusively, taking a holistic approach.
6. Setting targets.
7. Enhancing incentives.
8. Lobbying for better national and local policy and regulations.
9. Securing funding.

Specific ideas for action were:

1. Demonstration of effective models

- Focus on two species, e.g. totara and beech. Follow through from seedling establishment to marketing of products.
- Explore and report on population genetics of key indigenous species.
- Establish demonstration plots in:
  - planted monocultures e.g. totara.
  - species mixtures planted to demonstrate continuous-cover forestry.
  - existing forest managed for selective extraction using modern techniques.

2. Preparation of a business case

- Develop the case for indigenous forestry.
- Develop the case for using New Zealand native timber instead of imported wood products.
- Develop a range of cases for realisation of pre-harvest returns e.g.:
  - carbon
  - nitrogen
  - natural extracts
  - mulch production
  - biofuel.

- Develop a multi-value calculator that is:
  - free
  - expandable
  - applicable for wood and non-wood products.

- Prepare maps of the entire resource:
  - LiDAR (high resolution aerial photography)
  - spatial
  - temporal.

- Work towards development of an internet-based log/timber market e.g. a Timber "Trade Me™".

3. Communication/getting it out there

- Get the message out:
  - workshops
  - demonstrations
  - face to face.

- Participate in Agriculture Field Days.
- Run Forestry Field Days.
- Put successful projects onto YouTube.
- Increase children's perception of the value of trees so that it lasts for their lifetime.
- Establish regional demonstration stands featuring important native species.
- Support Tāne's Tree Trust.
- Produce a brochure promoting the benefits of indigenous forestry as a viable land use.
- Collate and condense existing information (e.g. the new TTT Manual).
- Re-educate the public about selective sustainable logging.
- Send all regional councils a summary of the Proceedings of this Conference so that they can pass information on to the public.

4. Making the most of opportunities on farms/in the landscape

- Facilitate cooperative forestry groups among landowners in an area or catchment:
  - Share skills.
  - Share expertise.
  - Centralise organisation of planting, fencing, maintenance.
  - Promote use of native trees for shelter belts.
  - Encourage Transit NZ to grow podocarps on roadside reserves (emphasise ease of access for harvesting) and motorways.

5. Working inclusively, taking a holistic approach

- TTT and NZFFA Indigenous Section need to work together.
- Restore the mauri of the forest – the whole forest. Take an holistic approach.
- Enhance utilisation of iwi knowledge in partnership with Maori.

6. Setting targets

- Set specific targets for the indigenous forestry industry e.g. 10% of the total value of NZ forestry from indigenous forestry by 2100.
- Set a national target for planting a million native trees by 2020.

7. Enhancing incentives

- Put in place practical mechanisms for making it all happen e.g. workshops, subsidies.
- Complete research on carbon sequestration by native species, then lobby government to increase the value of carbon credits for native forests. Subsidise if necessary to encourage planting (recognise ecosystem benefits, biodiversity value, in line with Biodiversity Strategy commitments).

8. Lobbying for better national and local policy and regulations

- Torpedo government policy with regard to mining in Fiordland.
- Encourage use of MAF certification for native plantings.
- Lobby for development of a National Policy Statement on indigenous forestry.
- Coordinate a letter-writing campaign for change of government policy on support for locally-consumed export timber.
- Lobby government for removal of barriers e.g. rules, research bias.
- Lobby for removal of disincentives for planting of natives rather than exotics e.g. ETS, local council rules.

9. Securing funding

- Obtain funding for the implementation of the strategy.

Summary of Field Day

Michael Bergin

About the Author

***Michael** has a Diploma in Forest Management and has worked as a technical assistant to a number of landowners, trusts and government agencies.*

Conference field trip

The Conference was rounded off on Friday 20 November 2009 with inspection of three native forestry sites in the Waikato region. These were the Warrenheip reserve near Karapiro; the Maungatautari Ecological Island; and the Whatawhata Hill Country Research Station. Apart from time constraints, the day was a huge success, mainly thanks to the organiser, Roger MacGibbon.

Warrenheip, Karapiro

Warrenheip is a deer stud farm property owned by David Wallace and his partner Juliette. It includes a Mainland Island consisting of 16 ha of regenerating indigenous forest. Trials of different designs for predator-proof fencing, carried out more than a decade ago, resulted in the technology now used for enclosures in New Zealand and overseas. The fenced area at Warrenheip is free of common predators such as rats, possums, mice and stoats. It is home to a number of “Operation Nest Egg” kiwi, endangered brown teal ducks and giant weta. Roger MacGibbon and David Wallace provided a comprehensive commentary on the erection and management of the fence, the removal of predators and the planting of indigenous trees and shrubs Figures 1 and 2. David Bergin noted that the impressive stands of native trees could provide an excellent opportunity for establishment of permanent sample plots to be used for growth assessments. These could be linked to the Tāne’s Tree Trust (TTT) Indigenous Plantation Survey and the TTT Indigenous Plantation Database projects.

Maungatautari Ecological Island

This forest near Lake Karapiro on the Waikato River has a 47 km fence that encloses a pest-free environment for indigenous fauna and flora. Fencing was carried out over several years by the Maungatautari Ecological Island Trust (MEIT). Gordon Stephenson, Patron of Tāne’s Tree Trust and also Deputy Chairman of MEIT provided an eloquent account of the development of this Mainland Island, Figure 3. Conference participants were then guided through the forest by dedicated MEIT volunteers. The tour included the impressive pole-and-timber canopy tower (Figure 4) and bird enclosure. There were plenty of opportunities for seeing released endangered bird species such as hihi, takahe and kaka.

Whatawhata Hill Country Research Station

The final stop was made at the AgResearch hill country research station lying to the northwest of Hamilton city. Here Conference participants inspected a catchment-scale trial designed to compare the effects of exotic forestry (mainly radiata pine), native forestry and pasture on water quality and biodiversity. Mike Dodd of AgResearch, John Quinn from NIWA and Roger MacGibbon of Natural Logic presented results to date, Figure 5. Handout notes have been included in these Conference Proceedings.

High survival rates and good early growth were evident in kauri and totara plantations on upper slopes. Performance of these and other native tree species on lower slopes had been affected by frost. A discussion of the pros and cons of establishing native forest on this type of hill country brought the enjoyable and productive field trip to a close.

Postscript

Following this Conference, with permission from Mike Dodd and Shane Hill, Whatawhata Agresearch Station Manager, several permanent sample plots have been established in stands of kauri, totara, rimu, kahikatea and silver beech in the Whatawhata trial area. Growth-monitoring plots have also been established in planted shrub/hardwood stands (karamu, kohuhu, whauwhaupaku, kanuka, manuka, ti kouka, and tarata plantings) that surround the podocarps. Data from these plots will make a valuable contribution to the TTT Indigenous Plantation Survey and Database projects. As part of another TTT joint research project, core samples have been taken from several shrub/hardwood species for wood density analysis. This will assist estimation of carbon sequestration rates at various stages in the development of native forest communities.

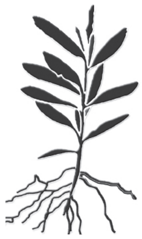
FIGURE 1: Warrenheip. TTT Conference participants being addressed by Roger MacGibbon. Thousands of native trees and shrubs have been planted within the predator-proof enclosure.

FIGURE 2: Warrenheip. David Wallace discusses the management of kiwi released into the enclosure in collaboration with the Department of Conservation.

FIGURE 3: Conference participants gathered at the entrance to Maungatautari Ecological Island. Gordon Stevenson provided a history of the Maungatautari project and described ongoing management of the fence, the monitoring of forest regeneration, and the introduction of endangered native bird species.

FIGURE 4:
The impressive pole-and-timber observation tower at the edge of Maungatautari Forest. Visitors climb 16 m into the canopy to view native orchids, flowering rata and rewarewa or to watch kaka swooping between the tree tops.

FIGURE 5: Mike Dodd (left) and Roger MacGibbon (right) provide details about the AgResearch Whatawhata Catchment Trial. Immediately behind them is a kauri plantation established on a steep slope 10 years earlier. A fenced native forest remnant can be seen in the background.



Field Day Handout No. 1 –

Native tree and forest research at Whatawhata Research Centre

Mike Dodd,

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Introduction

This programme of research from 2000-2008 included the following studies:

1. Characteristics of grazed forest fragments;
2. Restoration of forest fragments by fencing/pest control;
3. Establishing native trees on hill country pasture by transplanting;
4. Establishing native trees on hill country pasture by oversowing; and
5. Historic growth rates of podocarps.

Each of these studies is summarised separately on the following pages.

Acknowledgements

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- Bruce Burns (Landcare Research/University of Auckland)
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- Tim Newton (University of Waikato)
- Ian Power (AgResearch)
- Mark Smale (Landcare Research)
- Phil Thomson
- Linda Trolove (AgResearch)

1. Characteristics of grazed forest fragments

We selected six sites around Whatawhata to look at the structural and botanical differences between grazed forest fragments surrounded by pasture and "ungrazed" forest (Figure 1). At each site we installed a number of 5 × 10 m permanent sample plots and recorded species cover by forest tier (0-0.3, 0.3-2, 2-5, 5-12 and >12 m), total canopy cover, sapling numbers, seedling numbers, ground cover, coarse woody debris and exposed roots.

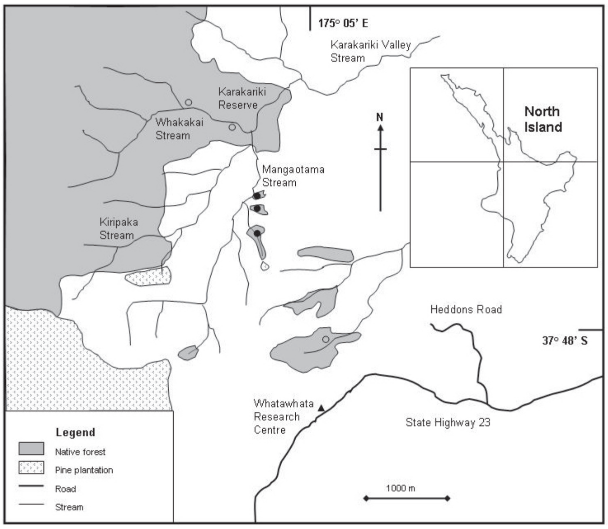

FIGURE 1: Location of study sites at Whatawhata, Western Waikato, New Zealand. Open circles represent ungrazed forest sites, filled circles represent grazed forest fragment sites.

The comparison for a number of characteristics is shown in Table 1. Grazed fragments had shorter and more open canopies, sparser understoreys, tree populations with larger mean diameters, ground layers with lower litter cover, greater bare soil cover and higher vegetation cover (mostly adventives grasses & forbs). Grazed fragments also had lower indigenous plant species richness (but little difference in total plant species richness), lower sapling numbers and few palatable indigenous shrubs.

The overall pattern in the grazed fragments was towards a shorter canopy of different species composition and little regeneration, and hence the likelihood is that these fragments will gradually disintegrate over the next century.

Reference

Smale, M.C.; Dodd, M.B.; Burns, B.R. & Power, I.L. 2008: Long-term impacts of grazing on indigenous forest remnants in a North Island hill country catchment, New Zealand. *New Zealand Journal of Ecology 32(1)*: 57-66.

TABLE 1: Characteristics of grazed fragments vs. ungrazed forest at Whatawhata.

		Grazed fragment	Ungrazed forest
Species number	native trees/shrubs	28	35
	adventive trees/shrubs	3	0
	native herbs	20	9
	adventive herbs	22	0
% canopy cover	tawa	15	58
	silver fern	12	30
	mahoe	16	7
	wheki	15	2
	hen & chicken fern	<1	3
Density (stems/ha)	trees	2000	2000
	saplings	27	6700
	seedlings	25000	37000
% ground cover	litter	44	70
	bare	14	5
Total % canopy cover		92	99
Basal area (m^2/ha)		49	65

2. Restoration of forest fragments by fencing/pest control

Of the three grazed forest fragments in the previous study, in 2001 all were included in a possum/rat control programme involving trapping, shooting and bait stations (Pestoff). Two of the fragments were also fenced to exclude livestock. In 2002, 2004 and 2008 we re-measured the permanent sample plots to examine recovery patterns, as well as the original ungrazed forest control sites. While most of the data has not yet been formally analysed, some changes are evident (Table 2).

Interestingly, basal area and tree density appear to be declining in the forest reserve, despite a reasonable level of regeneration via a diverse species mix of saplings. The grazed fragments are also losing both basal area and tree numbers, with low sapling regeneration of a few species (wheki, mahoe, supplejack). The fenced fragment has largely maintained basal area and tree numbers, with a substantial increase in regeneration of a wider range of species (~20).

The estimates of possum trap catch rates (using the Residual Trap Catch method, RTC) over the three formerly grazed fragments were 17% RTC prior to the control measures and 4% RTC a year after the bait stations had been in place. The initial trapping also caught about one rat for every 10 possums, but this ratio increased to 2 : 5 a year later, indicating that we had not had much impact on the rats.

TABLE 2: Changes in the structure of three native forest sites between 2000-2008.

Site	Management	2000	2002	2004	2008
		Basal area (m^2/ha)			
Karikariki	Forest reserve	80.0	78.5	77.1	69.4
Swamp	Small fragment fenced 2001	51.1	52.1	53.2	52.9
Gully	Small fragment grazed	50.9	51.4	53.3	49.5
		Tree density (stems/ha)			
Karikariki	Forest reserve	2000	1940	1760	1600
Swamp	Small fragment fenced 2001	2130	2100	1950	1810
Gully	Small fragment grazed	1870	1800	1730	1590
		Sapling density (stems/ha)			
Karikariki	Forest reserve	8540	9020	8420	10620
Swamp	Small fragment fenced 2001	35	1440	4080	5680
Gully	Small fragment grazed	0	1570	1690	1140

3. Establishing native trees on hill country pasture by transplanting

An area of approx 12 ha, which included exiting forest fragments within a sub-catchment of approx. 30 ha, was set aside for restoration of native forest. The intent was to augment the existing forest fragments by fencing them from livestock, controlling pests (mainly possums and hares) and increase their area by replanting native trees and shrubs. In May-June 2001 we planted 5.2 ha in mixed trees and shrubs, 0.8 ha in totara, 0.5 ha in kauri, and small blocks of rewarewa, rimu and beech. Overall we planted some 18 000 plants over 7.4 ha (Figure 2).

The majority of the first year cost of this project was in the planting, with the tree purchase alone comprising 55% of the costs (Table 3). Fencing costs overall would have been greater but for the use of some existing fencelines (the per metre cost was $8.50). Following the loss of plants in winter frosts (see below) blanking in the second autumn cost approx. $16,000. Release spraying in the subsequent two years cost about $16,000 per annum. Pest control via the bait stations has cost approx $2000 per annum in time and bait. Gorse control has been sporadic, amounting to approx. $5000 overall.

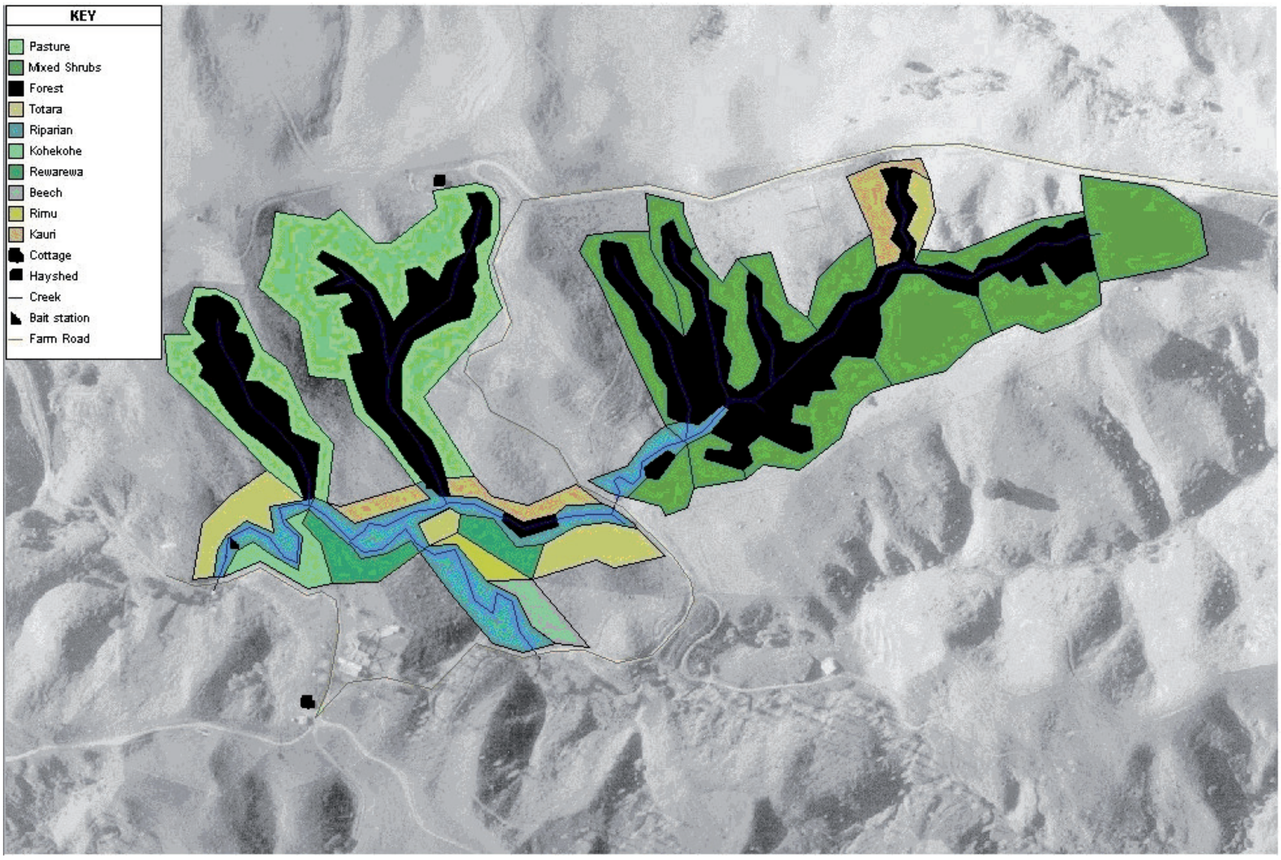

FIGURE 2: Map of native tree planting areas at Whatawhata

TABLE 3: Cost breakdown for native tree planting at Whatawhata.

Activity		Cost (excl. GST) Year 1	%
Planning		5600	4
Fencing		18400	13
• labour	9400		
• materials	9000		
Weed control		7900	5
• mulching 0.5 ha gorse	2100		
• cutting dispersed gorse	900		
• clearing pine slash	4900		
Pest control		2800	2
Planting		107800	73
• plant purchase	81500		
• labour	26300		
Release spraying		4500	3
Total		147000	100
$ per ha		19800	

Three periods of heavy frosts in July 2001 killed initial plantings of kohekohe and puriri, and these were immediately replaced with rimu and totara. The frost also caused significant damage to rewarewa (90% losses) and kauri (50% losses), particularly in the lower reaches of the area planted. Other issues included gorse regrowth, wind pressure, hare damage, spray drift and one instance of cattle being accidentally allowed into part of the area. Growth over the first two years was excellent, helped by mild conditions and moist summers. Measurements of tree and shrub heights were made after 15 months and five years (Table 4).

TABLE 4: Height growth in native tree plantings, ordered by year-5 data.

Mixed species	Planted height (m)	1 yr height (m)	5 yr height (m)
kohuhu	0.63	0.94	3.73
ake ake	0.79	1.18	3.60
lemonwood	0.92	1.15	3.50
cabbage	0.65	0.69	2.70
five finger	0.35	0.65	2.69
wineberry	0.49	0.90	2.86
karamu	0.44	1.00	2.25
puka	0.23	0.58	2.15
mahoe	0.53	0.57	2.08
kanuka	0.88	0.85	1.92
red matipo	0.44	1.15	2.00
koromiko	0.47	0.74	1.78
Stands	**Planted height (m)**	**2 yr height (m)**	
kauri	0.81	0.95	
totara	0.77	1.22	
rewarewa	0.63	1.00	

4. Establishing native trees on hill country pasture by oversowing

Mortified by the huge cost of restoration the "Rolls Royce" way, we decided to investigate alternative approaches to establishing native trees into pasture. Direct seeding is a technique that we were told had been tried and found wanting – however given the significant amount of work on oversowing pastures in hill country that had been done at Whatawhata during the 1980s, we thought that by applying the same approaches we might have some success. Specifically, the use of a combination of hard grazing, spraying resident pasture and treading the seed with mob stocking. So we designed a small plot experiment to apply these treatments using a native shrub seed mix instead of pasture seed. The results were encouraging, as we were able to establish good populations of koromiko (*Hebe stricta*) and karamu (*Coprosma robusta*) that after a year were past the point where recovering pasture might smother them (Figure 3). The sheep treading led to significantly greater establishment in the spring sowing but not the autumn, which we attributed to the better soil moisture conditions in autumn.

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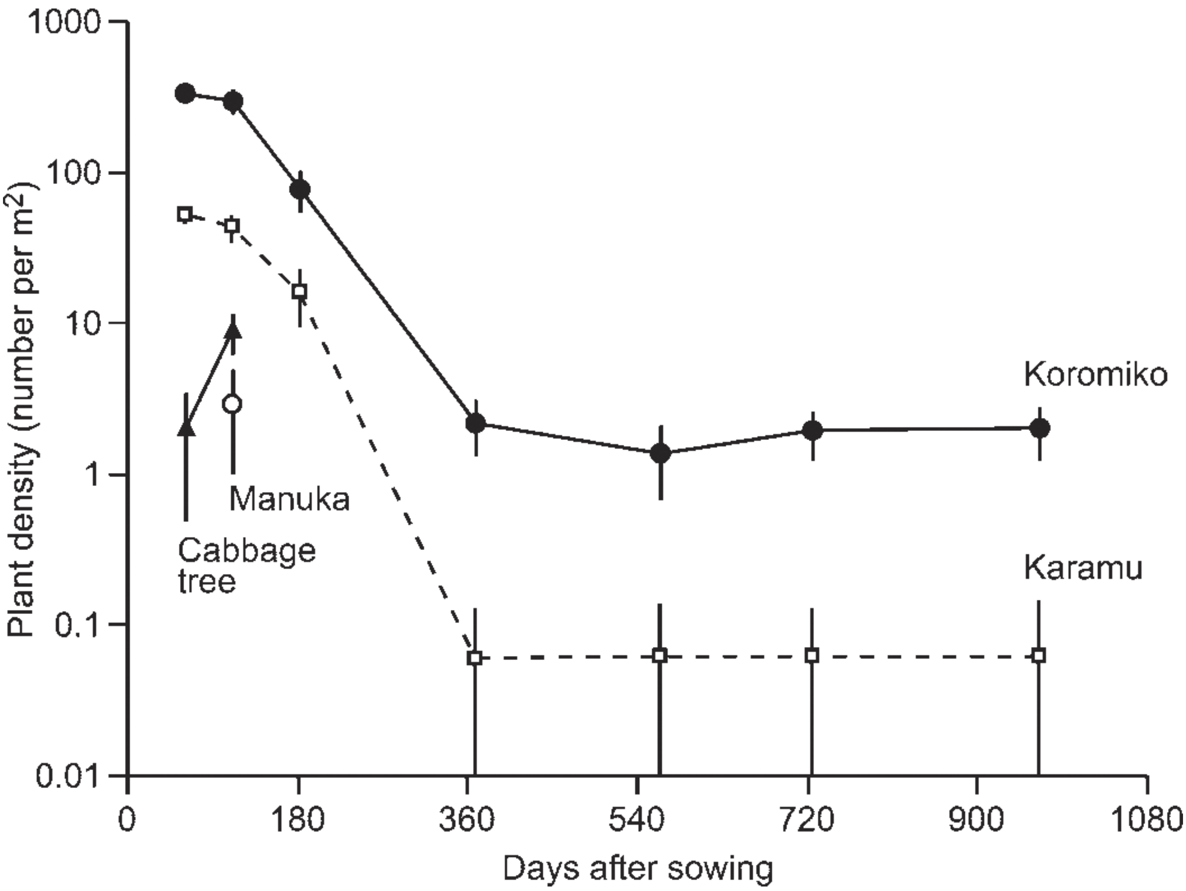


FIGURE 3: Plant populations of direct seeded native trees.

5. Historic growth rates of podocarps

A Waikato BSc. (Tech) student who was working with us in the summer of 2003 took tree-ring cores from a number of the podocarp trees at Whatawhata. The kahikatea cores were most straightforward to interpret, so we compared the stem growth of trees from the adjacent Karikariki reserve, fragments on the farm and open pasture. The mean radial increments of 40-80 year old trees in fragments and open pasture were approximately twice the rate of those in the reserve (Table 5).

The few 110+ year old trees that were sampled also showed variation in stem growth rates (Figure 4). The miro had much lower basal area increments than the kahikatea. There may have been an effect of fragmentation (probably in the 1920s when this farm was cleared) in terms of increasing the growth rate of the kahikatea in the fragment relative to the forest reserve but decreasing the growth rate of the kahikatea left in open pasture, which has improved its growth in recent decades.

TABLE 5: Mean annual radial increments of kahikatea trees at Whatawhata

Site	Increment	Increment
	(DBH vs. age)	(Measured rings)
Reserve forest	0.23 ± 0.02	0.24 ± 0.04
Farm fragment	0.48 ± 0.04	0.43 ± 0.04
Open pasture	0.40 ± 0.04	0.46 ± 0.08

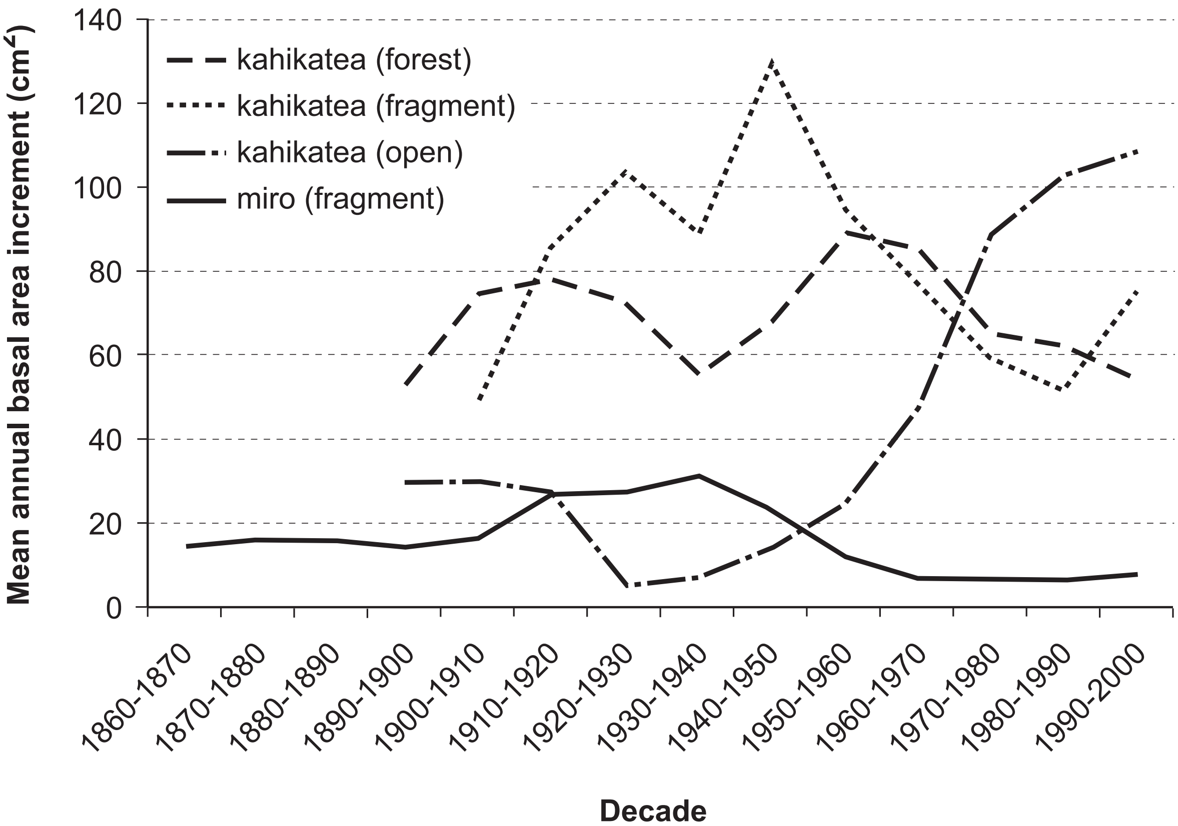
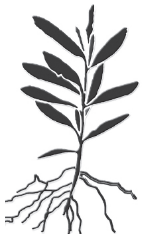


FIGURE 4: Stem growth rates for four long-lived kahikatea and miro trees.



Field Day Handout No. 2 –

Overview of Whatawhata Integrated Catchment Management (ICM) Project

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Introduction

The Whatawhata project arose out of research collaborations between AgResearch and the National Institute of Water and Atmosphere (NIWA) in the early 1990s (Smith et al. 1993) and formally commenced in 1996 with the formation of a stakeholder catchment management group (Parminter et al. 1999). This group included representatives from three domains: science (AgResearch, NIWA and later Landcare Research), policy (Environment Waikato, Auckland Regional Council, Waikato District Council, Department of Conservation, Federated Farmers) and landowners (local farmers, foresters and Maori). Over the subsequent 10-year period the group went through a process of setting land management goals and objectives; choosing appropriate management indicators; assessing catchment performance based on the 300 ha Mangaotama catchment at the Whatawhata Research Centre; planning land use and management change using forecasting processes based on ongoing research; and implementing land use change and monitoring outcomes (Dodd et al. 2008a,b,c). While the stakeholder group is no longer functioning and the farm management has been integrated back into the research centre, monitoring of terrestrial biodiversity by Landcare Research is ongoing and NIWA maintains both ongoing monitoring (flows, water quality, habitat and biota) and active targeted research projects on climate effects on nitrogen dynamics, wetland mapping/prediction, stream biota recolonisation processes, and responses to land management interventions.

Purposes

- To achieve the stated vision of the stakeholder management group “a well managed rural hill land catchment farm” across six domains – business viability, ecosystem health, landscape values, partnerships, demonstrable environmental performance and rural infrastructure; and
- To understand the processes driving land-use effects on stream flow, water quality and stream biota and the time-scales of responses to ICM and various sub-catchment treatments.

Outputs

To date, the project has produced 55 refereed journal publications (including a dedicated special issue of the NZ Journal of Marine and Freshwater Research: 1997, Vol 5), 24 unpublished reports, 29 conference papers and popular articles and five postgraduate theses (contact John Quinn for the latest publication list). Many of these involve international collaborators from the UK, Australia, USA and Canada. These outputs encompassed studies on terrestrial and aquatic ecosystem processes, enterprise and farm-scale economic analyses, management group processes and adult learning. Findings formed a key component of the 13 half-day workshops around the country for dry-stock farmers in 2006 on ‘Intensifying your farm: what are the effects?’. The site has hosted a stream management workshop (Quinn & Thorrold 1998), a New Zealand Grasslands Association field day (2001), a national ICM workshop field day (2004) and regular training days for Environment Waikato land management officers and NIWA’s “Targeted Riparian Management” training courses. It is used for annual stream evaluation training sessions by Wintec students studying their Ecosystems and Conservation module.

Major findings

- Comparisons of the initial status of pastoral vs. forested sub-catchments showed very clear differences: higher suspended solids, nitrogen and phosphous levels, sediment and nutrient loads, light levels, stream temperatures, erosion rates, faunal densities, instream productivity, faecal coliforms; lower biological diversity, and narrower stream structure (e.g. Quinn et al 1997, 2007; Quinn & Stroud 2002).

- Riparian deforestation has reduced stream invertebrate biodiversity at the catchment scale by homogenising many aspects of stream habitat.

- Koura (freshwater crayfish) are abundant in both pasture and forest streams and act as a keystone species through their effects on bioturbation and roles as omnivores and organic matter processors. Pasture stream populations are more vulnerable to extreme flow disturbance than those in forest streams where more refuges occur.

- Headwater and riparian wetlands play key roles in reducing instream concentrations of sediment, nitrogen and phosphorus. Cattle should be excluded from small shallow wetlands because they are attracted to these and their faecal bacterial inputs result in very high export during high flows.

- Stream shade/riparian vegetation has profound effects on stream ecology through effects on geomorphology (channel width), water temperature, periphyton biomass, organic matter input and nutrient uptake. Surveys, experimental streams studies and models have defined the relationships and threshold levels between shade and these attributes.

- Stream size is the main control on retention of both fine and coarse organic particles.

- Rainfall simulator experiments demonstrated that soil treading damage from intensive livestock grazing is a key driver of sediment and nutrient input to streams. Under heavy rainfall on steep pastoral land, overland flow can transport substantial quantities of faecal bacteria to streams within overland flow and it is unlikely that vegetated buffer strips will be particularly effective at attenuating these bacteria under these conditions.

- The concentrations of sediment and nutrients in overland flow were strongly correlated with % bare ground in the rainfall simulator area. Impacts of grazing on sediment and nutrient losses were less in summer than winter due to less damage to vegetation and greater soil infiltration rates in summer.

- Modelling highlighted a range of land use and management changes with potential to improve environmental and economic performance, centred around paddock restructuring, tree planting and livestock intensification.

- Time scales for environmental improvements varied depending on the indicator of interest and in the short-term were not always as predicted by modelling and stakeholder experience.

- Extreme weather events have a strong influence on sustainability of land use in marginal environments (i.e. drystock agriculture on steep hill land) and impacts of land use on stream ecosystems (Parkyn & Collier 2004, Collier & Quinn 2003, Quinn & Basher 2007). For example, after an intense rainstorm (97 mm in four hours) in February 2007, land slips were 13 times more frequent in areas maintained in pasture than in areas (assessed as more erosion prone when in pasture) that were afforested with pines in 2001 (Quinn & Basher 2007).

Outcomes

Measured improvements (after five years) in the following key performance indicators (Dodd et al. 2008d, Quinn et al. 2009):

- Increased lamb productivity by 87% and beef productivity by 170% from new enterprises on a reduced pastoral area (285 ha down to 131 ha).

- A 40% increase in terrestrial native plant diversity on an area basis within fenced and pest controlled forest remnants, which have been increased in area from 5 to 12 ha by native tree planting.

- Mean annual sediment export reduced by 76%.

- Mean annual phosphorus export reduced by 62%.

- Mean annual stream temperature differential (forested vs. pastoral) declined from 6.7 to 3.8 ºC.

- Increase in the macro-invertebrate community index (MCI) and change in composition in post-ICM streams towards conditions in forest streams.
- Afforestation (mostly with pine) of 62% of the catchment reduced annual water yield relative to an adjacent native forest catchment by 6%/year over the first six years.
- Habitat and biota responded to riparian restoration more rapidly in smaller than larger streams.
- The research has contributed to policy development by Environment Waikato (Hill & Blair 2005) and was featured in the Parliamentary Commissioner for the Environment's (2004) "Growing for Good" report.

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APPENDIX:

List of common and botanical names of plants mentioned in the text.

Common or Maori name	Botanical name
Akeake	*Dodonaea viscosa*
Aruhe (fern root)	*Pteridium esculentum*
Beech	*Nothofagus* spp.
Black beech	*Nothofagus* var. *solandri*
Black maire	*Nestegis cunninghamii*
Blackberry	*Rubus fruticosus*
Bracken	*Pteridium esculentum*
Broadleaf	*Griselinia littoralis*
Broom	*Cytisus scoparius*
Cabbage tree	*Cordyline australis*
Contorta pine	*Pinus contorta*
Corokia	*Corokia buddleioides*
Cypress	*Cuppressus* spp.
Douglas-fir	*Pseudotsuga menziesii*
Eucalypts	*Eucalyptus* spp.
Five finger	*Pseudopanax arboreus*
Flax	*Phormium tenax*
Fuchsia	*Fuchsia excorticata*
Gorse	*Ulex europaeus*
Halls totara	*Podocarpus hallii*
Harakeke	*Phormium tenax*
Hen and chicken fern	*Asplenium bulbiferum*
Hinau	*Elaeocarpus dentatus*
Hoop pine	*Araucaria cunninghamii*
Kahikatea	*Dacrycarpus dacrydioides*
Kanuka	*Kunzea ericoides*
Karaka	*Corynocarpus laevigatus*
Karamu	*Coprosma robusta*
Kauri	*Agathis australis*
Kawakawa	*Macropiper excelsum*
Kikuyu	*Pennisetum clandestinum*
King fern (para)	*Marattia salicina*
Kohekohe	*Dysoxylum spectabile*
Kohuhu	*Pittosporum tenuifolium*
Koromiko	*Hebe* spp.
Kowhai	*Sophora* spp.
Kumara	*Ipomoea batatus*
Lancewood	*Pseudopanax crassifolius*
Lemonwood	*Pittosporum eugenioides*
Lucerne	*Medicago sativa*
Macrocarpa	*Cupressus macrocarpa*
Mahoe	*Melicytus ramiflorus*
Mangeao	*Litsea calicaris*

Common or Maori name	Botanical name
Manuka	*Leptospermum scoparium*
Mapou	*Myrsine australis*
Marble leaf	*Carpodetus serratus*
Matai	*Prumnopitys taxifolia*
Mingimingi	*Coprosma propinqua*
Miro	*Prumnopitys ferruginea*
Monoao	*Monoao colensoi*
Mountain beech	*Nothofagus solandri* var. *cliffortioides*
Mountain ribbonwood	*Plagianthus regius*
Narrow-leaved lacebark	*Hoheria angustifolia*
Ngaio	*Myoporum laetum*
Northern rata	*Metrosideros robusta*
Para	*Marattia salicina*
Pikopiko (fern shoots)	*Asplenium bulbiferum*
Pohutukawa	*Metrosideros excelsa*
Puka	*Griselinia lucida*
Puriri	*Vitex lucens*
Radiata pine	*Pinus radiata*
Ramarama	*Lophomyrtus bullata*
Rangiora	*Brachyglottis repanda*
Rata	*Metrosideros* spp.
Red beech	*Nothofagus fusca*
Red matipo	*Myrsine australis*
Redwood	*Sequoia sempervirens*
Rewarewa	*Knightia excelsa*
Rimu	*Dacrydium cupressinum*
Silver beech	*Nothofagus menziesii*
Silver fern	*Cyathea dealbata*
Southern rata	*Metrosideros umbellata*
Supplejack	*Ripogonum scandens*
Tanekaha	*Phyllocladus trichomanoides*
Taraire	*Beilschmiedia tarairi*
Tarata	*Pittosporum eugenioides*
Tawa	*Beilschmiedia tawa*
Tawhara	*Freycinetia banksii*
Ti kouka	*Cordyline australis*
Titoki	*Alectryon excelsus* subsp. *excelsus*
Toetoe	*Cortaderia richardii; C. fulvida*
Totara	*Podocarpus totara*
Tree Lucerne (tagasaste)	*Chamaecytisus palmensis*
Whau	*Entelea arborescens*
Whauwhaupaku	*Pseudopanax arboreus*
Wheki	*Dicksonia squarrosa*
Wineberry	*Aristotelia serrata*