# NEW ZEALAND FORESTRY
## SCIENCE AND INNOVATION PLAN

FOREST OWNERS ASSOCIATION

**Research and development to increase the profitability of the New Zealand forest growing sector**

**June 2011**

# Table of Contents

# Foreword

This Innovation Plan concerns the forest growing sector and its focus on excelling in the management of plantation forests to deliver logs and other woody biomass to the downstream processing sectors of the forest industry. The NZ Forestry Science and Innovation Plan has defined goals that will lead to significant increases in forest productivity of consistent good quality solid wood even without expanding the area under trees. Consequently the sector will be more profitable and environmentally sustainable. This will create opportunities for investment in high-tech sawmilling for domestic and export markets. Although solid wood is the main economic driver of the sector, complimentary industries such as pulp, energy, and panel production will utilise the residues from sawmilling and harvesting operations. New Zealanders will benefit from the range of employment and business opportunities that the sector will generate along with the environmental and recreational services that well-managed forests provide.

The big opportunity for the sector and New Zealand is to lift the game in forestry science so that leading-edge research is initiated and step-change technologies are developed and implemented.

*David Rhodes*

*Chief Executive*

NZ FORESTRY SCIENCE AND INNOVATION PLAN

# Executive Summary

*No one knows better than us how to grow trees and our leadership will be important to the early realisation of the full potential of forestry*

Plantation forestry currently contributes around 3% of New Zealand's GDP, is the country's third largest export earner, and has a projected potential harvest increase of almost 70% by 2025. It offers sustainable wood production with the additional benefits of clean water, erosion control, recreation, enhanced biodiversity (compared to other productive land uses), and carbon capture in trees. Wood-based construction materials offer significant "carbon" and environmental benefits over other construction materials such as steel and concrete.

The forestry sector has a vision to significantly improve profitability by doubling productivity on a per hectare basis while also improving wood quality and increasing tree resistance to pests and diseases, particularly those not yet present in New Zealand. The forestry sector is aligned with the wood processing sector insofar as growers want to produce a consistent and superior raw material at the lowest possible delivered cost to the solid wood processors so as to enhance that sector's processing efficiency and profitability.

Enhanced high quality research effort is required to achieve this vision. In particular focussed research is required in the following priority areas:

1. Increased stand productivity – better wood, faster growth.

- Priority research that will lead to enhanced foliar disease resistance while also increasing productivity across rotations and not negatively impacting wood quality.

2. Management and logistics – doing things smarter and cheaper.

- Priority research to reduce harvesting costs etc.

3. Energy, waste, non-wood products and environmental impact – new revenue streams and licence to operate.

- Priority research to reduce chemical usage in the production of plantation forests – especially reduced herbicide application.

Knowledge transfer is a priority for all aspects of forestry research but in some areas it has been better addressed than others. For example, in recent years the sector has focused considerable effort understanding the impacts of silviculture on wood quality and now the opportunity is to transfer the knowledge gained into practice. There is an urgent need for knowledge transfer from current and previous environmental research that demonstrates the sustainable nature of well-managed forests.

As a consequence of new technologies, and particularly with the proliferation of the internet into all aspects of business and society in general, it is possible to transfer technology and knowledge much more rapidly and thoroughly than it has been in the past. The government's move away from competitive bidding will also make it possible for researchers to spend more time with industry "getting the message across". This is a very important opportunity that needs to be embraced and implemented as a priority.

Essentially, the forest growing sector requires both step-change technology that will enable much greater gains in productivity and profitability, but also incremental research and technology transfer that will help to realise some of the immediate productivity gains available at relatively low cost and effort. Both government and industry have a role to play in directing and funding this research and technology/knowledge transfer. Government, particularly for the public good aspects and also the higher risk programmes; industry where forest owners receive significant and direct benefit, and where research results can be implemented in a relatively short time frame.

There are several key enablers for success that need to be implemented before significant progress can be made. These include:

1. Making industry needs and CRI management more relevant to science direction.

With the introduction of competitive funding in the early 1990s, scientists were more accountable to the Foundation for Research, Science & Technology than to CRI management or the sector. The move to reverse this situation is an excellent start to CRI reform and to improve the returns from research investment to the forestry sector and NZ as a whole.

2. Increasing the quality of science in the forestry sector.

There is an urgent need to ensure that the importance of science to New Zealand's economic performance continues to extend throughout New Zealand and to influence the country's culture encouraging bright students to pursue a career in science. We must adequately reward top scientists to remain in New Zealand and to work in research that can benefit key sectors such as plantation forestry. Mediocrity should be discouraged and excellence should be rewarded.

3. Industry and research providers stepping up to the challenge.

Industry too needs to play its part; most importantly by identifying research needs and the most effective delivery mechanisms. Industry is committed to increase funding to forest growing research provided it is confident that the research proposed will deliver value. Mechanisms are in place to deliver on this partnership approach, but much greater investment in people as well as in projects is required to ensure high quality science that delivers benefit to the sector.

# The Vision for Plantation Forestry in New Zealand

## "The NZ forest growing industry will continue to be recognised as a world leader in sustainable wood fibre production to meet the needs of domestic and international markets."

**Targets for 2035:**

1. Radiata will have been developed to grow at an average MAI (mean annual increment) of 40 ($m^3$/ha/yr) (stands currently being harvested average 20 MAI; current crop planting, with improved genetics and silviculture will be 30 MAI at harvest; improved genetics and disease resistance will provide up to 40 MAI) with higher density (average increase of 100 kg/m3) that is consistent between pith and bark and can meet structural grade MGP 10 (Machine Graded Pine) and above. This target is for trees planted from 2035 onwards.
2. Radiata will be more resistant to pathogens and insects, as a consequence of breeding, the use of beneficial organisms, and also genetic engineering.
3. It will also be resistant to the more environmentally acceptable herbicides, thus reducing establishment costs and reducing environmental impact.
4. As a consequence of government investment, contingency species will be readily available for planting in the event of a radiata pine catastrophe. Alternative species will also be available for growers to provide a choice in species to target niche markets and specific site characteristics.
5. Forest land ownership structure will be varied from small private growers, large Maori owners, timber investment management organisations, and fully vertically integrated enterprises.
6. The area in plantation forest will have increased from 7% to 10% of the New Zealand land area (i.e., by 700,000 hectares) to meet the increasing demand for wood from Asian countries, to provide wood as a substitute for carbon-negative building materials such as steel and concrete, and to meet demand for carbon offset markets.
7. Forest plantings will also have increased to meet local government, and increasing public demand to reduce sediment output and improve water quality from currently eroding steep pastoral land.
8. The sustainable annual plantation harvest will be in the order of 40M m3 rising to 50M m3 as the faster growing improved crops come on stream. The prime use of the forest will be solid wood with a large exporting business to Australia and Asian countries.
9. Logs will be sold into NZ sawmills and plymills on the basis of return to log determined at the headrig / lathe using sensors that detect wood properties and sawn lumber / veneer value.
10. The forest growing and log processing industries will have optimised the value chain to domestic and export markets. Consistent quality logs, world class logistics, and sawing technology will comprise an efficient supply chain where price competitive products deliver world class margins to the NZ participants in the supply chain.
11. Residue industries, utilising technology developed by major oil and motor vehicle industries, will provide support for the solid wood processing industries.

See later for Strategic Research Objectives to address these targets.: (From the Woodco Statement on RS&T for the Forest Industry – July 2010).

# The Forestry Sector Defined

The forest industry includes two major subsectors: the forestry subsector and the wood processing and forest products subsector. Forestry is about growing and protecting forests, harvesting, and transporting logs to market. It starts with genetics and generally ends at the mill yard or the export wharf. The wood processing and forest products subsector generally starts with the log and includes a wide range of industries from sawmilling, pulp and paper, chemical extractives, through to energy etc.

The plantation forestry sector is generally regarded by local government as being the most sustainable productive land use for New Zealand hill country (e.g. Horizons Regional Council Proposed One Plan [1]). Provided it is prudently managed, plantation forestry is recommended in council plans for protecting water quality because of its general ability to reduce soil erosion and reduce nutrient inputs to groundwater and surface waters (e.g. Lake Taupo [2]), compared to other productive land uses such as pastoral agriculture. It is also superior to other productive land uses for providing biodiversity values (e.g., birds, frogs, bats, fish), recreation, and hunting.

1. http://www.horizons.govt.nz/assets/one-plan-august-2010/HRC_OP_Vol4_Chapter5.pdf
2. http://www.waikatoregion.govt.nz/Projects/Lake-Taupo/Nitrogen-management-in-the-Lake-Taupo-catchment/#nonfarming

*New Zealand's main competitive advantage in international forestry lies in the efficient production of solid wood from softwood plantations, primarily radiata pine*

# Current Situation – NZ Forestry in the World

New Zealand's main competitive advantage in international forestry lies in the efficient production of solid wood from softwood plantations, primarily radiata pine and to a lesser extent Douglas-fir. Everything else, including all other product types, all other species, carbon markets, ecosystem services etc, is of secondary importance to the main purpose for NZ plantation forests – which is to make a profit. The carbon market is an emerging one.

The main areas for industrial softwood in the world are the Northern Hemisphere; Russia, Europe, and North America. These forests are either natural forests being exploited or managed natural species. The productivity of most of these forests is lower than current NZ radiata pine forests by a factor of five. However, the wood quality from these older, natural forests is generally better than NZ radiata pine, particularly for structural uses, and the main products are solid wood. Other products, such as pulp, MDF, and bioenergy, are generally subsidised by the solid wood industry and are only practical if produced from residues.

The economic return from natural, or semi-natural northern hemisphere forests is less than radiata pine on average as the cost of forest replacement is rarely covered. In more populated areas the forests are under increasing quasi-environmental constraints that increase production costs, but in some cases are government-subsidised. The ownership of these forests either belongs to the state, institutions, or private co-operatives. There has been a general move away from vertically integrated forest businesses, as processing companies have unlocked the large amounts of capital invested in their forests.

The expectation is that energy costs will rise and there will be increased regulation of and costs attached to environmental pollution. Wood is well placed to position itself as a building material of choice in this new operating environment.

# The NZ Forestry Sector Potential

*The (government's) export target requires New Zealand to nearly treble the value of our exports, from $60 billion to nearer $160 billion over 15 years. New Zealand cannot rely on business as usual to reach these goals. We need a step change in our performance. That is the basis of the government's Economic Growth Agenda. (From New Zealand's Economic Growth Agenda)*

New Zealand plantation forestry is a world leader in sustainable wood production primarily as a consequence of the implementation of several decades of government and industry-funded research. Over the last 20 years the country has moved away from a reliance on its rich natural forest resource to virtually 100% production from the exotic estate. However, the transition has not been straightforward as several challenges have had to be overcome to realise the large resource of valuable forest that exists today and to develop the large and varied markets for the wood and fibre.

While plantation forestry and the accompanying processing and utilisation industries are success stories that we can be proud of, there are many new research challenges and opportunities to protect the existing resource, maintain and develop new products and markets, and remain internationally competitive.

## 1. Why invest in forest growing and protection research

The forest industry provides a significant opportunity to meet the government's export targets to treble the value of the country's exports over 15 years. It can do this both by growing and harvesting more and better wood more efficiently, and also by adding value to the processed product.

### Markets want our wood and demand is growing!

Just looking at three markets, China, Japan and India, there are large opportunities for New Zealand wood – both as logs and lumber. China's wood fibre demand is predicted to increase to > 450 M m3 by 2020, and Japan is facing a very large demand for wood to rebuild after their recent devastating earthquake. New Zealand is already a significant supplier of wood to China (Figure 1) and this is expected to increase. India's economy is also expanding rapidly and demand for wood is increasing.

### Large and early returns on investment

New Zealand has 1.8 million ha of plantation forests already in the ground, of which 90% is radiata pine and approximately 45,000 ha of this is harvested and replanted every year.

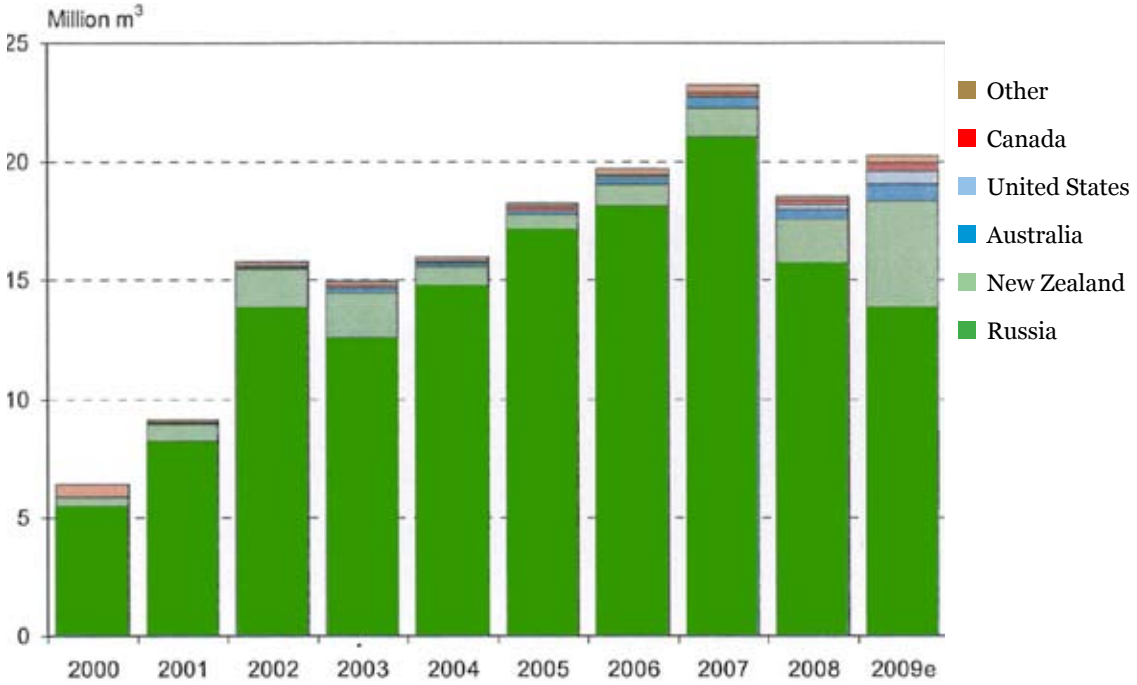



Figure 1. China's softwood log imports (Poyry 2010 [3])

[3] Poyry 2008 Sino-Forest Corporation www.sinoforest.com/pdf/filings/Poyry-Sino-Forest_Valuation Report_2009.pdf

**A 5 m³/ha/yr increase in productivity across the 1.6 million ha radiata pine estate would lead to an increase in production of 8.1 million m³/yr, leading to a potential $1 billion/yr increase in export revenue. Graham West, Scion, pers comm, Future Forests Research Productivity Workshop March 2011.**

The opportunity for industry and New Zealand is to increase the profitability of forestry and to provide flow on economic benefits to New Zealand. This can be achieved by improving the net value of the harvested trees, enhancing the production (and quality where possible) of the trees in the ground, and establishing new forests that are faster growing, higher quality and more disease resistant.

Many industry leaders consider a 5 m3/ha/yr increase in productivity over the next 10 to 15 years as a very conservative estimate of what can be achieved by applying existing knowledge more effectively through greater technology and knowledge transfer. An additional 5 m3/ha/yr (total = 10) can be gained by applying advanced genetics and by reducing losses by pathogens, although much greater effort and close partnerships with researchers are required to achieve this goal (pers comm. David Balfour, CEO Timberlands).

## 2. Industry Profile

Plantation forestry occupies 7% of New Zealand's land area, contributes around 3% of New Zealand's GDP and together with wood processing, employs 21,000 workers directly and many more indirectly. At ~ $4.0 billion pa forestry is New Zealand's third largest export earner and has a projected potential harvest increase of almost 70% by 2025 (Figure 2). This will make forestry a $6 billion industry.

**NZ Forestry Industry Characteristics**

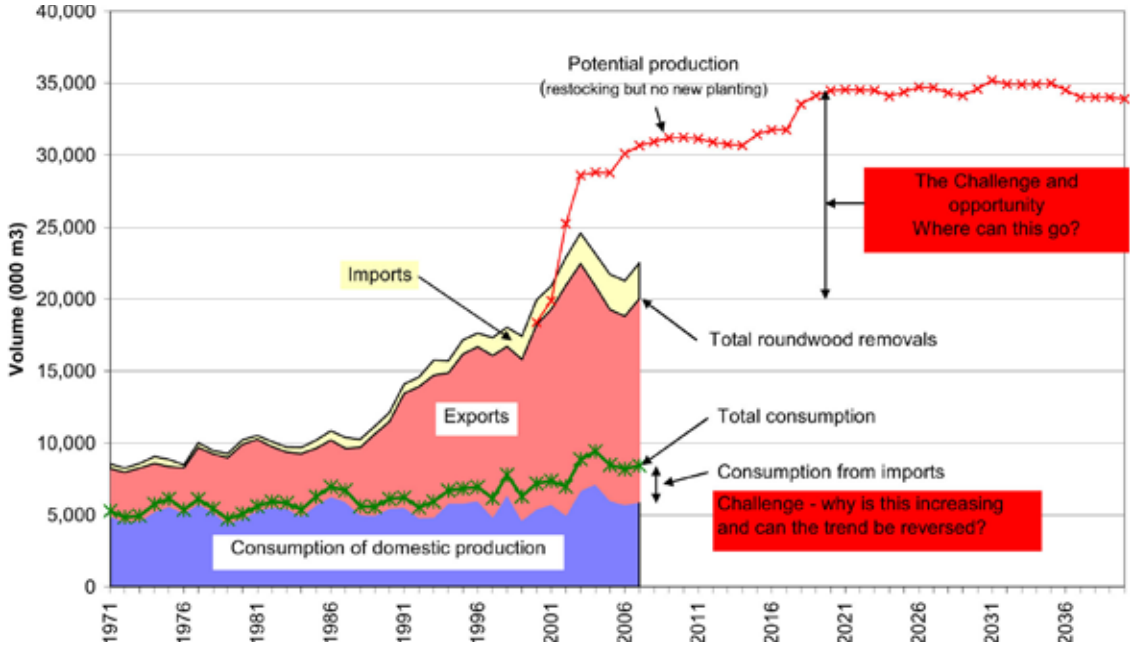



Figure 2. Plantation forestry potential production from the existing estate. (Forestry Briefing Paper 2008 [4] ))

It is this projected harvest increase that offers one of the best economic opportunities for New Zealand in the next 10 to 15 years. Research offers the opportunity to help deliver on this potential by reducing costs, increasing return, and protecting the forests from biotic and abiotic agents.

[4] Forests And Forestry An Essential Ingredient Of New Zealand's Economy, Society, Environmental Briefing Paper To The Incoming Government November 2008 Prepared for the NZ Govt by the NZ Institute of Forestry and available at www.nzif.org.nz under "submissions"

*New Zealand's competitive advantage with radiata pine and other fast-growing plantation species, has been and will continue for the foreseeable future to be in our ability to cost-effectively produce logs and solid wood for high value/high volume applications. That is where the bulk of the Science and Innovation funding should be directed in the future. That is where the forest owners and sawmillers want to see the effort put in. Research into pulp and paper, reconstituted wood materials, bioenergy and other residue-utilising products should be a lesser focus, primarily aimed at building on and adapting overseas learnings to radiata pine. Peter Clark, CEO, PF Olsen Limited."*

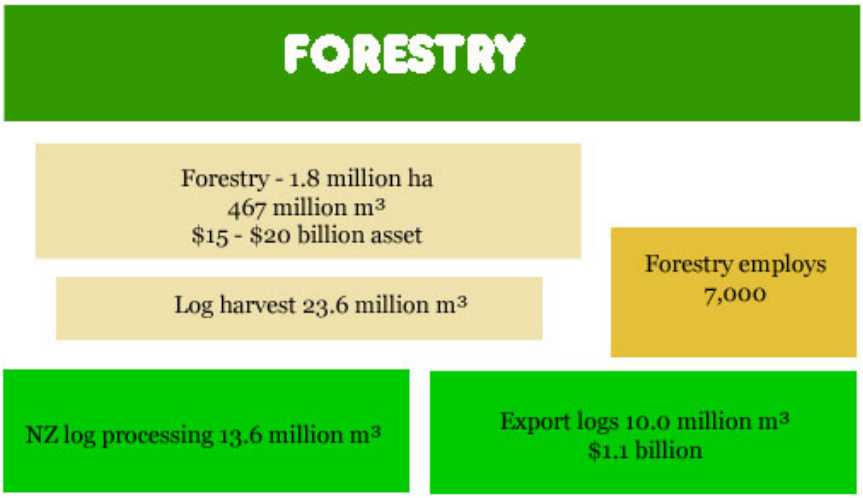
Of the 1.8 million ha of plantation forests, 38% is privately owned in small estates (less than 10,000 ha) and there is a significant component of Maori owned forest and land. (www.nzfoa.org.nz/images/stories/pdfs/fand-f2011web.pdf)

The industry is characterised by a complex and interdependent supply chain. As with pastoral farming, major assets are located either "inside the forest gate" (forestry) or "outside the forest gate" (processing). However, the 10 million m3 of export logs that leave the forest are still very much of the "forestry" component of the supply chain until they reach processing plants overseas.

Forestry has only recently become reasonably profitable, mainly because of increasing Chinese demand, but the fundamentals of the industry remain on a knife edge in terms of international competitiveness. Costs are high and productivity is relatively low compared to many competing countries. In recent years large tracts of NZ plantation forest have been converted to dairy pasture. The acceleration in conversion to dairy was exacerbated by poor government policy i.e., target date for pre-1990 forest cutoff for ETS. Investment in new land planting has been absent or very low for the last six years and New Zealand faces many challenges to reverse this trend and provide productive and environmentally sound uses for large tracts of "marginal" land.

The main opportunities facing New Zealand forestry in the next 10 years include:

1. Increasing profitability from existing forests, for example by reducing harvesting costs and increasing margins by producing and segregating higher quality wood.
2. Profiting (in terms of revenue, tax take, and employment) from the large increase in harvest volume expected in the near future as more forests mature.
3. Increasing productivity, while increasing wood quality, from re-established (and new) forests.
4. Protecting forests, and also trade, from biosecurity threats.
5. Reducing costs to achieve competitiveness against foreign suppliers, often producing wood at much lower costs and closer to key markets. There is an opporunity for NZ wood to get into higher value markets.
6. Demonstrating sustainability to international markets, and gaining recognition from government and the public of the major social and environmental benefits that plantation forests produce, including recreation, soil stability, clean water, enhanced biodiversity , and carbon storage – especially relative to other land uses.
7. Managing carbon credits and liabilities.
8. Promoting the increased use of wood relative to competing products, especially in higher value end uses.



# The Contribution of Research to Achieving the Potential


*Figure 3. Breakdown of current forest growing research. (The SWI figure is for research related directly to forest growing only).*

**Industry Investment in RS&T in Forestry**

Government and industry together contribute approximately $21M/year to forest growing science (Figure 3). Of this approximately 14% is industry funded. This doesn't include the considerable Arborgen funding that leverages the Scion molecular biology programme.

Industry also funds in-house research, although the level of funding is confidential and the results are generally not made available to the wider industry. This is mainly operational research, but it does add considerable knowledge and benefit to the investor.

Industry in particular funds those research programes where it expects to get the greatest return on its investment. The Solid Wood Innovation (SWI) (which was previously the Wood Quality Initiative), the Structural Timber Innovation Company (STIC) research consortia, the Radiata Pine Breeding Company (RPBC) and the Innovative Harvesting PGP are all 50/50 funded between industry and government (MSI or MAF). Components of SWI and STIC have direct relevance to forestry (e.g., log segregation technology) and benefit the forest growers by potentially raising the value of the end products. Similarly, the RPBC benefits the wood processors and product manufacturers in the longer-term by producing logs with preferred properties such as stiffer and more stable wood.

Most of the programmes funded by PGSF through Future Forests Research (FFR) have a higher ratio of government to industry funding due to the higher component of longer term more riskier research and the benefit these programmes also provide to smaller forest growers and the wider community.

Forest biosecurity research receives considerable direct ($350K/yr plus) and indirect ($1M/yr for Forest Health Surveillance, diagnostics, and database) financial support from the forestry sector. Additional to this, and not shown in Figure 3, is the recently approved Primary Growth Partnership research programme to find a replacement for methyl bromide for export log treatment (and other applications). This programme is managed by STIMBR (Stakeholders in Methyl Bromide Reduction) and is funded to $2.5M over 5 years on a 50/50 split between industry and government.

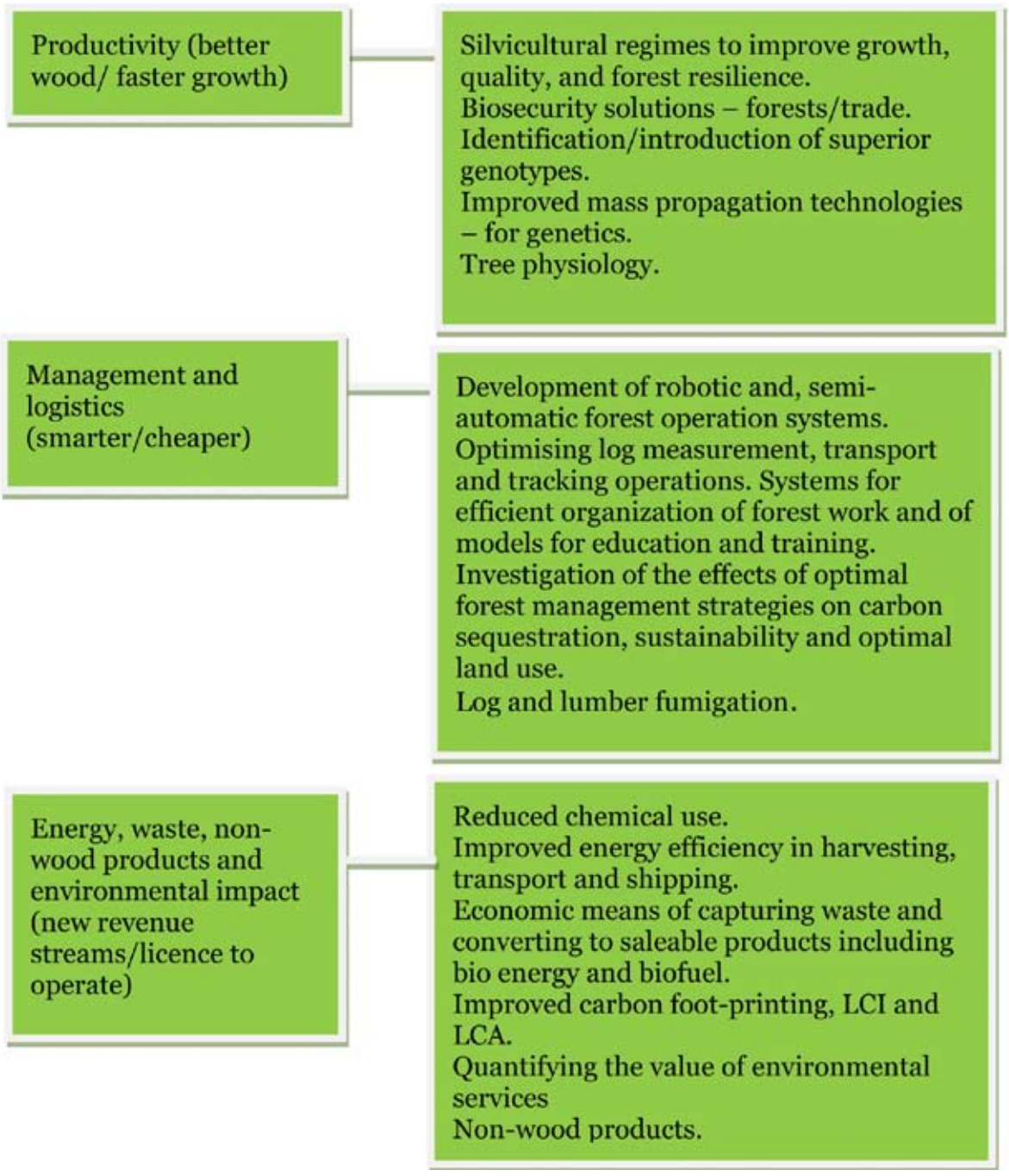
Also not specifically shown is the well-supported Fire Research programme, which includes stakeholders outside of the forestry sector and to which FOA contributes $60,000 per year.

# The Research Plan

From the Woodco Statement on RS & T for the Forest Industry - July 2010

The following research plan is designed to show the growth opportunities for the forestry sector and how these can be delivered. The focus is mainly "inside the forest gate" but extends to the supply chain from forest to mill and to the export destination. It also covers aspects of forest bioenergy, mainly considering supply chain logistics.

The Strategic Objectives that follow are in priority order of importance, and within each Objective priorities are also identified.




woodco
WOOD COUNCIL OF NZ INC

# Forestry Research

| Market Size | | |
|---|---|---|
| Log production<br>23.6 million $m^3$ | Export<br>10 million $m^3$ | NZ processing<br>13.6 million $m^3$ |

**Strategic Objective - Productivity**

**Productivity (better wood / faster growth)**

**Rationale:**

New Zealand radiata pine plantations are producing at sub-optimum levels of productivity and wood quality for a variety of reasons including: (a) not realising the full potential of improved genetics across all sites; (b) inability to match genotypes to specific site types; (c) sub-optimum management of soils, weeds and nutrition, and mammalian pests; (d) substantial (up to $200M/yr) productivity losses due to pathogens and insects; (e) periodic losses from wind and fire; and (f) in general, sub-optimal silvicultural regimes to optimise growth and quality and also carbon maximisation. The reasons for this include gaps in knowledge and technology transfer, but also a need for research to address key issues.

There are similar issues for Douglas-fir and other plantation species. In the case of Douglas-fir, productivity gains that have been made in genetics have been negated by the impacts of Swiss needlecast disease.

**Supporting research projects:**

**Silvicultural regimes to improve growth, quality, and forest resilience.**
**Biosecurity solutions – forests/trade.**
**Identification/introduction of superior genotypes.**
**Improved mass propagation technologies – for genetics.**
**Tree physiology.**

# Opportunities/Benefit/Examples

### Silvicultural regime opportunities

Comparing the National Exotic Forest Description to research trials and model predictions, the radiata pine estate is producing on average at 5.9 m3/ha/year below what it should be (Graham West, Scion, pers comm, FFR Productivity Workshop March 2011). The need is for forest managers and researchers to understand, basically at a site level, why productivity is sub-optimal and for them to apply research and existing knowledge to address the problems. For example, in the hypothetical case below, there is an opportunity at many intervention points to optimise productivity. The fundamental question comes down to knowledge being available to transfer and the cost of implementing the knowledge versus the value of the benefit gained.

In many cases it is very applied research that is required to realise the opportunities facing forest managers. A great deal is known from research trials but is not always applied, primarily because information is either not available or not adequately communicated to the level that budget and management decisions are made.

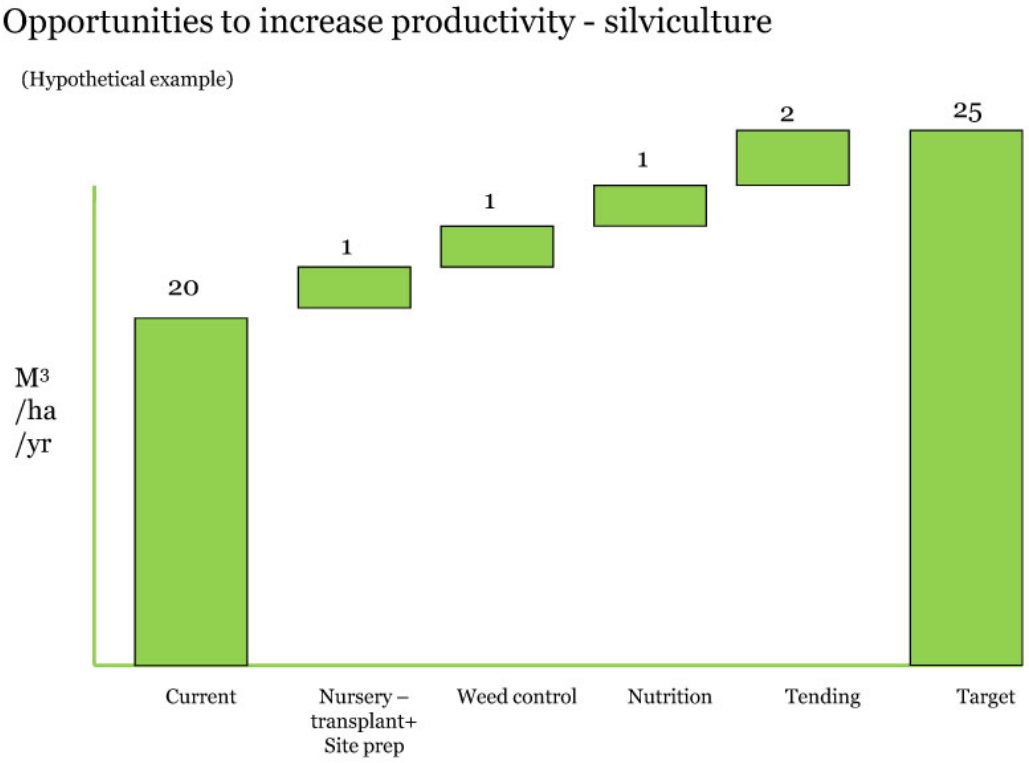
However, there are also step-change opportunities to increase productivity that need to be researched, developed, and implemented. These include opportunities to short-circuit the breeding cycle and opportunities to introduce new technologies, such as the application of endophytes and genetic engineering.

### Biosecurity Research Opportunities

The FOA Forest Biosecurity Committee has recently launched a new Forest Biosecurity Research Strategy. While recognising the need to maintain capability to respond to new pest incursions, the strategy identifies two key research priorities:

1. Solutions to foliar diseases of radiata pine – both existing diseases but also ones currently offshore
2. Alternatives to methyl bromide log fumigation. This priority is being covered in a Primary Growth Partnership project.

The current impact of pests and pathogens on the productivity of New Zealand forests is estimated to be in the order of $200M/year, although it is recognised that a precise figure is



difficult to determine. In addition, insects and fungi increase the cost of log exports, primarily as a consequence of the need to fumigate. Contingency planning is required and research should investigate the usefulness of debarking as a potential solution if required.

Scion recently published a worst-case scenario on the potential downside of an exotic pathogen impacting forest health and also the log trade.

> If China, Japan, and South Korea banned imports of New Zealand logs altogether, and the pest continued to spread at historical rates, the present value of New Zealand growers' revenues would decrease by US$8,200 million. Turner et al. 2007 [6]

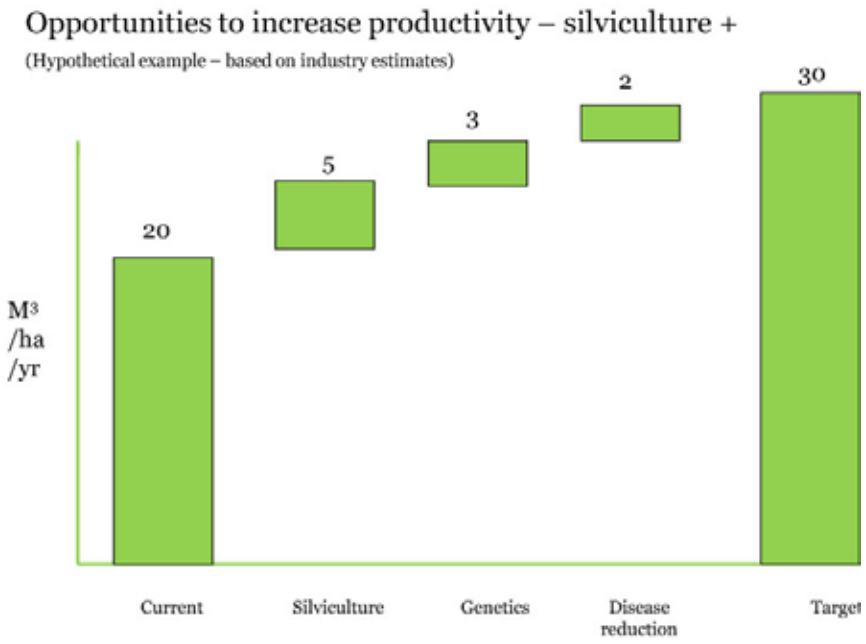
The Forest Biosecurity Committee recently (15 February 2011) ran a workshop on "Foliar Disease Research Ideas" and is currently progressing specific high priority projects. In particular there is a strong interest in researching the use of beneficial organisms, including endophytes, to investigate the opportunity to induce resistance at stand establishment. There is also strong interest to test new chemicals for effectiveness against existing pathogens, and also pathogens not currently present in New Zealand.

> "Endophytes have been the single biggest success in increasing pasture productivity" Bruce Thorrold, DairyNZ Strategy and Investment Leader for Productivity – presentation to Future Forests Research Workshop 8 March 2011.

As well as offering promise for disease resistance, endophyte technology has also been very successful for improving pasture productivity in New Zealand.

There is a need for much greater understanding of the mechanisms that confer disease resistance in radiata pine and other species. There are existing opportunities to study this that have not been fully exploited, e.g., radiata germplasm with contrasting levels of resistance to Dothistroma and Cyclaneusma (and other disorders); field plantings showing strong genetic differences to needle cast; disease-free radiata pine in areas of the country that have all the factors that should cause disease, but don't; and age-related disease symptoms, apparently triggered by physiological changes in radiata pine.

Industry is also seeking cost reductions and improved working conditions in silvicultural operations and ideally would like to see cost-effective mechanised pruning equipment developed.




[6] Turner et al 2007. New Zealand Journal of Forestry Science 37(3): 383–411 (2007)

### Radiata Pine Breeding Opportunities

Tree breeding is a slow but proven process to deliver gains to plantation forestry. The specific goals of the Radiata Pine Breeding Company are by 2025 to (J Butcher, RPBC pers comm):

1. Achieve wood volume gains of 10%.
2. Achieve higher wood density by 10 kg/$m^3$.
3. Produce stiffer trees - >70% parents with juvenile wood stiffness above the threshhold of 7Gpa.

RPBC aims to deliver improved germplasm with these gains by 2025. There will be partial gains towards these targets from new introductions in 2017.

The RPBC estimates that the expected benefits to arise from this programme are:

**Future Value** – additional $160M/yr at harvest each year for 20 years.

**Present Value**

- $19M from genetic improvement;
- $57M from faster deployment;
- $14M from site matching;
- $10M from reduced losses from disease.

Opportunities include clonal forestry and faster propagation and delivery technologies.

RPBC is currently working on the development of a Decision Support System Genotype Selection Tool to match genotypes with sites to optimise performance against profitability and market matching.

(with regard to wood quality) "Our new idea is to treat trees like an agricultural crop. If a tree is a loser at age 1-2 the chances are that it will be a loser for life; if it is a winner at age 1-2 it will be a winner for life." John Walker, University of Canterbury, March 2011.

There is a great deal more research effort that could be undertaken into tree breeding including research into improving stability and durability. Additionally, there is a need for more rapid early selection. The University of Canterbury is conducting research in this area and metabolomics has also shown promise where it has been tested overseas. However, recommendations of specific research projects is beyond the scope of this document.

"Rejuvenation" continues to offer promise to short-circuit traditional breeding programmes, but the success to date indicates this is a very high risk programme that should be approached with caution. However there is ongoing research in this area both in New Zealand and overseas that the industry needs to be cognisant of.

### Understanding Tree Physiology to Produce Better Wood

There has been a distinct lack of effort in tree phsyiology research since funding to this area was cut in the early 1980s. Our understanding of how trees grow, how management practices and environmental conditions affect wood properties at the fundamental level, and basically our lack of knowledge as to what can be done to grow straighter, stronger, "resin-free" and more stable wood is holding the industry back. The advantages of reducing the variability in plantation grown radiata pine are enormous and tree physiology research is a key element. The Wood Quality Initiative was established in 2003 and went some way to tackling these issues (but has since moved firmly into the processing space). Unfortunately there is a general lack of science capability in this area and many questions remain unanswered.

### Genetic Modifcation for Future Forests

Research into genetic modfication or genetic engineering has been met with considerable resistance in New Zealand and elsewhere because of the perceived risk associated with transgenic organisms. The FOA's position is that research should be encouraged, including field trials, but deployment should not be considered until there is enough confidence to allow it to proceed safely.

**"Breeding for plant traits based purely on genetic markers can be unreliable due to the GxE effect, and metabolic markers should perform better because they are more proximal to phenotype (arguably, metabolite profiles are molecular phenotype) and account for post-genetic processes and environmental factors. Therefore, metabolite profiles may be a source of accurate markers for traits of interest to the forestry industry." Andrew Robinson, NZ Metabolomics Scientist**

*Priority research areas to include projects that will lead to enhanced foliar disease resistance*

There are several compelling examples of where genetically modified trees may hold considerable promise for plantation forestry in New Zealand, including:

- Enhanced resistance against pathogens and insects, which are becoming an increasing problem internationally as the movement of goods and people rapidly rises. New Zealand native and exotic tree species are under increasing threat from the arrival of new organisms, and this has recently been highlighted by the accidental introduction of myrtle rust into Australia;
- increased productivity – and basically far greater production on a per hectare basis providing greater profitability from wood production but also carbon storage;
- improved wood properties, such as increased wood density;
- reduced herbicide application;
- eliminating wilding tree spread.

We encourage the government to support the development of new molecular technologies, including the application of "intragenics", which would get around some of the concerns associated with genetic engineering. Sterility should be a research target (to avoid potential wilding tree spread) and, in particular we believe that work should proceed to research potential solutions to biosecurity threats, especially some of the needle disease pathogens not currently in NZ.

### Priority Research

The priority research areas in this Strategic Objective include projects that will lead to enhanced foliar disease resistance while also increasing productivity and not negatively impacting wood quality. Projects that are ultimately funded should be those that can deliver these benefits at a reasonable cost and in a reasonable time frame.

Fundamental tree/cell physiology research should be funded if sound hypothesis can be developed and tackled by high quality research teams that are likely to deliver useful results. Because of the fundamental and relatively high risk nature of such research it would be reasonable to establish an international research consortia focused on radiata pine physiological research.

### Strategic Objective - Management and Logistics

**Management and logistics (smarter / cheaper)**

### Rationale

New Zealand is a world leader in growing plantation softwoods for solid wood, although much more can be done. However, where some more rapid gains in productivity and profitability can be made is in the area of harvesting and logistics.

There has been a hiatus in harvesting research in New Zealand for aproximately 15 years, which was to a significant extent caused by the new rules in science funding. Consequently industry has lost ground relative to competing countries; technology has not developed as fast as it could and comparative costs have increased.

Currently, forests in some parts of the country are not being harvested as the cost of harvesting plus transport exceeds the value of the crop. Furthermore, approximately 60% of the plantation estate is first rotation, which means that expensive roads will need to be constructed before logs can be extracted. This is going to become a significant issue around 2015 when many of these forests mature, and unless harvesting costs can be reduced, many forests may not be harvested.

There is an enormous variation between logs coming from a single stand. WQI and now SWI, have conducted research and developed technologies to capitalise on this variability which enables log optimisation to targeted processing plants and markets. The challenge is not just developing the technology but implementing it within the existing supply chain.

### Supporting research projects

- Development of robotic and, semi- automatic forest operation systems. Optimising log measurement, tracking and transport operations. Systems for efficient organization of forest work and of models for education and training;
- investigation of the effects of forest management strategies on carbon sequestration, sustainability and optimal land use;
- log and lumber fumigation.

# Opportunities/Benefits/ Examples

### Harvesting

With harvesting representing about 46% or $32 of the $70 per $m^3$ of a log extracted on a typical hilly site such as the East Coast, the FFR harvesting research programme will create savings of an average of $8/$m^3$ of wood produced and result in an improvement in net stumpage returns. Keith Raymond, 2010[7].

The Future Forests Research programme, Innovative Harvesting Solutions, seeks to reduce steepland harvesting costs by $8/$m^3$. This will reduce the overall cost of steepland harvesting operations by $54 million/year by 2020. Reduced harvesting costs will also have a spinoff benefit as more steepland will be planted and the area of productive plantation estate expanded, potentially doubling in size to around 3.5 million ha. Mechanisation of steepland harvesting will also save lives as workers can be removed from hazardous environments.

Improvements are also needed in the supply chain, including optimising log allocation so that logs (based on internal as well as external features) go to the most appropriate processing plant or export port and the grower is suitably rewarded. As a result of WQI research and associated technology development, log segregation technology has made considerable advances. However, there is still much more effort needed in this area to maximise returns. There is some suggestion that we need to develop a system to link log payment in NZ mills to sawn outturn as a material price variation for log quality will be a key driver of both research funding and uptake by forest owners.

More work is needed on developing a systems approach to improving harvesting productivity and FFR plans to tackle this in the near future. Other opportunities are in the logistics and transport area - log tracking, automated scaling and stock tracking, automated reading

[7] Keith Raymond 2010 – NZJ of Forestry, Nov 2010, 55(3)

of log export dockets etc. as well as the trucking area. There is also a need to ensure that NZ is extremely efficient at exporting logs and work is required to reduce costs and improve efficiency on both roads and at ports.

**More Intensive Management**

Precision Forestry – including better knowledge (mapping) of site factors and utilising this knowledge to optimise chemical and fertiliser applications; matching genotype/species; and understanding the variability of radiata pine performance.

Reducing Crop Variability – by first of all identifying what causes it and then looking for solutions to the problem. This should be approached with a genetic overlay to understand the variability caused by different seedlots, age etc. For example, a strong relationship has recently demonstrated between productivity and site, aspect, and seedlot. (P. Beets, Scion, pers comm)

Integrated Crop/Regime Modelling – FFR is doing some work in this area but more is needed, specifically to improve the ability to quantify, in both physical and financial terms, the inevitable tradeoffs that impact on decision making. For example:

- Increasing growth through either selecting germplasm to achieve that, or through fertilising, at the expense of wood density;
- increasing tree diameter growth through complete weed control, and consequently increasing tree taper and reducing wood stiffness;
- thinning to relatively low stockings to increase pruned log diameter at the expense of wood density and branch control.

**Remote Sensing**

New Zealand forestry has a good opportunity to be a fast follower in applying remote sensing technology developed elsewhere in areas such as resource definition, forest health, biosecurity, carbon sequestration and construction of roads and landings for harvesting. Professor Erik Naesset (Norwegian University of Life Sciences) recently won the Marcus Wallenberg prize for his leading edge research on the application of LiDAR as an integral part of foresty inventory (including harvesting assessment). The opportunity is to transfer this technology to New Zealand. Work is currently underway in programmes funded by FFR and also in the MfE LUCAS programme. Additionally, PF Olsen is researching use of LiDAR in conjunction with civil engineering software to better define steepland terrain and quantify earthworks for road and landing construction.

*Priority Research*

The Future Forests Research (PGP) harvesting research programme is high priority.

Log and lumber fumigation research is also high priority and is being addressed by STIMBR in its PGP methyl bromide reduction programme.

**Strategic Objectives - Energy, Waste, Non-Wood Products and Environmental Impact**

**Energy, waste, non-wood products and environmental impact.**

**(New revenue streams/ licence to operate)**

### Rationale

Forestry provides many environmental benefits to society, but most of these have not been quantified or valued. The opportunity is to demonstrate to government and the public the full value of NZ plantation forests, not only to provide revenue and employment, but also for recreation, biodiversity, clean water, soil stability and carbon sequestration.

There are also opportunities to earn revenue from non-traditional products, such as mushrooms and understory crops, such as ginseng, and energy crops - areas of research that have received relatively little attention to date in New Zealand.

There are opportunities within the industry to both become more energy efficient, but also to provide energy for self sufficiency and to other sectors and users. Bioenergy, biofuels, and other chemical streams, that have the potential to replace petrochemical sourced materials, are a part of the equation, as is providing better measures of the life cycle assessment of wood.

Market pressures, especially through Forest Stewardship Council (FSC) certification, are forcing the search for alternatives to existing chemical use and a reduction in application rates. New Zealand forestry is too small to justify the development of new chemicals but there is a need to transfer knowledge and test chemicals from other countries with similar weed issues. There are also opportunities to develop new biological control options.

Markets are also pushing NZ forestry to demonstrate sustainability, although this has been a focus of research for the last 25 years and long-term site productivity trials planted in the 80s are nearing full cycle. The opportunity is to summarise the data and report results to industry and other stakeholders.

Much of the research in this objective needs to be done to support industry's "licence to operate".

### Supporting research projects:

- Reduced chemical use;
- improved energy efficiency in harvesting, transport and shipping;
- economic means of capturing waste and converting to saleable products including bio energy and biofuels and other chemicals;
- improved carbon foot-printing, Life Cycle Inventory and Life Cycle Assessment;
- quantifying the value of environmental services;
- non-wood products;
- extension of knowledge to industry and non-industry stakeholders.

# Opportunities/Benefit/ Examples

### Reduced Chemical Use

Future Forests Research manages a research programme testing herbicides for the control of major weeds of plantation forests. Additionally, there are many herbicides used overseas that are not yet approved for use in New Zealand. The opportunity is to continue research testing the available herbicides, but also to bring in knowledge from overseas that may be applied in a New Zealand forestry situation and still meet FSC requirements.

### Bioenergy

Internationally there is a range of technologies that are already at the stage of pilot commercial development. With the demand and the technology for conversion of wood to heat energy well established the focus for NZ forestry bioenergy R&D should be in the production and supply of feedstock to energy plants. The

feedstock may come from harvest and process residues derived from the production of primary wood products such as logs, lumber and pulp wood, or from dedicated energy crops. The production of wood feedstock for bioenergy is complementary to traditional forestry operations.

The choice of species for production of alternative wood products, which includes wood energy and feedstock for a chemicals industry, may be quite different from species grown primarily for logs and lumber. Research has been undertaken previously on the range of species (including grasses) which would be suitable for growing. What is now required is the commercialization of that knowledge, supported by further R&D on management regimes and optimizing species / site choices.

**Life Cycle Assessment**

The opportunity is to build on the LCA work currently being conducted in the forestry sector and to demonstrate the sustainability and carbon benefits of forest growing and wood products versus other competing materials. The challenge is to get wood credentials accepted by certifying schemes / organizations.

**Resource Valuation**

Forests provide many societal values other than just wood products and employment including recreation, clean water, soil stabilisation, carbon sequestration, biodiversity, and non-wood products such as mushrooms etc. There is an opportunity to determine the value of non-forest products and to communicate this information to stakeholders, including government and the community. One of the drivers for this is to ensure that government understands the true values of forests and supports demands to protect these values in the case of a biosecurity incursion.

**Licence to Operate**

A key focus for the forest industry is to be able to demonstrate good stewardship while maintaining profitability. Industry requires sound, peer-reviewed research to determine management impacts on long-term site quality (sustainability) and to assess potential impacts of practices, such as herbicide spraying and steep land road construction on the environment, including water quality, biodiversity, and soil properties. A great deal is already known in this area, and there is also a large amount of unanalysed and therefore unreported data available, particularly in Scion. The opportunity is to synthesize this information, package it up into meaningful reports to industry, and have the results and conclusions peer-reviewed by scientists, and publicised via mass media. Extension of such knowledge to the public, regulators and policy makers will be critical in the face of changing expectations on rural land use by a mainly urban public.

*Priority Research*

The biggest opportunity in this Strategic Objective is in research to reduce chemical usage in the production of plantation forests – primarily reduced herbicide application. The research will be a combination of field trials and knowledge transfer from other sectors and from overseas; it will not be in the development of new chemicals. However, there are certainly opportunities to develop new biological agents to help manage weeds and also reduce the need for chemicals.

There is also an ongoing need to transfer knowledge from current and previous research that demonstrates the sustainable nature of well-managed plantation forests. Under the competitive bidding process scientists were under pressure to propose and research new projects, however, in many cases the real need is to collate and deliver on what has already been done.

**Knowledge Transfer**

As a consequence of new technologies, and particularly with the proliferation of the internet into all aspects of business and society in general, it is possible to transfer technology and knowledge much more rapidly and thoroughly than it has been in the past. The government's move away from competitive bidding will also make it possible for researchers to spend more time with industry "getting the message across". This is a very important opportunity that needs to be embraced and implemented as a priority.

# Research and Capability

New Zealand has a long history of forestry research and NZFRI has long been regarded as a world leader in plantation forestry science. However, the current science system, which has been in place since 1991, has contributed to the erosion of NZFRI's standing as a premier forest research institute. Instead, industry has turned to the establishment of other business models to provide research on priority areas, including the Radiata Pine Breeding Company and the Solid Wood Innovation (previously the Wood Quality Initiative), both research consortia. Recently industry has worked with Scion (NZFRI) to establish Future Forests Research (FFR), which has been formed by combining several industry/NZFRI research cooperatives. FFR is relatively new and is just starting to make traction across many areas.

The reduced capacity and capability in forestry and wood processing research is critical in several areas and will be a limiting factor in our capability to capture future opportunities.

The opportunity is to build high quality research capability to address the key research priorities facing the forest industry. Many of these priorities require technology and knowledge transfer, rather than hard science; whereas other areas require a step-change approach to potentially produce breakthroughs in forest growing.

Essentially, the forest growing sector requires both step-change technology that will enable much greater gains in productivity and profitability, but also incremental research and technology transfer that will help to realise some of the immediate productivity gains available at relatively low cost and effort. Both government and industry have a role to play in directing and funding this research and technology/knowledge transfer. Government, particularly for the public good aspects and also the higher risk programmes; industry where forest owners receive significant and direct benefit, and where research results can be implemented in a relatively short time frame.

# Key Enablers for Success

There are several key enablers for success that need to be implemented before significant progress can be made. These include:

1. **Making industry needs and CRI management more relevant to science direction**

The government, by following the recommendations of the 2010 Crown Research Institute Task Force report is in the process of implementing this key enabler for research by making end-users, and also CRI management, much more relevant than they have been for the last 20 years. With the introduction of competitive funding in the early 1990s, scientists were more accountable to the Foundation for Research, Science & Technology than to CRI management or the sector. The move to reverse this situation is an excellent start to CRI reform and to improve the returns from research investment to the forestry sector and New Zealand as a whole.

2. **Increasing the quality of science in the forestry sector**

The present government recognises the opportunities that science can deliver to New Zealand and this has been evident in a number of key initiatives including the appointment of the Chief Scientist who reports directly to the Prime Minister, and also evident in the CRI Task Force Review recommendations. There is an urgent need to ensure this message continues to extend throughout New Zealand and to influence the country's culture by encouraging bright students to pursue a career in science and adequately rewarding top scientists to remain in New Zealand and to work in research that can benefit key sectors such as plantation forestry. Mediocrity should be discouraged and excellence should be rewarded.

3. **Industry and research providers stepping up to the challenge**

Industry too needs to play its part; most importantly by identifying research needs and the most effective delivery mechanisms. Industry is committed to increase funding to forest growing research provided it is confident that the any research proposed will deliver value.

High quality, world class research is required to make step-change advances, but a strong partnership between industry and research providers is needed to deliver incremental, but very valuable gains. Mechanisms are in place to deliver on this partnership approach, but much greater investment in people as well as in projects is required to ensure high quality science that delivers benefit to the sector.

# NZ FORESTRY - SCIENCE AND INNOVATION PLAN

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