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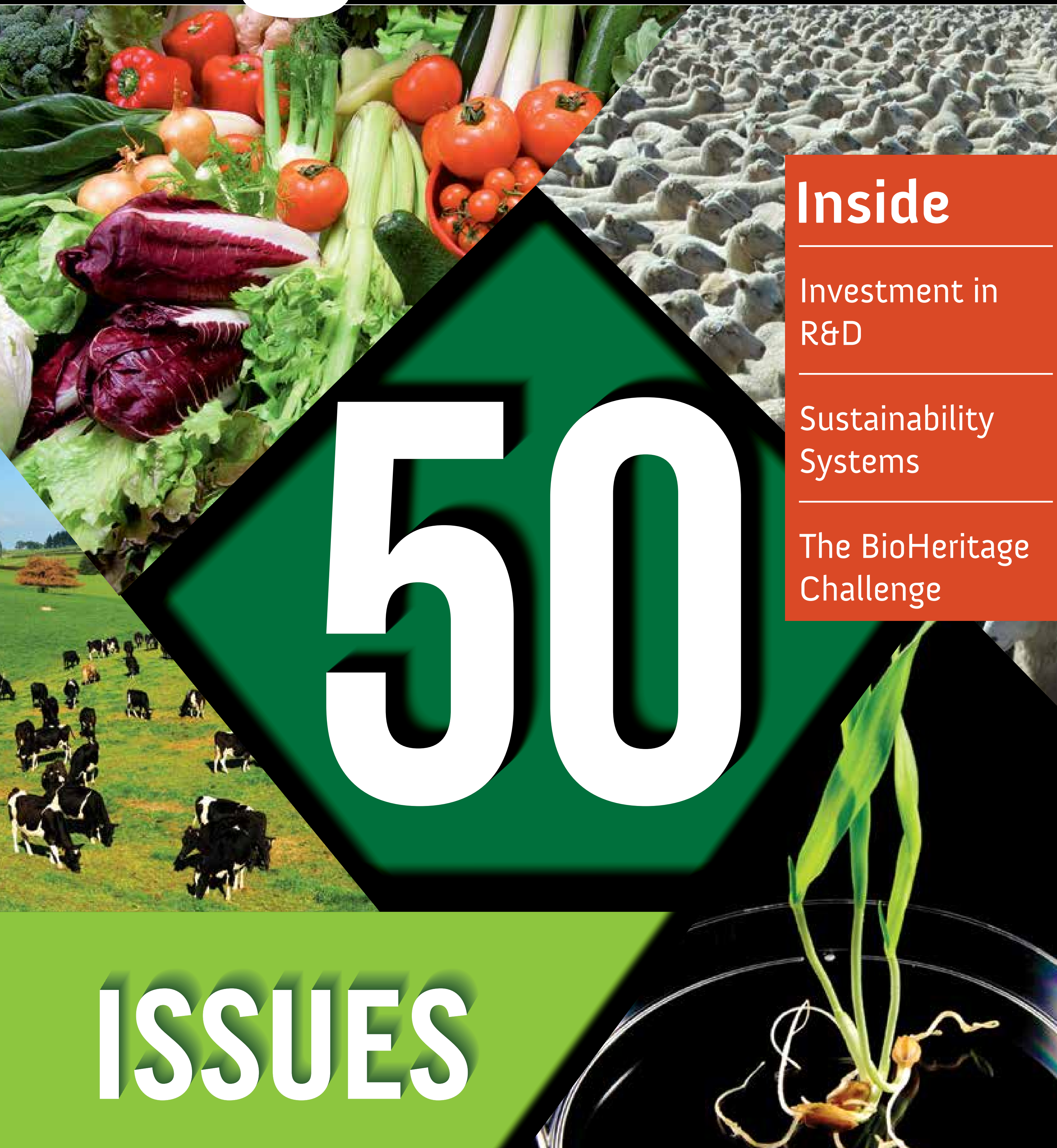

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The New Zealand Institute of Agricultural & Horticultural Science Inc

WELCOME TO OUR 50TH EDITION of the *AgScience* magazine, which we are publishing just over 15 years after the first issue was published in December 2000. Inside there's a nod to the content of that first issue with an article by Bob Edlin that gathers some data on research funding over the past 15 years. It's a mixed picture, really. On the good side we see a growing economy in terms of GDP, much of this fuelled by the performance of the primary sectors, and alongside that a steadily increasing total national annual investment in research and development. Growth in business sector R&D investment appears to be a strong contributor to this performance. Great. This is what we all want to see.

For me, however, two aspects emerge that are less encouraging. First, the ratio between the government's R&D investment and GDP appears to be resistant to substantial positive change, despite successive administrations putting up very realistic and reasonable targets for the growth of that specific indicator. In 2000 the target for 2010 was for government investment to be 0.8% of GDP, but based on the Statistics New Zealand survey data it stayed around 0.7% and is now back to 0.6%. The same 0.8% target has re-appeared in the National Statement of Science Investment, so what shall we make of it?

Second, as far as the primary sector is concerned, the picture appears to be worse, with a declining proportional investment from government (relative to both GDP and total R&D). This comes at a time when, as our other feature article points out, one of the biggest challenges facing New Zealand is the sustainable development of our land and water resources.

In my view, the research required for this is clearly public good – we can neither expect the business sector to foot the lion's share of the bill, nor buy the knowledge from overseas. As a side note, it is also of concern that one of the most difficult things about this sort of analysis is being able to get robust data that is consistently measured and reported on over time – something that we scientists consider a basic principle of methodology. The initiative in the National Statement of Science Investment around an annual performance report is welcome, if it fulfils this fundamental criteria.

Once again, I congratulate the Canterbury Section on a well-run and engaging forum, from which – regrettably – I was absent. What strikes me about the content as reported is the innovation required to turn variability into consistency. By this I mean taking a highly variable climate, soil, vegetation, animal, water and human resource and producing consistently high quality food and fibre products for a consumer population who have come to expect everything at every time. Now we add to this the expectation to produce a consistently 'clean' environment. It's really quite an astonishing paradigm.

Returning to this edition as a milestone for the Institute, I pondered briefly what has changed in 15 years? In 2000 *AgScience* was a publication of the NZIAS. Now, of course, we are the NZIAHS and is fitting that your council is now considering a refreshing of our communication tools, such as the web presence, social media and this magazine. We still see a lot of value in this publication, as a physical item that adorns the reception areas of many key sector organisations.

Despite healthy activity in the Waikato, Canterbury and Auckland Sections, and a Manawatu re-emergence, our regional section activity appears to have declined overall. Our annual convention has morphed into greater alignment with other organisations and the Forum days have emerged to become our high-profile events, perhaps a reflection of the short time spans available to us all.

There are, of course, a few key objectives that haven't changed. These include our intent to:

1. Promote the value and interests of primary sector researchers;
2. Have our views heard at policy and political levels;
3. Profile examples of excellent applied science;
4. Financially support emerging researchers;
5. Publically recognise our outstanding leaders.

Finally, we include in this issue what I hope will be the first of a number of articles profiling the new National Science Challenges. These initiatives represent substantial new investment in public good R&D and the expectation is that there will be broad participation from New Zealand's best scientists.

The BioHeritage Challenge is now well advanced with its programme leadership and new lead off projects, a number of which will be of high relevance to the primary sectors from the point of view of biosecurity and land/water management.

Mike Dodd
President

R&D spending

are we getting our fair share?

We put the matter of money under the microscope for this 50th issue of AgScience. The first issue – published in December 2000 – had recorded Government commitments to research and development in the primary sector. So what has happened since then and how much has the private sector chipped in? Consistent data to isolate agricultural and horticultural R&D investment from other R&D spending over the past decade and a half are not readily available. But here's what we can say…

PROFESSOR JACQUELINE ROWARTH, then President of the New Zealand Institute of Agricultural Science, wrote the first article in the first edition of *AgScience* published in December 2000. She had taken note of a speech given to the Institute's Auckland Section by Pete Hodgson, who had assured his audience that "at last, you have a government that is on the side of science".

Dr Hodgson was Minister of Research, Science and Technology and of Crown Research Institutes in the Labour-led government elected a year earlier. The final words of his written speech said traditional agricultural and horticultural science would always be relevant. "Even with the fanciest molecular biology in the world, we still need to know how new crops will grow in different soil types, different climates and latitudes. We need to know how they will respond to different pests and management regimes."

"And so say all of us," a heartened Jacqueline Rowarth remarked in her article. She described the Minister's statement as "a mantra worth repeating" in the hope this view reached society in general, and the funding bodies and potential recruits to science in particular.

Dr Hodgson also said he had made a commitment to lift public investment in research and development to 0.8% of GDP by the year 2010. A start had been made in the 2000/01 Budget by increasing the total investment by about 10%, he said.

In dollar terms government spending has increased since then (see Table Two) from $393 million in 2000 to $584m in 2008 (when the government in which Dr Hodgson served was replaced by John Key's National-led government) and $622m in 2014.

By the time Labour left office, however, the government contribution had been trimmed from 0.36% of GDP in 2000 to 0.32% in 2008 although the higher education contribution increased from 0.33% to 0.36%. Under National-led coalitions the government contribution has slipped further to 0.27% while the higher education contribution has held at 0.36%.

Total R&D investment nevertheless has increased from 1% of GDP in 2000 to 1.2% in 2014 thanks to the business contribution, which has been lifted from 0.30% of GDP to 0.54%. But what's been happening to R&D investment in the agricultural and horticultural sectors?

For this 50th issue, we asked the Ministry of Innovation, Business and Employment if they could provide us with a useful set of figures to show trends in science spending with a farming/horticultural breakdown since 2000. They couldn't.

We were told the actual amount of combined investment made by government, the private sector, and universities into particular sub-sectors is hard to obtain. This dearth of detailed data is being addressed in a government project signalled in the Business Growth Agenda and National Statement of Science Investment to produce an annual science System Performance Report to help inform future investment and show trends.

With some caveats, the ministry could isolate key government investments in agricultural industries through different government appropriations to show a total and a trend over the past five years. They provided us with Table One, showing funding from the Ministry for Business, Innovation and Employment, the Ministry for Primary Industries and the relevant Centres of Research Excellence.

The ministry acknowledged the shortcomings in what they had sent us: the data are "indicative only" for several reasons. For example, a number of research organisations participate in agricultural research but they haven't been included because the bulk of their work is in other areas (such as NIWA and GNS, the Allan Wilson Centre and the Maurice Wilkins Centre). Similarly some agricultural research institutions conduct a limited amount of research work in other (non-agricultural) areas.

The table provided by the ministry shows the annual Ministry of Business, Innovation and Employment, Ministry for Primary Industries and Centres of Research Excellence spending on agricultural research has risen from $260.1m to $334.6m over the past five years – a growth of 29%. But "this will understate the total amount funded by government," the ministry said.

The ministry also provided us with data showing expenditure on R&D by purpose of research and sector of expenditure in 2014. This placed agricultural and environmental research in the context of New Zealand's total research investment. The critical figure for our readers is that the total spend on research for primary-industries purposes was estimated at $444m. Government agents and the university sector together were by far the majority funders of research in the sector.

INDICATIVE SELECTED SCIENCE EXPENDITURE RELATED TO PRIMARY INDUSTRIES

Table 1

		2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Vote Research and Technology/ Business, Science and Innovation		$ thousands					
Contestable Funding	Biological Industries	167,962	108,869	106,452	94,693	94,918	92,153
CRI Capability Funding / Core Funding *(10/11 numbers are Capability Funding)*	Plant and Food	10,030	43,103	43,103	43,103	43,103	43,103
	AgResearch	11,700	38,889	38,889	38,889	38,889	38,889
	Scion	4,260	17,733	17,733	17,733	17,733	17,733
	Landcare	6,160	24,204	24,204	24,204	24,204	24,204
National Science Challenges New Funding *Annualised estimate, does not include transferred contestable funding or CRI core funding*	High Value Nutrition	0	0	0	0	0	3,060
	Biological Heritage	0	0	0	0	0	3,410
	Our Land and Water	0	0	0	0	0	3,410
Vote Agriculture and Forestry/Primary Industries							
PGP		24,221	38,532	37,591	55,805	56,850	69,877
Sustainable Farming Fund		8,976	10,450	9,300	8,941	8,291	8,311
Climate Change Research		8,600	9,200	8,472	7,819	4,836	2,384
Global Research Alliance on Agricultural Greenhouse Gases		4,094	4,025	5,635	9,284	6,000	14,772
Vote Tertiary Education							
Centres of Research Excellence (CoREs)	**Agricultural CRI Partner**						
Gravida, Host UoA	AgResearch	7,157	6,895	6,342	6,142	7,707	6,641
Bioprotection Research Centre, Host Lincoln	AgResearch, Plant and Food Research	3,723	3,838	3,952	4,166	2,974	3,326
The Riddet Institute, Host Massey	AgResearch	3,135	3,239	3,473	2,978	2,945	3,309
OVERALL TOTAL (NB the CoRE values are from calendar years; the others are from financial years)		**260,017**	**308,977**	**305,146**	**313,756**	**308,449**	**334,581**

Notes on Vote RS&T / BSI funding

- The biological industries funding numbers drop because some funding was pulled out of all contestable funds in 2011/12 to create core funding.
- Almost all AgResearch, PFR and Scion core funding expenditure is related to primary industries.
- Significant amounts of research related to primary industries supported by core funding occurs in other CRIs. For example, some environmental research.

Notes on Centres of Research Excellence

- The CoRE funding listed is contracted so is legally committed
- All CoREs have a mid-term review at which point the Crown/TEC could theoretically reduce funding if progress was deemed to be inadequate.
- Funding is not tagged to agribusiness.
- Funding is provided to support research themes and projects
- CoREs are designed to be investigator-led, ***not*** industry-driven research like MBIE funds.
- Some of these research projects will be done corroboratively with CRIs like AgResearch and will have end users in the primary sector as potential users of the research outputs.

Further help from the ministry came in the form of a table setting out figures from Statistics New Zealand's two-yearly R&D surveys. This showed the sectors where research expenditure has been carried out in primary industries and compared 2008 with 2014.

The table (which we have expanded to create Table Three) did not show who paid for or invested in the research. But the "government" sector mostly means Crown Research Institutes.

"Primary industries" include fishing and mining as well as agriculture, horticulture and forestry.

The figures showed a total increase of 12% in agricultural research over the six years from 2008 to 2014. These figures did not include environmental research which totalled an additional $279m annually, a significant amount of this being related to the primary sector (such as research into nutrient management and freshwater management).

The table encouragingly showed that the annual amount of agricultural research conducted in the business sector had risen by 45% over the six-year period, while the amount conducted in the university sector had risen by 12%. The amount of research conducted in the

GROSS EXPENDITURE ON R&D

Table 2 *Source: Statistics NZ*

	Business	Govt	Universities	Total R&D	Total as % of gdp
			$(million)		
2000	324	393	374	1091	0.99
2002	524	456	436	1416	1.14
2004	677	461	522	1660	1.19
2006	760	473	593	1826	1.16
2008	923	584	653	2161	1.19
2010	971	615	802	2388	1.26
2012	1193	596	836	2625	1.25
2014	1246	622	817	2685	1.17
Average annual % change since 2000	20	4	8	10	

government sector had decreased by 10%.

The ministry said this indicated a growing preference for New Zealand agricultural companies to conduct more of their research within their own companies rather than contracting it out to government agencies.

The table showed that despite this shift, an unusually high proportion of primary sector research continued to occur in government agencies compared to other industry sectors (except for environmental research).

Finally, the ministry provided data (included in the online version of this article) recording total revenue reported by Crown Research Institutes in 2008/09 and 2013/14. These figures aren't for agricultural research alone but AgResearch, Plant & Food Research and Scion operate almost exclusively in the agricultural and forestry sectors and Landcare Research crosses over the agricultural and environmental sectors.

As well as the current funding the ministry reminded us there are three new National Science Challenges which provide around $85m in funding over the next five years to agricultural or biological research: "New Zealand's Biological Heritage", "Sustainable Seas", and "Our Land and Water". But Table One suggests those three challenges account for about $10m of this expenditure.

Overall, the ministry said, the government's investment in science and innovation has risen by more than 70% in the past seven years from $850m in 2007/08 to around $1.5 billion in 2015/16. But let's not forget this has been less than growth in GDP.

AgScience was keen to go back to 2000, not only because that's when Professor Rowarth had been so heartened by Pete Hodgson's commitments but also because the ministry's tables were confined to periods when the Key Government was calling the shots.

We turned to Statistics New Zealand, which gathers R&D survey data every two years. But the published survey results do not give breakdowns to show investment in agriculture and horticulture.

The best we could do was use survey data from 2006 to expand one of the tables provided by the Ministry of Business, Innovation and Employment (Table Three). This shows business, government and university investment for primary industries purposes over an eight-year period.

First, we can see R&D spending for these purposes has slipped from 18% to 17% of total R&D.

Second, growth in the university sector is greater (although much smaller in dollar terms) than in the business and government sectors.

Third, in the government sector it has shrunk by 10% since 2010.

And fourth, whereas total R&D spending shown in Table Two increased by 47% from 2006-2014, the sums put to primary industries purposes increased by just 33%.

We await with interest the results of the 2016 survey. Meanwhile, it's sobering to note that average R&D investment in the OECD increased from 2.2% of GDP to 2.4% in the 10 years to 2014. In this country it shrunk from 1.19% to 1.17%.

R&D FOR PRIMARY INDUSTRIES PURPOSES

Table 3 *Source: Statistics NZ*

	Business	Govt	Universities	Total	Proportion of total R&D
			$(million)		
2006	151	145	37	333	18%
2008	134	213	52	398	18%
2010	137	214	51	402	16%
2012	194	213	50	457	17%
2014	195	192	58	444	17%
Average annual % change since 2006	4	4	7	4	

Sustainable farming systems for the future

SUSTAINABLE FARMING SYSTEMS FOR THE FUTURE was the theme for 2015 Forum of the Canterbury Sector of NZIAHS. The 12 speakers discussed sustainability from a range of perspectives, each highlighting the importance of finding a balance between productivity and environmental and economic sustainability.

Blake Holgate, Sustainable Farm Systems Manager at Rabobank, set the scene in relation to population growth and the global food crisis. Every month – he reminded the audience – the world population grows by a city the size of Hong Kong and by 2050 we will need to produce considerably more food, using fewer resources.

Holgate identified four key areas that must be addressed: food availability (our ability to produce food), food accessibility, balanced nutrition and global stability. He believes New Zealand production could be enhanced by greater cooperation within supply chains, using existing knowledge more effectively, greater investment in research and development, reducing losses in the supply chain and improving education around agriculture and food. His key message for New Zealand producers and exporters was that we shouldn't try to be the world's supermarket; rather, we should aim to be the deli, selling high-quality, high-value food products.

On the subject of high-value products, Lincoln University's Honorary Professor of Agri-Food Systems, Keith Woodford, discussed the constraints that New Zealand dairying's seasonal production systems place on the industry's supply and value chains. He explained that the manufacture of up-and-coming products such as extended-shelf-life milk, which has a shelf life of five to nine weeks but no unpleasant UHT taste, requires massive investment in processing plants. These plants need to be utilised at levels well above the 50% of most powder plants to make a return on investment. This in turn requires access to a steady year-round supply of milk of a consistent quality. His solution here is to shift more herds inside.

Farm management consultant Andy Macfarlane was more focused on the farm business, listing the factors which are necessary for successful agricultural industries and businesses. For primary industries, those factors are access to and management of resources; targeted and effective research, development and extension; exposure to high-value markets; access to capital; and, again, a robust and cost-effective supply chain. For farm businesses, they revolve around the ability to balance product demand and supply; be resilient to volatility and change; balance inputs and outputs and develop and execute a plan.

Consultant Jim Grierson's list of critical requirements for horticulture were similar – availability of land and water, a strong supply chain including back-to-back contracts, transport infrastructure and market access, and strong industry organisations and support. He said about 12,000 hectares of horticultural crops are grown in Canterbury, the largest areas taken up by fresh vegetables (9,000 ha) grapes (1,600 ha) and berryfruit (1,100 ha).

The benefits of improved access to water were outlined by Susan Goodfellow, from the Central Plains Water Scheme. The scheme will result in 27,000ha of dry land being converted to irrigation, the level of intensification set within a capped nitrogen load. CPW believes this increased access to irrigation will contribute to community sustainability, as well as farm businesses, estimating that annual direct and indirect regional agricultural output will increase by $592m per annum with a wider economic impact of over $1b to $1.4b per annum.

In contrast, Professor Derrick Moot, of Lincoln University, enthusiastically proclaimed the benefits of dryland pasture plants such as Lucerne, calling for more interest in the development of dryland farming systems. His ideal dryland pasture has a high legume content with a high leaf-to-stem ratio and a young herbage age. Such

a pasture will be drought-tolerant, produce its own nitrogen (N) and meet animal-feed requirements while being productive, profitable and socially acceptable. He would like to see greater investment in research around plant growth and resource-use efficiency, legume systems to meet economic production demands across diverse soil, climate, topography and technology transfer and implementation to enhance environmental and production outcomes.

The development of the Matrix of Good Management Programme (MGM) was covered by Dr Ina Pinxterhuis, from DairyNZ. MGM was set up to quantify the typical nitrogen (N) and phosphate (P) losses expected from Canterbury farms managed to industry agreed good management practices. MGM required buy-in from regulators, researchers and the relevant primary sectors to succeed. This was achieved through an approach which Dr Pinxterhuis says went beyond conventional collaboration to co-development, based on clearly defined common goals and time, patience and perseverance.

At a time when the environmental impacts of dairying are a hot topic of policy debate, a presentation by Prof Grant Edwards and Ron Pellow comparing the productivity, economic return and environment impact of high and low input systems on the Lincoln University Dairy Farm provided much food for thought. Their project compared a system with more cows and more inputs with one using fewer cows and lower inputs. They found the low-input, high-efficiency strategy reduced the environmental footprint, but it also impacted on profit. The work will continue with the aim of finding ways of greater gains in feed production on the milking platform, while maintaining an acceptable environmental footprint.

North Canterbury sheep and beef farmer James Hoban is concerned with the sustainability of the whole industry as well as his own small part of it. He believes the industry is good at innovation, pointing out that today's sheep farmers export the same amount of meat, from a national flock of 28 million, as they did from 70 million in the 1980s. He has concerns about farming to meet blanket regulations. While he believes the industry as a whole is doing OK on the environmental front, he would like to see more research being done to fill some gaps in knowledge around farm systems.

Farm systems are a key focus for the cropping industry where soil, water and nutrient management, integrated weed, pest and disease management and agrichemical resistance are high on the list of sustainability issues being addressed. FAR chief executive Nick Pyke says research has shown that appropriately selected and managed crops can add sustainability to farm systems, for example by "mopping up" nutrients. But like all other primary industries, cropping farmers are searching for a good balance between economic and environmental outcomes. The industry is placing more emphasis on environmental reporting and has recently developed a specific Farm Environment Plan template for cropping farms. It is also encouraging growers to take up the electronic recording system ProductionWise®.

Professor Steve Wratten, from Lincoln University, switched the focus firmly back to environmental management, listing the unsustainability of many conventional farming systems and the benefits of agro-ecological farming methods, which maximise the contribution of ecosystem services such as biological control, pollination and beneficial microbes.

Prof Jacqueline Rowarth finished the day by noting that in terms of nitrogen use per unit of production, New Zealand is a model of best practice and that our future role as a food provider could be the production of high-quality animal protein – milk and meat. She also suggested that dairy goats and sheep are likely to be part of the new scenario.

The key messages, which were repeated throughout the day, were around the need for new technologies for use on farm and in manufacturing that will support the development and production of safe, high quality food products for discerning clients.

Biological Heritage – quite a challenge

THE NATIONAL SCIENCE CHALLENGE for New Zealand's Biological Heritage, led by Dr Andrea Byrom from Landcare Research, is now fully under way with the recent appointments of two programme leaders to complete the science team.

Central to the challenge are the four pillars of wellbeing: a belief that our biological heritage can contribute to economic, environmental, cultural and social outcomes, and that conservation gains should enhance – not diminish – the economic gains delivered by New Zealand's primary sector.

PROGRAMME 1 is led by Thomas Buckley (Landcare Research), who has been involved in the challenge from its inception. The aim is to create solutions to allow biodiversity and biosecurity decision-makers to have accurate, comprehensive information at their fingertips.

Maureen O'Callaghan (AgResearch) and Duane Pelzer (Landcare Research) this year picked up Programmes 2 and 3 respectively.

PROGRAMME 2 is focused on reducing rates of incursion or establishment by foreign invader species; improving efficacy of pest management by scaling-up control operations.

PROGRAMME 3 brings everything together. Enhancing and restoring the resilience of vulnerable ecosystems (including primary sector ecosystems); preventing biodiversity loss, and mitigating the effects of global change.

A call for contestable funding proposals will kick off in May, the exact timing to be advised.

Projects already funded include Phil Lester's multi-pronged wasp control research, Robert Holdaway's collaborative work on e-DNA profiling, Phil Lyver's project on customary approaches to management of taonga species, Phil Hulme's work on invasion pathways and networks, and Jason Tylianakis's multi-disciplinary approach to social and ecological tipping points in ecosystems.

The challenge is all about driving step changes in the science by aligning and complementing existing research across the 17 challenge parties. Advances in e-DNA profiling, and new science and technology to multiply pest eradication efforts, are obvious examples. The challenge will have a particularly strong public engagement aspect, as much of the work to apply the research, or capture data, cannot be done without public buy-in and involvement.

We are already seeing thousands of people in literally thousands of spontaneous formations, volunteering to set and clear trap-lines, monitor birds, and restore land and waterways on various scales. The movement is building. The challenge's goal is to win many more hearts, minds, volunteers, investors and private sector champions. But the foundation of this will be science, not rhetoric – science that rewards and spurs these efforts on with help to define objectives, achieve greater efficiency and economies of scale, and provide reference data to measure their progress.

The challenge will be profiling and supporting some joint privately/publicly/community funded endeavours around the country, starting with the Cape to City project in Hawke's Bay. An inspiring team of private philanthropists (Andy Lowe and Julian Robertson), Hawke's Bay Regional Council staff (Campbell Leckie and team), Landcare Research scientists (led by Grant Norbury) and DOC staff are building on the success of the Cape (Kidnappers) Sanctuary, to see if they can extend the pest-free zone right through to Hastings and Havelock North – urban and agricultural/horticultural/viticultural land – and reintroduce native plant and animal species. It has worked on the farm at Cape Kidnappers. If it can succeed on this much larger scale, other regions may be able to do the same. There is already strong interest from neighbouring regions.

This challenge is not confined to conservation land. It is interested in all 29 million hectares of New Zealand and every resident within, plant and animal. Quite a challenge.

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New Zealand's Biological Heritage National Science Challenge is hosted by Landcare Research and supported by the Ministry of Business, Innovation and Employment. The Challenge partners are AgResearch, Auckland University of Technology, Department of Conservation, ESR, GNS Science, Lincoln University, Massey University, Ministry of Primary Industries, NIWA, Plant & Food Research, Scion, University of Auckland, University of Canterbury, University of Otago, Victoria University, and University of Waikato.

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