NEW ZEALAND FORESTRY
SCIENCE AND INNOVATION PLAN



FOREST OWNERS ASSOCIATION

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

January 2012

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FOREWORD

David Rhodes

Chief Executive

New Zealand's biological resources are its key global competitive advantage. Plantation forestry sustainably uses these resources to produce wood, energy and store carbon. Plantations designed for customer needs in the end market will provide the feedstock for a high-tech manufacturing industry based in NZ and exporting finished goods abroad. To attract this investment, produce from plantations needs to meet manufacturers' requirements e.g. consistent quality, fit for purpose, competitively priced and sustainably supplied. Scandinavia provides an example of how such forest industries survive in a high-wage economy so that once companies have invested in NZ they will stay for the long-term.

This science and innovation plan describes research to transform plantation forestry from a log production business to the starting point of a market led and automated capital-intensive manufacturing industry. The potential opportunity is for NZ to grow the forest industry by $3 billion by 2030 and to have more in common with Sweden and Finland than just conifer forests.

LINKAGE TO MARKETS

Forest owners are acutely conscious and in frequent communication with their direct log-consuming customers, be those internal or external to the firm. The log processors are in turn dealing with remanufacturers, wholesalers or consumers of wood products. The primary linkage to markets and customers occurs via the price, quality and market pathway signals that travel along this chain from consumer to forest owner. Many New Zealand forest owners have, via their parent, associated or sister companies, direct linkages to consumers and market trends and others make a point travelling to meet end users of the wood they are growing, albeit that the supply has come though processors or remanufacturers.

At the industry leader and association levels there is frequent contact and sharing of views. The co-location of FOA, WPA, FFA, NZIF and NZ Wood at the ForestWood Centre on The Terrace in Wellington is a deliberate and successful means of facilitating the sharing of ideas and positions on various topic and markets.

Despite this there remains a need for forest owners to pay attention to worldwide developments and trends that have the potential to impact on markets for forest products up to three or four decades in the future. The approach adopted in setting priorities in this Plan is that the science must focus on enhancing those wood properties that we know are desired in the highest value structural and appearance solid wood products. Such properties also work well for residue users for pulp and energy. But the industry will take care not to cut off options to change direction if market trends or niche markets start to favour some other log properties as new markets and products emerge in a world that will increasing rely on sustainable resources like forests for more and more of its basic needs.

This Plan has been endorsed by the industry leaders that process logs and remanufacture into consumer products. The Plan articulates well with the plan produced by that portion of the forest industry sector – the Wood Processing and Manufacturing – 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 NZ's GDP, is the country's third largest export earner, and has a projected potential harvest increase of almost 70% by 2025. The world demand for wood is increasing because of population growth and economic growth. At the same time, the supply of wood is decreasing due to a combination of deforestation, forest degradation, and increasing protection of natural forests. NZ is in an excellent position to capitalize on this situation with its large and maturing plantation estate. Our plantation forests offer sustainable wood production with the additional benefits of clean water, erosion control, recreation, enhanced biodiversity from the land-use it replaces, and carbon capture in trees. Wood-based construction materials also 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 NZ. 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 focused research is required in the following priority areas:

1. Improved productivity and consistency

- Research that will lead to enhanced foliar disease resistance while also increasing productivity, tree and stand consistency across rotations, and improvements in wood quality.

2. Sustainability

- Research to make rapid advances in remote sensing that will lead to lower operational costs and improved forest health and environmental monitoring.
- Research to reduce chemical usage in the production of plantation forests; especially reduced herbicide application.

3. Operational performance

- Research to reduce steep-land harvesting costs.
- Supply chain technology and costs.

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 will be substantial spin-off benefits realised from the successful implementation of results from the three priority research areas in addition to a more profitable and more competitive forest industry. In support of the government's recent initiative in High Value Manufacturing there are opportunities to both enhance harvesting and wood processing manufacturing capability in NZ and increase skilled employment along with export earnings. There will also be enhanced environmental benefits resulting from the programme as chemical use is reduced and more marginal pastoral land is converted to plantation forest.

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

1. Alignment of science effort with the strategic direction of industry.

The move to better align science with industry needs and to encourage collaboration between science providers, rather than competition, 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. Ensuring that the quality of science in the NZ forestry sector is world class.

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

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

Industry too needs to play its part; most importantly by identifying research needs, 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 NZ

"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."

Imagine 30 years from now ...

The world's population is approaching 9 billion. There is global pressure for low carbon use because of constrained energy supply, rising costs of energy and greenhouse gas emissions. Land that has access to water and the ability to grow crops for food, energy and materials is under pressure from the increasing population and there is intense pressure to raise productivity from all productive land. A changing climate is inducing more frequent and extreme weather events and forcing novel land uses that also mitigate impacts of the extreme productivity demands. The media has reported on several mass migrations by "environmental refugees" from desolate areas in developing countries and wars over access to food and water. Combined pressure on resources, sustainability, environmental footprint, and the requirement for demonstrably 'clean green' products and services, means that valuation of externalities is commonplace and plantation forestry is a competitive and welcomed land use. Plantation forests in NZ have faster growing germplasm, are better at utilising elevated carbon dioxide levels, soil nutrients, water and sunlight and are free of disease and pests ravages through genetic and biological (e.g. tailored endophyte) processes.

Production of high quality logs from indigenous tropical and boreal forests has declined to 50% of 2011 levels, despite rising demand. The world demand for solid wood products is now predominantly supplied from wood processing plants located in close proximity to large plantation forests and reliable supplies of renewable energy and water.

Remote sensing technology is so well advanced that satellites can relay forestry data on demand to provide forest owners with information on log and wood quality, tree health, and stand productivity. Nanosensors, already in development in 2011, are used extensively throughout the industry to provide readily accessible low-cost data on environmental processes occurring in the forests and growth and disease resistance processes occurring in trees. Ground-based inventories are no longer required to determine the current resource available for markets and harvest planning can be done from an office with no need to visit a forest. Recreationalists are the most common visitors to these forests.

The introduction in 2018 of payment based on log and wood quality determined at the mill yard/headrig/peeler helped lead to the establishment of larger processing plants (capable of sending the right log and the right flitch to the right production/product line). This has greatly reduced the practice of log segregation in the forest.

Research scientists have a world-leading resource of phenotypic data alongside genetic footprints that replaces experimental plots/reference trees, and gives real-time updates. They treat NZ plantations as one big model exchanging information in real time with the forest owners to support decision-making along the value chain. This has dramatically altered the way research is undertaken, reducing data collection costs and enabling very rapid technology translation. The interface between forest owners and researchers is dynamic.

Obviously, there is uncertainty in identifying options so far into the future but forestry is an industry that has always needed to have a long view – the key will be not cutting off

options, frequently testing changing needs and so future proofing the industry. This will build resilience through adaptability and agility – the "30-year harvest horizon" that constrained possibilities in 2011 is now significantly diminished.

We can confidently predict greater pressure on fossil fuel supplies and increased energy prices, thus providing wood, a truly renewable resource, a sound position in markets substituting for more energy intensive products. Additionally, increasing demand for wood from China and India alone, regardless of the intrinsic properties of the wood, justifies increasing the productivity of New Zealand plantations.

A designer forest development example: accelerated genetic selection

- Remote sensing and nanosensor technology used to identify elite germplasm from forest populations (vs. selection plots) to fit the desired designer characteristics;
- genoptyping then clonal/GE technologies used to accelerate the national breeding programme;
- forest and tree attributes clustered for the need of each forestry company; varietal forestry implemented to deliver 'fit for purpose' trees (improving processing yields) to niche market needs;
- information shared to dramatically accelerate genetic progress on a national basis but with flexibility for individual companies to manage their own specific portfolio of characteristics.

By finding the elite germplasm and creating the designer forests the remote sensing and nanosensors technology will then ensure the supply of a consistent product (no need to grade-out) and logistics management will be significantly simplified. At the same time, much smaller areas will be able to efficiently deliver to high-specification markets, which NZ doesn't currently have the scale or efficiencies to supply.

There will be significant cost savings at each step of the value chain:

- If stands of trees are developed that are exactly the same and targeted for a specific market then significant savings in planning, harvesting, logistics and processing will be gained. If core NZ production is 25 million m^3 / annum then, in today's terms, savings/benefits of up to \$10/m^3 (\$250m/annum) are realistic from designer forests of 30 years' time;
- productivity gains will further add to the benefits as either NZ core production can be increased by 50% at least or the core production could be obtained from lowest cost forests, which could save a further \$10/m^3 (\$250m/annum).

There will be changing land use for designer forests and the days of plantation forestry being pushed to cling to the low-value marginal land with its difficult (and expensive) harvesting characteristics would also be over. Designer forests will no longer have to have a 30-year rotation cycle; the varietal forests matched to market characteristics, including high value biochemicals as well as wood and fibre products, could be part of riparian planting on high value land with rotation times of perhaps 15 years . With widespread knowledge transfer to pastoral farmers and web-based decision support tools, forestry is now an integral part of paddock-by-paddock land-use optimisation.

THE FORESTRY SECTOR DEFINED

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

The forest industry includes two major subsectors: forestry and wood processing and forest products. Forestry is about growing and protecting forests, harvesting, and transporting logs to log processors. It starts with genetics and generally ends at the mill yard - be that in NZ or overseas. 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 renewable energy etc.

The plantation forestry sector is generally regarded by local government as being the most sustainable productive land use for NZ 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

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, although its potential to influence investment has already been demonstrated.

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. These forests are owned by either 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

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 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!

Within Asia, notably China, Japan and India, there are large opportunities for NZ wood – both as logs and lumber. New Zealand is already a significant supplier of wood to China (Figure 1) and this is expected to increase. China's wood fibre demand is predicted to increase to > 450 million m^3 by 2020 and despite increased domestic production will still face a deficit of about a third of that level. New Zealand's output by then could be around 35 million m^3 /annum. Japan is facing a very large demand for wood to rebuild after their recent devastating earthquake. India's economy is also expanding rapidly and demand for wood is increasing. By value exports to India have risen 450% over the last five years and the country has moved from 12th most important export destination to 5th. In addition, at some point the US housing market will return to life with significant flow on effects and our nearest market, Australia, has a sizeable latent housing demand which they are not able to meet solely from domestic production.

Large and early returns on science 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.

Expanding new forest planting is critical to offset the national carbon emissions that will arise from about 2018 with the harvesting of mid-1990s plantings.

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)

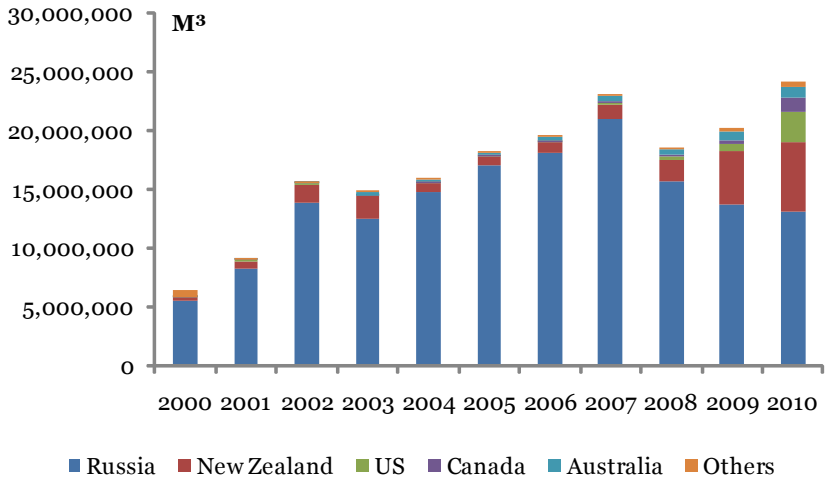


Figure 1. China Imports Coniferous Logs [3]

[3] Source China Customs / MAF

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.

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.

The opportunity for industry and NZ is to increase the profitability of forestry and to provide significant flow of economic benefits to NZ. 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 NZ'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 NZ'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.

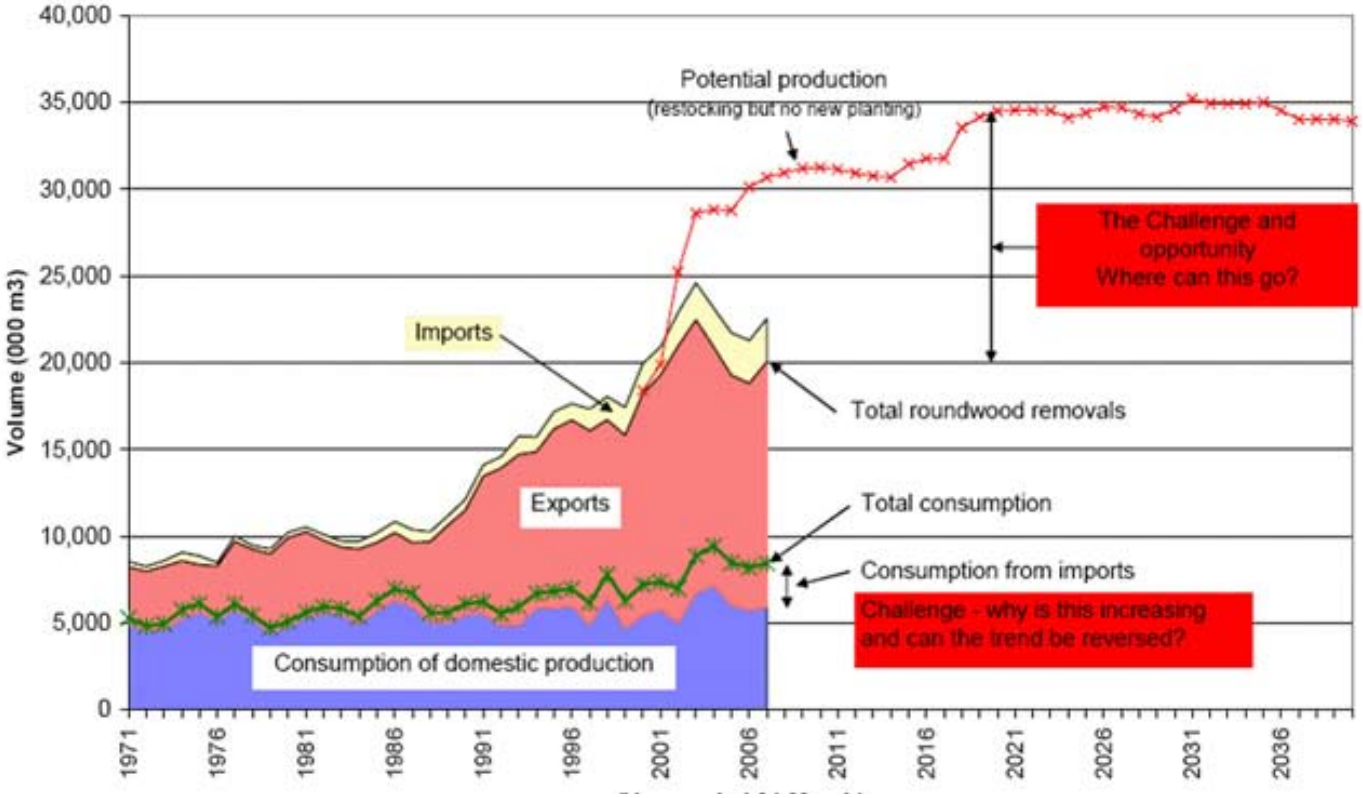


Figure 2. Plantation forestry potential production from the existing estate. (Forestry Briefing Paper 2008 [4]))

[4] Forests And Forestry An Essential Ingredient Of New Zealand's Economy and 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"

MARKET DRIVERS

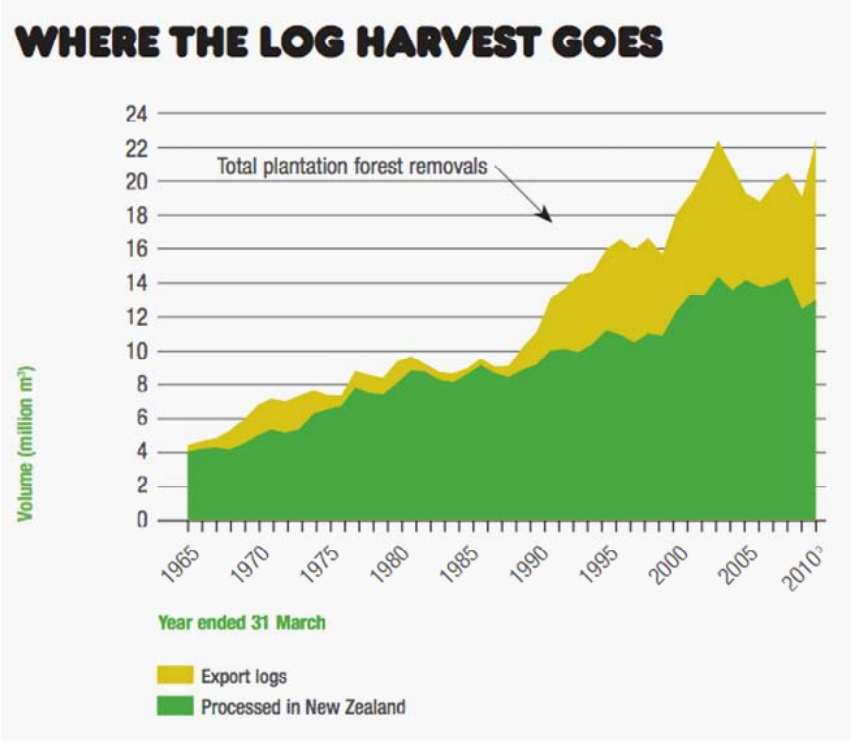
Plantation forests are established to provide feedstock to wood using industries. In order for a high labour cost country like NZ to compete, industries need to be capital intensive, and the more consistent the feedstock the more competitive will be the processing. The ideal forest tree is, and will continue to be, one that is fast growing, cylindrical, disease resistant, with small branches (knots) and uniform wood properties characterised by being stiff, stable, and strong.

Higher value markets generally require these wood properties, whereas markets that pay less for raw material (e.g. fibre board, pulp and paper, biochemicals, bioenergy, etc.) are presently much less discerning. Therefore, the focus of NZ plantation forestry will be to grow trees of consistent dimensions and wood quality suited for the higher margin, solid wood or engineered wood markets with residues very much a by-product. Consistency, quality and productivity will continue to be key to a successful industry.

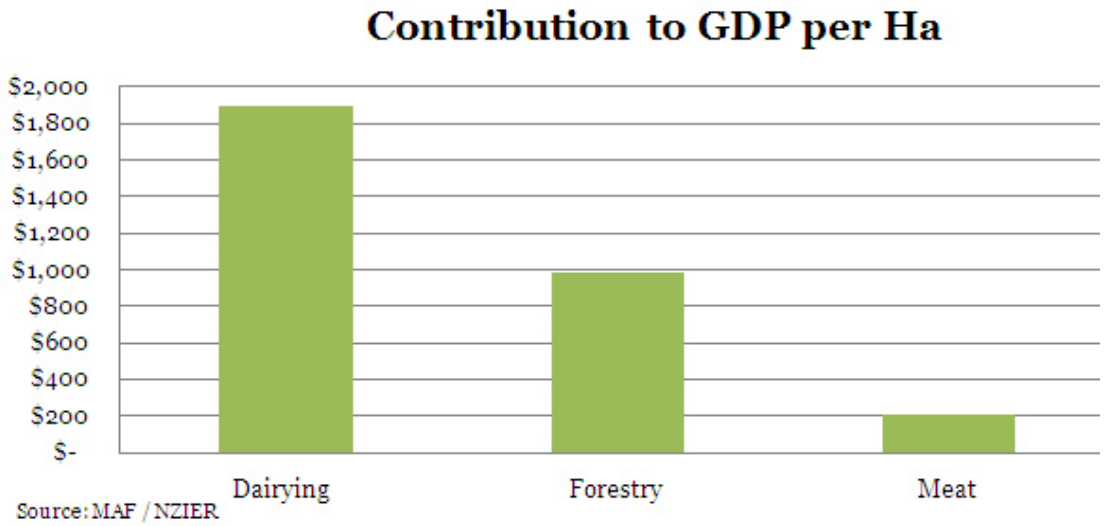
Over the last 40 years as the plantation resource has matured the volume of logs processed in NZ has increased from an annual supply of four million m^3 to 14 million m^3 / annum (see figure below). At the same time the log export market has also greatly expanded, most recently as Asian countries have increased their demand for raw materials to feed their expanding manufacturing capacity.

Traditional sources of high quality structural and appearance grade logs from tropical and boreal forests are declining for a variety of environmental protection, access/quality and biological reasons. The shortfall is being met by expanding plantations forests worldwide. New Zealand can play a significant role by exploiting our competitive advantage in fast growing softwood forests, including:

- Good structural and appearance grade properties of radiata pine;
- responsiveness of radiata pine to genetic improvement;
- access to renewable energy for log processing;
- a capacity to extract high value components from radiata pine and other species for the sustainable supply of biomaterials and green chemicals;
- fertile soils with good regular rainfall but unsuitable for intensive agriculture due to hilly terrain;
- fast growth rates.



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."

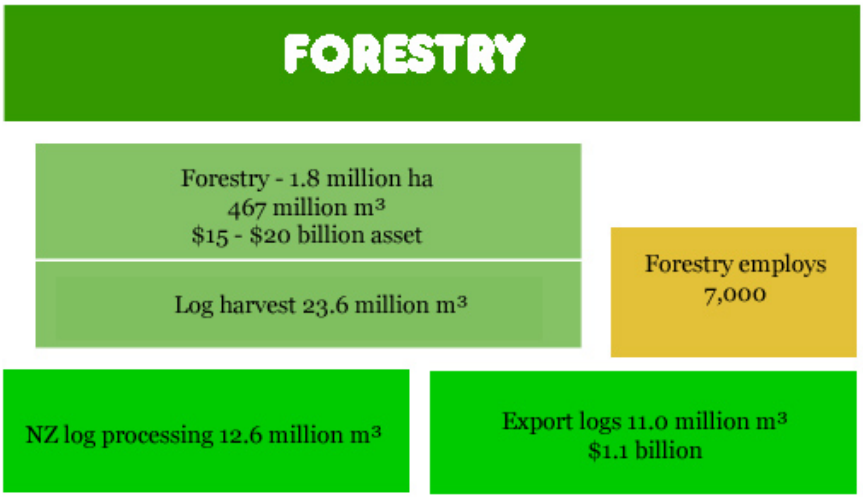


Forestry – an intensive land use with positive environmental impacts

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/fandf2011web.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 m^3 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 labour productivity is relatively low compared to many competing countries. In recent years large tracts of NZ plantation forest have been converted to dairy pasture. Investment in new land planting has been absent or very low for the last ten years and NZ faces many challenges to reverse this trend and provide productive and environmentally sound uses for the multiple tracts of "marginal" land that exist within pastoral farms at present.



The main opportunities facing NZ forestry in the next 10 years to which research can contribute include:

1. Increasing profitability from existing forests.
2. Fully exploiting the approaching increase in harvest volume expected.
3. Increasing productivity and wood quality from new planting and replanting.
4. Protection from biosecurity threats.
5. Reducing costs.
6. Demonstrating sustainability and renewability.
7. Managing carbon credits and liabilities.
8. Other ecosystem services: nitrogen reduction, soil conservation, improved water quality, and peak flood reduction.
9. Promoting the increased use of wood and wood fibre.
10. Integrating forestry for sustainable land-use on intensively farmed lowlands.

THE CONTRIBUTION OF RESEARCH TO ACHIEVING THE POTENTIAL

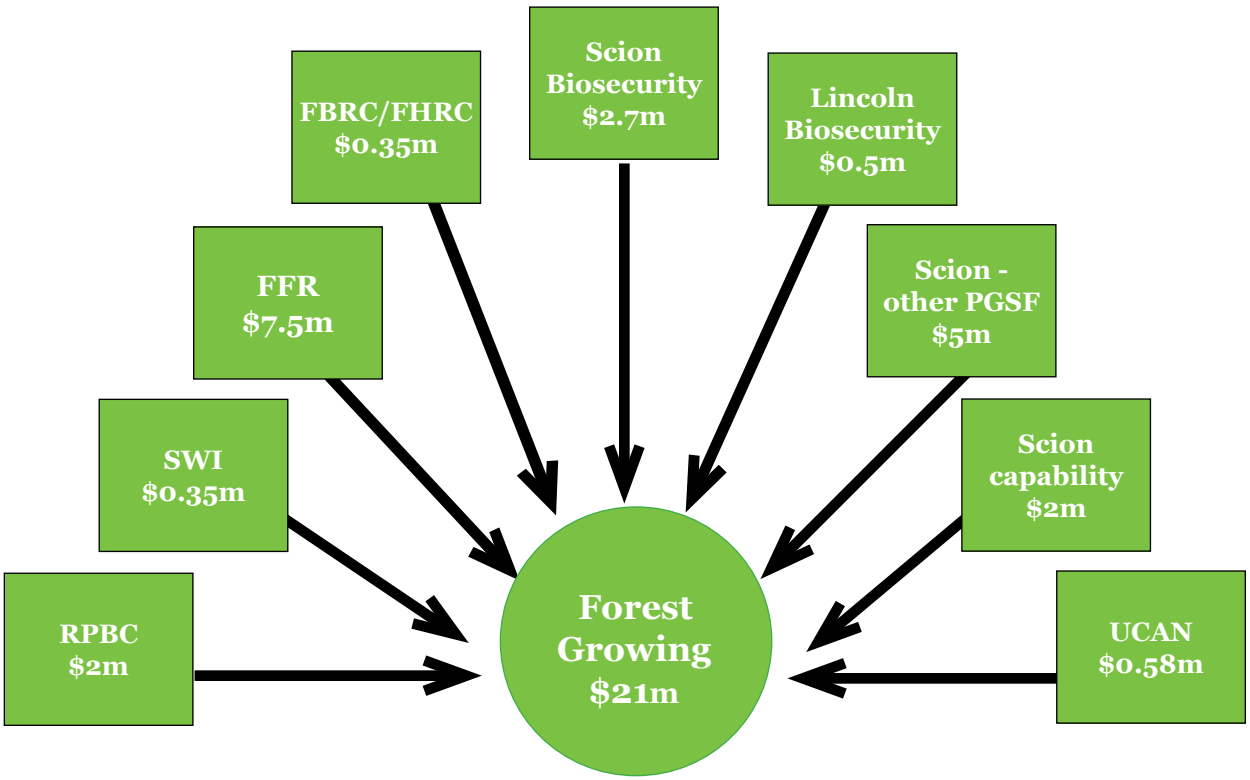


Figure 3. Breakdown of current forest growing research. (The SWI figure is for research related directly to forest growing only).

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 programmes 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 FFR 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 traits 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 small forest growers and the recognised wider public good benefits.

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 Fire Research programme, which includes stakeholders outside of the forestry sector and to which FOA contributes $60,000 per year.

THE RESEARCH PLAN

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 to high value manufacturing and to the export destination.

Most importantly, the research includes a "Market Trends" element that will inform forest growers and processors on global trends and changing end-user expectations from wood products and therefore the forest-based feedstock into wood processors.

Strategic Objectives / Research Themes

Improved Productivity and Consistency

- **Foliar Disease Solutions**
- **Genetics (breeding, varieties, GM)**
- **Long-term Market Trends**
- **Silviculture**

Sustainability

- **Resource Measurement**
- **Alternative Species**
- **Licence to Operate**
- **Verification of Sustainability for Market Access**
- **Rural Fire**

Operational Performance

- **Harvesting Steep Ground**
- **Supply Chain**

STRATEGIC OBJECTIVES

The Strategic Objectives that follow are in priority order and within each objective priority projects are identified.

Market Size		
Log production 23.6 million m^3	Export 11 million m^3	NZ processing 12.6 million m^3

STRATEGIC OBJECTIVE 1 – IMPROVED PRODUCTIVITY AND CONSISTENCY

Rationale:

New Zealand radiata pine plantations have historically been 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. However, considerable progress has been made in applying new genotypes (in some cases varietal forestry) and existing knowledge to new plantings and the new crop is producing at a much higher rate of productivity than the previous rotation.

Challenges still exist, however, and in particular there is an urgent need to find solutions to foliar diseases of radiata pine that are causing significant growth losses. There are similar issues for Douglas-fir and other plantation species. In the case of Douglas-fir, productivity gains have been made in recent years by the application of improved genetics, and it important that this work is supported and improved on.

Priorities:

Foliar disease solutions

- **Endophytes, induced resistance, genetic tolerance + other technologies**

Genetics and varietal forestry

- **Better and consistent wood quality, faster growth, disease resistance**
- **Rapid identification/introduction of superior genotypes**

Long-term market trends

Silviculture

OPPORTUNITIES/BENEFIT/EXAMPLES

1.1 Foliar disease solutions

Focus on: endophytes, induced resistance, and other technologies

At the beginning of 2011, the FOA Forest Biosecurity Committee (FBC) launched a new Forest Biosecurity Research Strategy. While recognising the need to maintain capability to respond to new pest incursions, the strategy identified 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 the Primary Growth Partnership project.

The current impact of pests and pathogens on the productivity of NZ forests is estimated to be in the order of $200m/year, although it is recognised that a precise figure is difficult to determine. It is anticipated that solving the problem of foliar diseases will lead to healthier and more productive plantations.

As well as reducing tree growth, there is another potential downside of unhealthy forests associated with trade restrictions triggered by concerns over potential biosecurity threats. Scion (Turner at al 2007) recently published a worst-case scenario on the potential downside of an exotic pathogen impacting forest health and also the log trade. The publication highlighted the need for constant vigilance at the border to keep out unwanted organisms that could negatively impact on forest health and trade.

> If China, Japan, and South Korea banned imports of NZ logs altogether, and the pest continued to spread at historical rates, the present value of NZ growers' revenues would decrease by US$8,200 million.
> Turner et al. 2007 [1]

The FBC has been implementing the new Forest Biosecurity Research Strategy and in February 2011 ran a workshop on "Foliar Disease Research Ideas". As a consequence of this workshop a number of new research projects have been initiated to counter the impacts of existing foliar diseases. In particular there has been 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 NZ.

As well as offering promise for disease resistance, endophyte technology has also been very successful for improving pasture productivity in New Zealand. A similar approach is currently being investigated by the Bioprotection Centre to potentially make new plantings of radiata pine more disease resistant and more productive.

> "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.

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.

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

1.2 Genetics and varietal forestry opportunities

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 threshold of 7 Gpa.

RPBC aims to deliver improved germplasm with these gains by 2025. There will be partial gains towards these targets from new introductions in 2017. RPBC also has a number of initiatives planned to develop increased disease resistance in the breeding population.

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

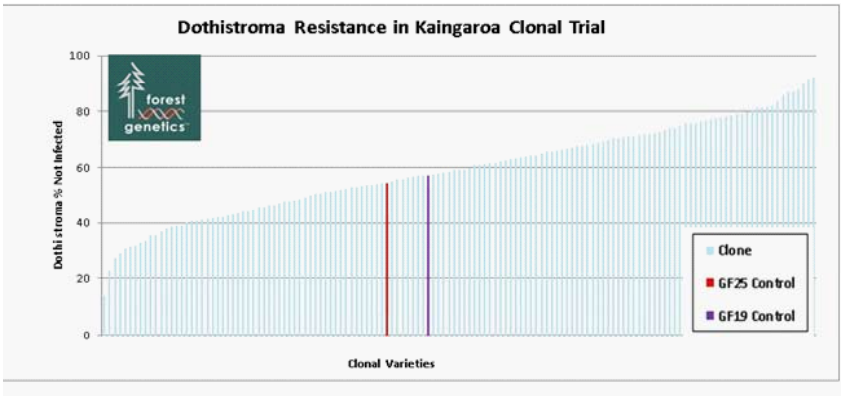
- $19m from genetic improvement;
- $57m from faster deployment;
- $14m from site matching;
- $10m from reduced losses from disease.

New Zealand's radiata pine breeding programme has led to significant improvements in producing planting stock that is more resistant to Dothistroma needle blight. However, conventional breeding programmes are relatively slow and advances are needed in early selection technologies and propagation and delivery technologies to get more rapid gains.

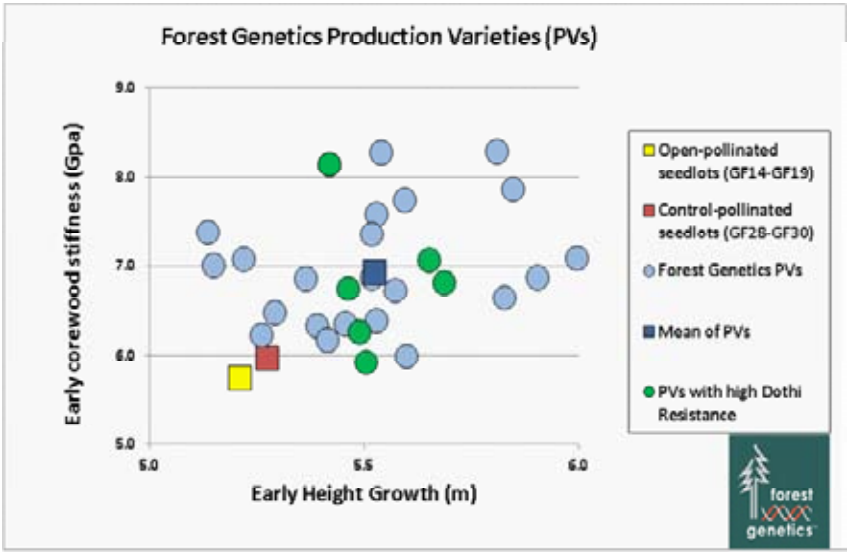
The University of Canterbury is conducting research into early selection using a novel approach to select genotypes at age 1-2 years. Molecular technologies, such as marker-aided selection, have been slow to deliver benefits to forestry; however, metabolomics has shown considerable promise as an early selection tool where it has been tested overseas.

Varietal forestry

Varietal forestry provides a good opportunity to increase disease resistance in radiata pine as demonstrated in the graph below from a Dothistroma resistance clonal trial in Kaingaroa Forest (source – Forest Genetics Ltd). Clearly some radiata pine varieties, some of which will also have good wood properties, are much more resistant to Dothistroma than the general improved GF19 and GF25 populations on average.



The big exciting opportunity for varietal (clonal) forestry is to substantially improve growth rate and wood stiffness, as well as disease resistance. The ability to accomplish this is demonstrated in recent data obtained from Forest Genetics Ltd (see figure below). Considerably more research effort and investment in operational field trials is required to identify and prove the varieties of radiata pine that are fast growing, disease resistant and produce high value wood.



Rejuvenation

"Rejuvenation" (basically the ability to select and propagate from mature trees/tissue) continues to offer promise to short-circuit traditional breeding programmes, but the success to date indicates this is a high-risk programme that should be approached with caution. However there is ongoing research in this area both in NZ and overseas that the industry needs to be cognisant of and should consider investing in research opportunities where justified.

Understanding Tree Physiology to Produce Better Wood

There has been a distinct lack of effort in tree physiology 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 Modification for Future Forests

Research into genetic modification 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.

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 - a particular problem with Douglas-fir in the South Island.

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). We believe that work should proceed to research potential solutions to biosecurity threats, especially some of the needle disease pathogens not currently in NZ.

1.3 Long-term market trends

New Zealand forest managers are generally aware of what the processing industry and its customers want and strive to grow and supply wood to meet this demand. What is generally not known is what the future "carbon" products might be and where NZ plantation forestry can meet the demand. However, it is generally considered that while there may be some high value product opportunities for NZ radiata pine, the demand for raw material to make these will mainly be for residues from solid wood production.

Individual forest companies have a good understanding of short-term market trends and supply demands, but more research effort is required to better understand how market demand might change in the future. This is especially important to understand some of the externalities that influence markets, such as what we have seen in the past with increasing demand for wood from sustainable sources. More recently we have also seen increased demand for "carbon forestry", and in the future may see greater value for managing forests for environmental services.

There is a perception in the industry, based on years of experience, that the market primarily

Economic Benefits – from increased productivity and consistency

- Increased Productivity 10 MAI/ha on core area of 1.2 million ha = 12 m m^3 / annum @ \$75/m^3 = \$900m revenue /annum
- Reduced Supply Chain Costs on 36 million m^3 at \$10/m^3 = \$360m
- Additional 20 million m^3 of logs processed in NZ adding \$100/m^3 log to NZ revenue = \$2000m annually

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

wants inexpensive logs that produce solid wood that is stiff, stable and strong and that it is the higher value markets (solid wood and engineered wood) that drive this demand and the residue markets will take what they can get. This perception should be tested and research programmes adjusted if necessary. It is also acknowledged that there is a national as well as worldwide demand for hardwood timbers for higher value end uses and also for durable timbers. The demand for this category is well known and the opportunity is to transfer knowledge from existing research to assist landowners to plant trees to meet this demand.

1.4 Silviculture

New Zealand forestry is well advanced in radiata pine silviculture. Ensuring high productivity and also stand consistency is mainly a case of applying what is already known. However, greater research effort is warranted to understand how wood quality is influenced by environment and silvicultural treatment in order to produce stands with more consistent higher quality wood.

Strategic Objective 1 : Priorities

The priority research areas in this Strategic Objective are for projects that will lead to enhanced foliar disease resistance while also increasing productivity, tree and stand consistency across rotations, and improvements in 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.

There is also a priority to continue with the Radiata Pine Breeding Company programme, particularly the focus on foliar disease resistance and research into more rapid methods of early breeding selection.

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.

Genetic modification is considered a high-risk research area but one that industry would like to see pursued, primarily funded by government until technology benefits are quantified.

STRATEGIC OBJECTIVE 2 – SUSTAINABILITY

Rationale:

Being able to demonstrate sustainability is key to forest investors and also to markets and regulators. Technologies, such as remote sensing, and potentially nanosensors, that can improve forest and environment measurement capability need to be further developed and applied at a cost-effective rate.

New Zealand forestry has a good opportunity to be a "fast follower" in the area of remote sensing. The main opportunity is to pick up on new technology and apply it to NZ forestry opportunities. LiDAR (Light Detection and Ranging) technology is currently being used for a wide variety of applications including harvesting planning, enivronmental risk assessment, inventory, and to log quality assessment. It is also showing potential application in assessing forest health and vigour. Future opportunities could see market demand linked to resource supply with the advent of improved remote sensing technology.

In the future nanosensor technology will likely be available that can be applied in the forest to measure environmental conditions, tree health, and potentially even changes in tree growth as a consequence of environmental conditions. It is likely that this technology will be developed overseas and become available for further development and application in NZ forestry.

Radiata pine is the main commercial plantation tree species in NZ making up 90% of the existing resource. Douglas-fir is second at 6% followed by cypresses and some eucalyptus species. Radiata pine dominates plantings today because of its proven track record to grow well on sites throughout NZ and because of the versatility of the wood, compared to other species. However, there is a need for other species to meet specific market needs and for planting on sites not well suited to radiata pine. There is also a need to identify contingency species should radiata pine succumb to pests and diseases. However, as is the case for all other crops in NZ be it apples, kiwifruit or grapes, radiata pine growers are focused on a single species and government needs to take a lead in funding research into alternatives to radiata pine as the country would be the main beneficiary in having a contingency species.

To provide evidence to regulators, and also to markets, and thereby maintain a "licence to operate" requires the demonstration of sustainability in scientifically robust research projects. New Zealand has a long history of research in this area and the most pressing need is to summarise the most recent research results and communicate these to stakeholders.

Supporting research projects:

Resource Measurement

- Remote sensing for forest, stand, and log assessment, biosecurity, environmental and growth monitoring

Alternative Species

- Selection/breeding - Douglas-fir, cypresses, E. fastigata, E. regnans, redwoods

Licence to Operate

- Verification of sustainability for Market Access
- Natural hazard management, floods, landslips

Rural Fire

- Mitigating hazards and climate change

OPPORTUNITIES/BENEFIT/EXAMPLES

2.1 Resource Measurement

Remote sensing for forest, stand, and log assessment

Remote sensing technologies, including LiDAR and RapidEye imagery are currently being used in forest management to reduce inventory costs and monitor environmental changes. These are but two examples of remote sensing technologies

that offer considerable potential for further developments to rapidly, and cost-effectively capture valuable information on tree and forest attributes. Future Forests Research (FFR) has recently demonstrated the ability to use LiDAR to estimate individual stem stiffness, and also to greatly improve the precision of forest inventories.

Biosecurity, environmental and growth monitoring

RapidEye, possibly combined with other technologies, appears to offer considerable potential in forestry monitoring operations, including forest health and environmental aspects such as soil erosion. There are considerable developments underway within forestry companies, environmental consultancies, and research organisations. There are also many potential end-users of environmental monitoring technologies. The bigger opportunity is to involve key end-users and key developers in a collaborative research programme.

2.2 Alternative Species

Selection/breeding - Douglas-fir, cypresses, E. fastigata, E. regnans, redwoods

Scion currently conducts research into breeding species other than radiata pine including Douglas-fir, cypresses (several species and hybrids), Eucalyptus fastigata and E. regnans, and Californian redwood. A key output of this research will be a decision support system to match species to sites for new forests or replanting. Information on seed sources, propagation techniques and use options will assist land owners to choose from a range of potential species to meet the needs in their region. The knowledge from this research programme is useful to provide small growers in particular with the confidence to invest in species other than radiata pine.

Swiss Needlecast continues to impact growth of Douglas-fir in parts of the North Island and it is important to include resistance to this disease in ongoing genetic improvement.

Licence to Operate

2.3 Verification of sustainability for market access

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.

There have been large investments by government and industry in research investigating the sustainability of radiata pine as a plantation crop and on the impacts of forestry and especially harvesting activities on the environment. The main opportunity is to collate new knowledge that has become available since the publication of Pier's Maclaren's book "Environmental Effects of Planted Forests in New Zealand" in 1996, and to transfer the knowledge to industry, government and the market through, for example, certification systems.

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.

The role forests can play in reducing the severity of natural hazards such as flood peaks, flood protection works and loss of topsoil could be better understood and quantified.

Research into valuing environmental services in New Zealand is in its infancy and much greater, but coordinated research is required to fully understand the needs and the opportunities. It is of interest to many stakeholders beyond commercial forestry companies.

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

2.4 Reduced chemical use

Market pressures, especially through Forest Stewardship Council (FSC) certification, are forcing the search for options 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.

FFR 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 NZ. The opportunity is to continue research testing the available herbicides, but also to bring in knowledge from overseas that may be applied in a NZ forestry situation and still meet FSC requirements.

2.5 Rural Fire Research

There is a well-established Rural Fire Research programme, which involves stakeholders outside of the forestry sector and to which FOA contributes $60,000 per year. The opportunity is to continue with this programme to improve our ability to predict and manage fire behaviour and thereby reduce losses.

Strategic Objectives 2 Priorities

The priority research opportunity in this theme is to make rapid advances in remote sensing that will lead to lower operational costs and improved forest health and environmental monitoring. In particular R&D (and most of what is needed is "development") should focus on more cost-effective ways to conduct forest inventories including improved accuracy of tree height and volume estimates, and remote measurement of wood quality parameters (e.g., stiffness).

There are some quick wins available to address issues around "licence to operate" as much of the long-term sustainability trials that were started 20 to 30 years ago are finished and the results need to be summarised and published. Preliminary indications are that the results from these trials support claims of long-term sustainability for radiata pine forestry as practised in NZ.

Additionally, greater knowledge is needed on new and existing herbicides and also on new biological control technologies in order to reduce chemical usage, improve productivity and profitability, and to ensure market access.

Economic Benefits

- Move plantations off the steep hills as better able to compete on the better ground – potential to expand area
- Sustainably proven industry - priceless
- Carbon storage
- Flood regulation
- Soil productivity protection
- Stream and lake water quality protection

STRATEGIC OBJECTIVE 3 – OPERATIONAL PERFORMANCE

Rationale:

New Zealand is a world leader in growing plantation softwoods for solid wood, although much more can be done. However, where some earlier and 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 NZ for approximately 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 commissioned research and introduced technologies to capitalise on this variability, which enables log optimisation to target processing plants and markets. The challenge is not just developing the technology but implementing it within the existing supply chain.

Payment based on log and wood quality determined at the mill yard/headrig/peeler has the potential to support larger processing plants (capable of sending the right log or even the right flitch to the right production/ product line) and will therefore reduce log segregation needs at the forest.

SUPPORTING PROJECTS

Operational

- **Harvesting Steep Ground**
- **Supply Chain Cost (smarter/cheaper)**

OPPORTUNITIES/BENEFIT/EXAMPLES

3.1 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.*[2]

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

A potential substantial and significant spinoff benefit from the innovative harvesting programme is the development of new technology, a greater skilled engineering workforce, and export earnings from sales of equipment and technology. Warratah NZ Ltd is an excellent example of what has been achieved, providing benefits to both NZ forestry in reduced harvesting costs and to NZ export earnings.

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 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.

3.2 Supply Chain

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 commissioned 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 the large price variation for log quality will be a key driver of both research funding and uptake by forest owners. Payment based on log and wood quality determined at the mill yard/headrig/peeler has the potential to support larger processing plants (capable of sending the right log or even the right flitch to the right production/product line) and will therefore reduce log segregation needs at the forest.

There is also an opportunity for big short-term profit gains by getting as much cost as possible out of the chain between log skid and customer. The transport weights and dimensions is under way and is one of the biggest costs that we can materially reduce, but there are some big wins to be had in the way we scale and track logs through to customer, optimise truck movements and deal with log storage double handling at congested ports.

Strategic Objective 3 Priorities

- Reduced steep-land harvesting costs.

Economic Benefits

- Savings in the order of $50m/year in steep-land harvesting.
- Spinoff economic benefits from high value manufacturing

[2] Keith Raymond 2010 - NZJ of Forestry, Nov 2010, 55(3)

PATHWAYS TO INDUSTRY UPTAKE

Unlike some primary sectors, the forestry sector is characterised by the bulk of the area and production being held in relatively few hands. The industry has had a long history of industry cooperatives and now consortia that have voluntarily funded R&D that is seen as relevant. The absence of a commodity levy has certainly constrained forest industry funding of R&D but, at the same time, focused the attention of individual firms on realising value from their voluntary contributions. It is in part due to R&D and its rapid uptake that the forestry sector has exhibited productivity growth higher than the general economy over the past two decades. [1]

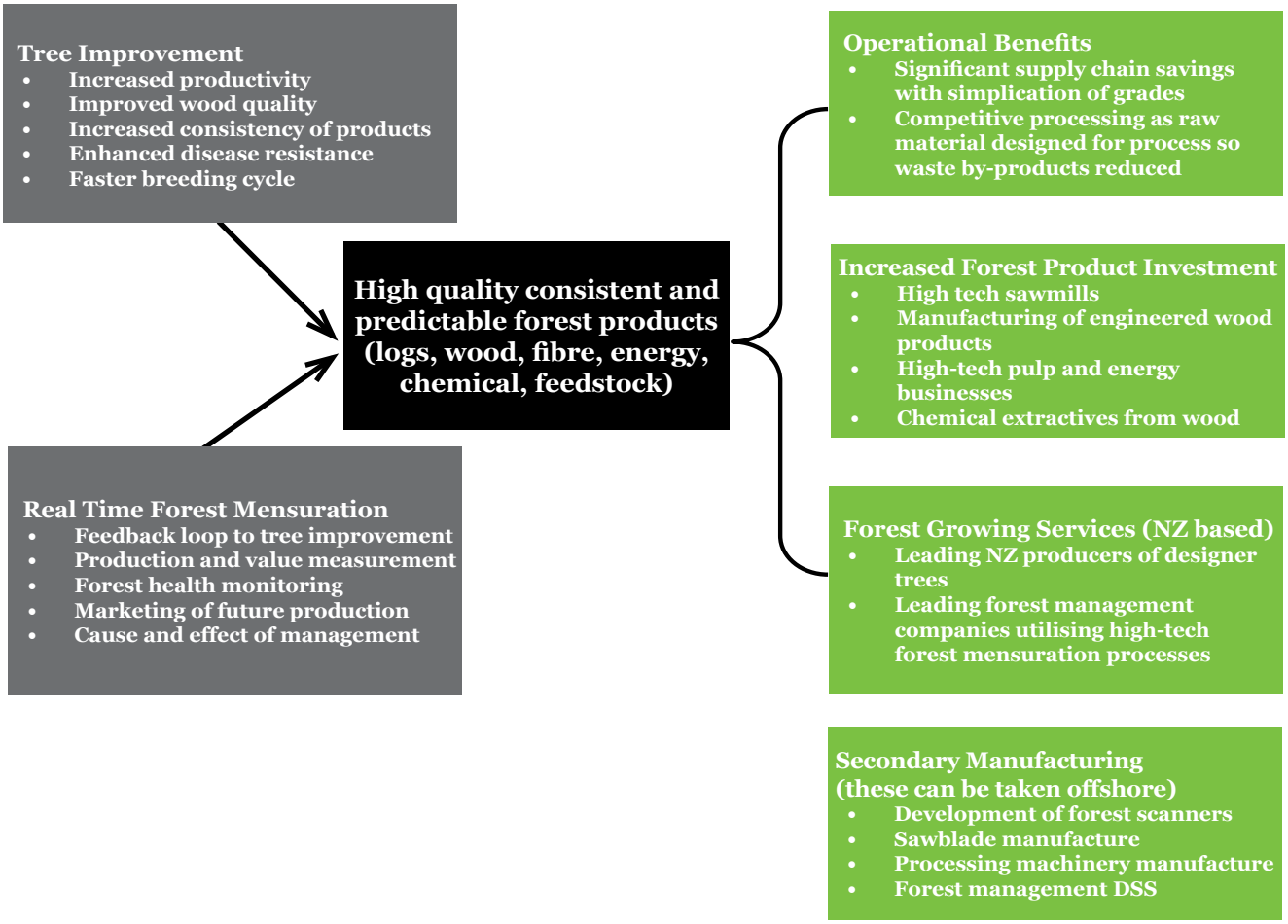
As a result there is a good track record of uptake of those R&D outputs that have added value to the New Zealand forest resource and the businesses that own those trees and land. We do not see this rapid uptake changing in the near future. Technology transfer and IP protection has been further enabled by IT advances in recent years.

The primary means of uptake are via frequent communications from dedicated industry appointed science managers such as Future Forests Research, Radiata Pine Breeding Company, Solid Wood Innovation and the Forest Biosecurity Committee, secure-access web-posted technical releases, technical workshops, shareholder visits by the CEOs of the research management entities, and in some cases dedicated personnel appointed by shareholder companies charged with monitoring, assessing and, where there is identified benefit, implementing RS&T within their respective firm's operations.

Smaller forest owners access research and innovation via either their association magazine (Tree Grower) or through the engagement of professional forestry service providers for the growing and/or harvesting of their trees.

1. MAF estimates the forestry sector's total productivity has increased by an annual compound growth rate of 1.6 percent from 1984 to 2007, compared with the wider economy's annual compound productivity growth of one percent.

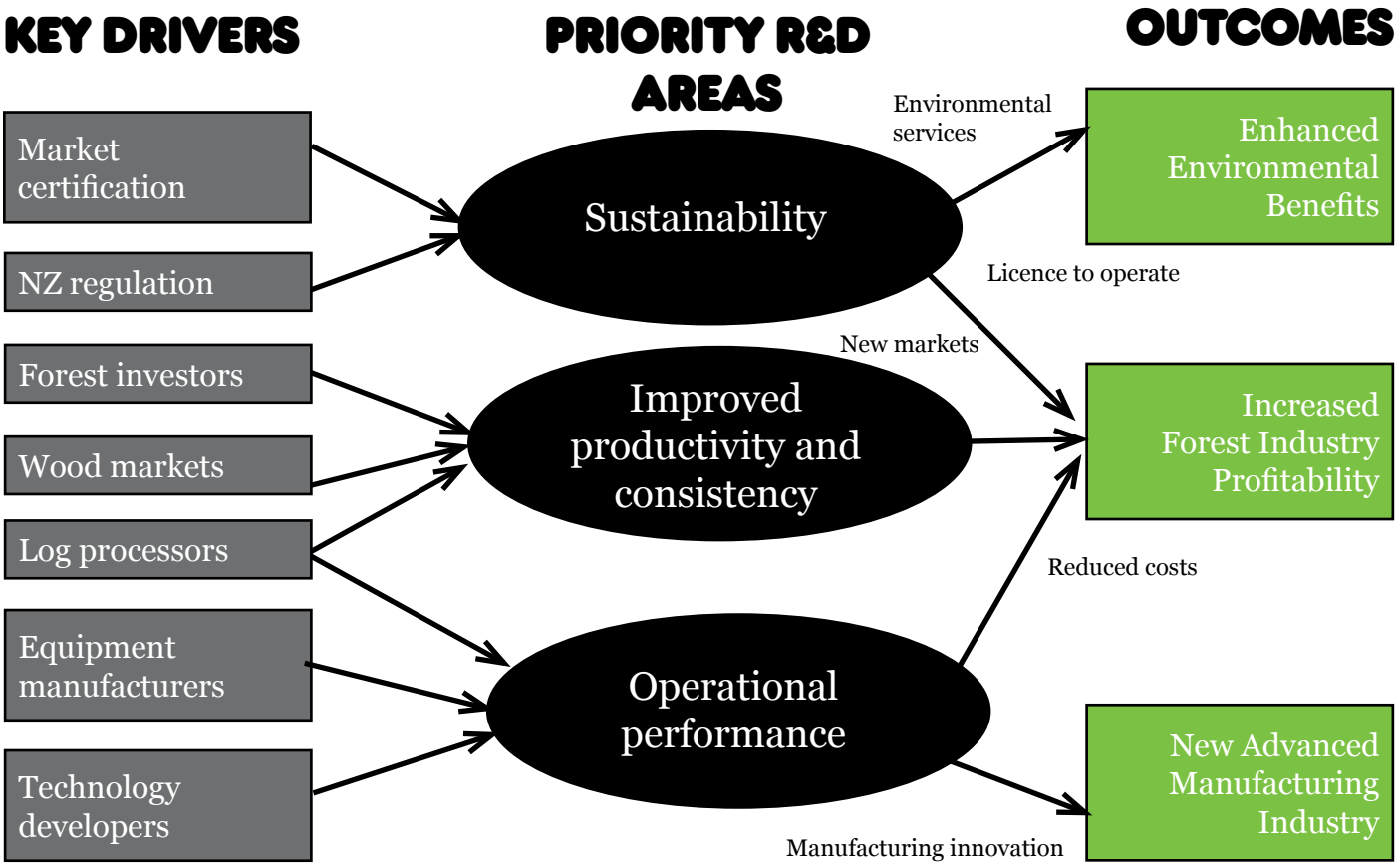
EXPECTED OUTCOMES



New Zealand forestry can realise many of the substantial opportunities identified earlier in this document if the research priorities can be initiated in a timely manner and results readily conveyed and implemented. The diagram shows the key drivers for each of the three priority research areas and the outcomes that may be achieved if research is successful. Forest investors, as well as NZ and international log markets and processors, are key drivers for large logs with consistent wood properties fit for specific end uses. Reducing the impact of foliar diseases of radiata pine is highlighted in this strategy as a key target area. Not only would success in enhancing the health and vigour of radiata pine lead to increased productivity, but it would also address many of the concerns around forest health and trade.

Market certification along with NZ regulation, including the industry's own Code Of Practice, are key drivers for sustainability research, which if conducted to a high standard and delivered in a manner that can be readily implemented, should lead to benefits to the wider country, as well as to the forestry sector.

Operational research, focussed on steep-land harvesting and supply chain efficiency can lead to benefits other than simply reduced costs to the forestry sector. In particular there is a need both in NZ and worldwide for technology to enable cost-effect steep-land harvesting. NZ companies such as Warratah have demonstrated in the past that they can compete on the world scene and deliver multiple benefits to NZ.



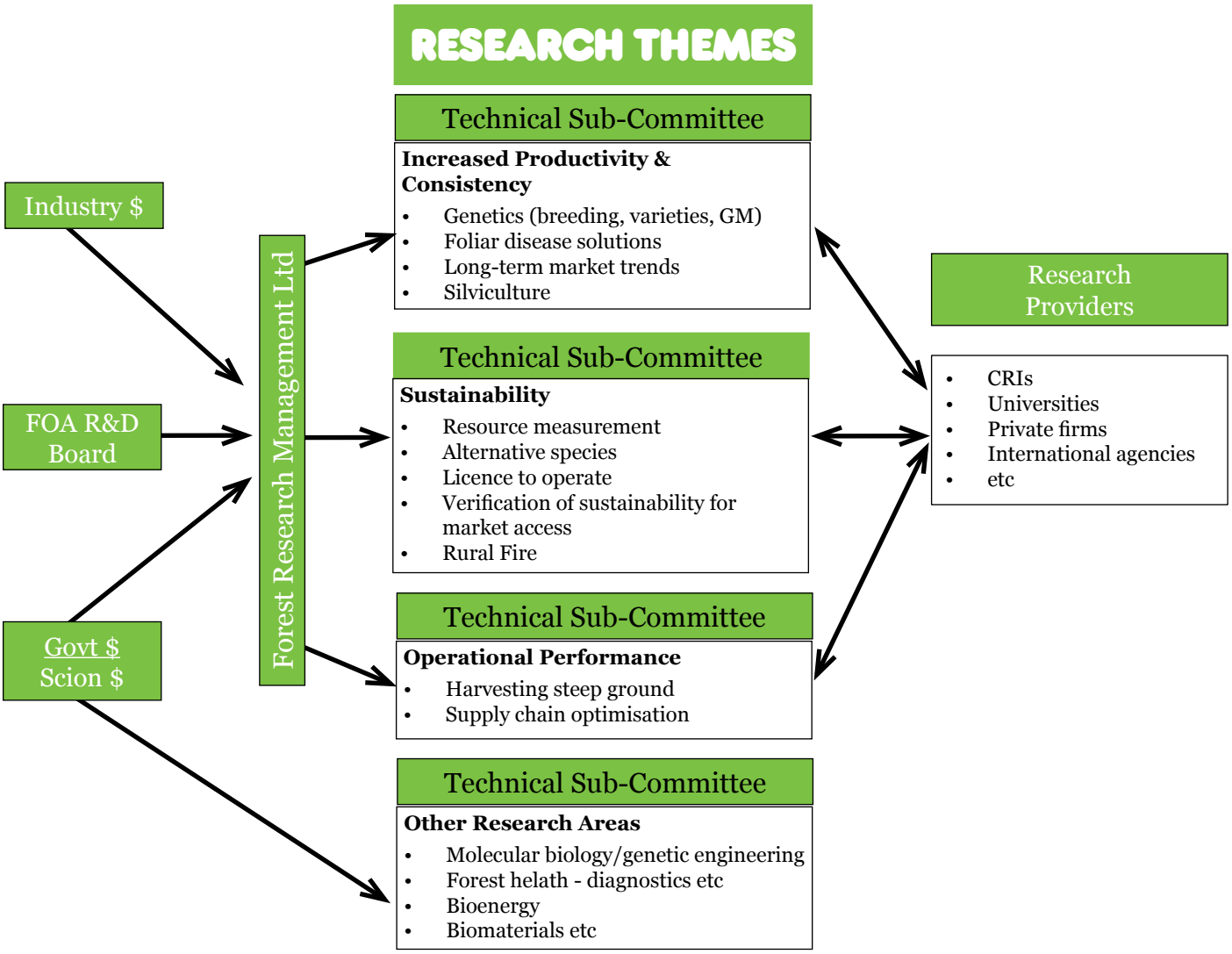
IMPLEMENTING THE STRATEGY

In order to achieve the priority research objectives identified in this forest growing research strategy there needs to be a fundamental shift in the way that research is managed and funded by industry. The structure below is proposed as a discussion point. It sees the existing research management structures, including Future Forests Research (FFR), the Radiata Pine Breeding Company (RPBC), and the Forest Biosecurity Committee (FBC) combining into one management unit "Forest Research Management Ltd". This would enable greater focus, reduce overhead costs and give forest industry, and others in the broader forestry sector, confidence to invest in forest growing research. Most importantly, it would ensure a strong focus on economic impact.

The three research themes identified in the strategy could be then managed using different mechanisms. For example, it may be that a Research Consortia structure is most appropriate for the "Improved Productivity & Consistency" theme, while other mechanisms may be more appropriate for the other two themes.

A great deal of effort will be required to successfully implement this research strategy, including developing relevant business cases around each of the three themes that provide convincing arguments to industry and to government that the research should proceed and be funded.

It is recognised that Scion has been identified in the CRI Taskforce Review as being specific to forestry research and close collaboration with Scion in developing and implementing the strategy is important. In addition there are other organizations that also contribute to forestry research and will likely continue to do so as a wide spectrum of skills are required to implement the research strategy.



As a next step in implementing the strategy it is planned to commission an external assessment. The terms of reference for the assessment would include:

(a) Providing additional input to the strategy to identify key research areas that might have been missed;

(b) assessing existing NZ research capability in terms of being able to address the research priorities;

(c) recommending to the FOA Executive the most effective means to achieve the vision set out in this strategy.

The assessment team would consist of at least two experts that are well qualified to address the terms of reference. The exercise would ideally need to be done in early 2012.