chapter five

RESEARCH IN TERTIARY EDUCATION

Research, Knowledge Creation and Uptake for Our Knowledge Society

INTRODUCTION

The country's innovation system is a complex network of research organisations, educational institutions, industry associations, financial institutions and communities. That system relies on the supply of knowledge, highly skilled workers and financing to support the growth of new ideas, products, processes and organisations to create economic, social and environmental benefits.

In 2001, New Zealand ranked 11th of 20 countries in research productivity per head of population, with a productivity rate similar to those of Australia, Canada and the United States[1].

The tertiary education system plays a key role in furthering research and innovation in New Zealand. The advancement of knowledge through education and research is a core function of the tertiary education sector. The sector also undertakes significant research focused on adapting, transferring and exploiting domestic and international knowledge and technology. It does this alongside, and sometimes in partnership with, other research organisations, industry and business, community organisations, and government. The tertiary education sector is responsible for the largest share of the country's research output.

Most importantly, the tertiary education sector is responsible for the training of the research workforce and for producing graduates with skills, knowledge and attributes that enable them to contribute to the innovation system.

This chapter discusses the contribution of the tertiary education sector to the innovation system. In particular, it focuses on the universities, which are the most significant producers of research in the sector[2]. It explores the sector's role in knowledge creation and innovation, looking at indicators of research output and productivity. It discusses trends in the financing of research in tertiary education. It also explores the implications of the new system for funding of research in tertiary education – the Performance-Based Research Fund (PBRF) – and reports on the information provided by the 2003 PBRF quality evaluation about the quality of research in tertiary education.

FOSTERING RESEARCH IN TERTIARY EDUCATION IN NEW ZEALAND

The New Zealand government, like other governments, has recognised the crucial role played by the innovation system in the creation of a knowledge-based society and economy and, hence, in economic and social development. It has also recognised the critical part played by the tertiary education sector in the innovation system. The sector is a significant producer of research and, consequently, of new knowledge – producing around 66 percent of the nation's research papers[3]. It also has the responsibility for the key task of training researchers for the innovation system.

The primary roles of tertiary education research activities are to:

- support degree-level teaching and ensure that degree graduates are of high quality and informed by up-to-date scholarship and developments in the knowledge base
- train New Zealand's future knowledge-creators and innovators
- contribute to improving the knowledge base through high-quality research that generates new knowledge, and
- interpret new knowledge and disseminate it as a means of influencing people in communities and business.

One traditionally important contribution of the universities to the national research effort is in the area of pure basic research, which involves exploring and expanding the frontiers of knowledge. Whereas the Crown Research Institutes (CRIs) and many other research providers are more likely to focus on applied or strategic research, the traditional role of the universities in postgraduate training and the nature of the funding for research in the universities mean that university-based researchers have greater opportunity to work in basic research. The Ministry of Research, Science and Technology (MoRST) and Statistics New Zealand (SNZ) estimate that one third of all research conducted in the tertiary education sector is basic research. The MoRST/SNZ survey reports that just over a half (51 percent) of the basic research in New Zealand was conducted in the universities[4].

Like governments in other countries, the New Zealand government has sought ways to enhance the excellence and relevance of the research produced by the sector and to increase the quantity of the high-quality research it produces. Successive governments have, therefore, sought to refine the system of funding research in the sector as a way of lifting performance. As part of its current tertiary education reforms, the government has developed two major new means of promoting and funding research in the sector.

The first is the Centres of Research Excellence (CoREs) established during 2002 and 2003. The CoREs have been designed to support world-class research that will contribute to New Zealand's development as a knowledge society. The CoREs are inter-institutional research networks with researchers working together on a commonly agreed research plan. Information on the seven CoREs is set out later in this chapter.

The second is the Performance-Based Research Fund (PBRF) which is being phased in over the period 2004 to 2007 and which will shift the basis of research funding from a system based on student enrolments to one where funding will be allocated on the basis of research performance[5]. One consequence of the shift to the PBRF is that much more information is now collected on research in tertiary education, for example the quality of the research, the people conducting research in tertiary education organisations and the relative research performance in different research fields and organisations. Much of the material in this chapter is drawn from information gathered in 2003 as part of the implementation of the PBRF.

[1] Ministry of Research, Science and Technology (MoRST), Foundation for Research, Science and Technology (FRST), Health Research Council (HRC) and Royal Society of New Zealand (RSNZ) (2003), *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research.*

[2] Section 162 of the Education Act 1989 characterises universities as institutions whose '… research and teaching are closely interdependent and most of their teaching is done by people who are active in advancing knowledge [and meeting] … international standards of research and teaching … '. The Act also states that universities are '… characterised by a wide variety of teaching and research …'.

[3] *National Bibliometric Report, 1997 to 2001,* op. cit., page 3.

[4] MoRST and SNZ, *Research and Development in New Zealand 2002.* See pages 4 and 39. The report estimates that about 20 percent of all New Zealand research is pure basic research. It makes these estimates by calculating the expenditure on research activities by research type, as reported in the responses to its survey.

[5] Detailed information on the operation of the PBRF can be found in *New Zealand's Tertiary Education Sector: Profile & Trends 2002,* Ministry of Education, 2003, pages 108-110 and in *Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment,* Tertiary Education Commission, 2004, pages 15-23.

DEFINING AND ASSESSING RESEARCH

The definition of research developed for use in the PBRF is drawn from the definitions used by a variety of authorities, including that used in international statistical studies conducted by the Organisation for Economic Cooperation and Development (OECD).

For the purposes of the PBRF, research is 'original investigation undertaken in order to gain knowledge and understanding. It typically involves enquiry of an experimental or critical nature driven by hypotheses or intellectual positions capable of rigorous assessment. It is an independent, creative, cumulative and often long-term activity conducted by people with specialist knowledge about the theories, methods and information concerning their field of enquiry'[6].

Eligible staff participating in the PBRF submit an evidence portfolio that includes a number of *research outputs*. Research outputs include articles in peer-reviewed journals, books, chapters, commissioned reports and periodicals. Theses, conference presentations and creative work count as research outputs. Research outputs can also include contributions to the intellectual infrastructure of subject areas, such as new scholarly editions, and investigation that leads to new materials, devices, products or processes.

In the PBRF, scores are assigned to each staff member by the panel of experts assessing the portfolio submitted by the staff member. The scores take account of the quality of the research outputs in the evidence portfolio, the contribution made to the research environment and the standing of the researcher in the community of researchers in that subject area. Those scores are used to assign a quality category to each researcher, with the quality category 'A' representing the highest quality standard.

Where a researcher does not meet a threshold for the 'A', 'B' or 'C' quality categories, an 'R' category is assigned. Those assigned an 'R' category include those who are embarking on a research career and hence have not yet had the opportunity to produce many research outputs or to acquire the research standing that would lead to the award of an 'A', 'B' or 'C'[7].

In order to aggregate and average performance across fields of study and between providers and for comparative purposes, these categories are translated into numerical quality scores. The maximum possible quality score for a provider or a subject area is 10; this would occur if every single PBRF-eligible staff member in that provider or subject area were awarded an 'A' quality category.

As well as assessing the quality of the research work of each researcher, the PBRF uses two other indicators of the research quality of a provider. One is the number of *research degree completions*. Research degree completions are an important indicator of research activity as they are a measure of the extent to which the provider is meeting its research training function. Research degree students are important contributors to the provider's total research activity. The other PBRF indicator is the amount of money generated by the provider by way of *external research income*. Research contract funding is a good proxy measure of research quality as it is usually won through competitive bidding and is often subjected to rigorous peer review[8].

In this chapter, comparisons of research performance between subject areas are made using PBRF quality evaluation scores. Comparisons between providers are made using all three dimensions of the PBRF.

[6] The full definition, from which the comment above was drawn, can be found in *Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment,* Tertiary Education Commission, 2004, page 22. Page 33 of the report lists the types of research outputs considered in the 2003 quality evaluation.

[7] Refer to *Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment,* Tertiary Education Commission, 2004, pages 19-21 and 37-38 for an account of the scoring system. That explanation includes the weightings assigned to each of the elements of the PBRF scoring system.

[8] In this context, it needs to be noted that some research funding is commissioned by industry or by public sector agencies and hence is not won in competitive tender. The capacity of providers to maintain income from these sources over time depends on their reputation for delivery of research of high quality. It should also be noted that the main public research funds are oriented towards certain types of disciplines or outcomes. This limits the extent to which external research earnings can be used as a measure of research quality.

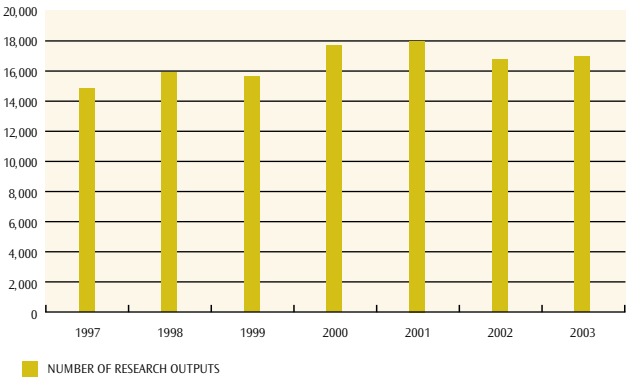
THE RESEARCH OUTPUT OF THE NEW ZEALAND TERTIARY EDUCATION SECTOR

The annual reports of tertiary education institutions provide information on the research activities undertaken and the research outputs produced in 2003. That information is complemented by information on the quality of research outputs of tertiary education providers drawn from the 2003 PBRF quality evaluation. These sources of information are also triangulated by independent studies of research output, and, in particular, bibliometric studies[9].

Any *count* of research outputs cannot capture the quality, scale or impact of the research behind those outputs. In addition, there are differences in publishing conventions and practices between disciplines. As a result, the information on trends in numbers of research outputs is balanced by data from the PBRF quality evaluation.

The annual reports of the universities indicate a significant increase in research output over the last seven years, but with output having levelled off in the last four years[10]. A total of 16,887 university publications and other research outputs was reported for 2003, compared with 16,686 in 2001 and 14,747 in 1997. The number of research outputs reported by the universities increased by 14.5 percent over the seven years between 1997 and 2003.

FIGURE 5.1: UNIVERSITY RESEARCH OUTPUTS 1997-2003



Note: There may be substantial lags between research activity and the resulting research output.

Source: Annual reports of universities.

Clinical medicine is the largest single category for tertiary education sector research publications[11], representing 22 percent of all tertiary education sector publications in 1996 and 2001. Out of the 24 subject categories, the top five in terms of output are: clinical medicine; plant and animal science; chemistry; social sciences; and biology and biochemistry.

Using the 2003 PBRF quality evaluation scores, a sense of the quality of research produced in each of the 41 research subject areas can be gained. The highest-scoring subject area was philosophy, with an average quality score of 4.74 against an overall average for all subject areas of 2.59[12]. Many of the highest performing subject areas were sciences, with five of the 10 highest ranked subjects in scientific fields. Of the 12 PBRF panels, the four panels with the highest average quality scores were in scientific and technological areas[13].

[9] Bibliometrics is the term given to the quantitative study of research output. Refer to the *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research,* 2003, for a detailed account of bibliometrics, the methods used in bibliometrics and the limitations of bibliometric data.

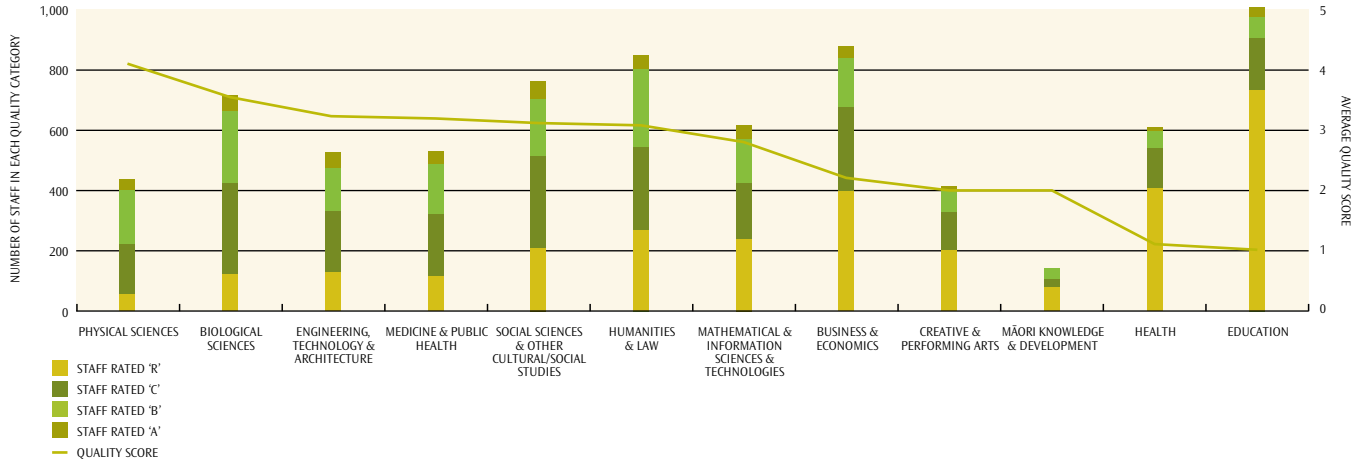
[10] Caution needs to be exercised in attributing an output to a particular year. In many cases the work needed to create that output took place over several years. There are also often significant delays in the appearance of completed publications.

[11] In this analysis, research papers are categorised according to Thomson-ISI subject fields.

[12] The scores quoted are weighted by the number of full-time equivalent PBRF-eligible staff members. The maximum possible score is 10, which would be obtained if every PBRF-eligible researcher working in the subject area was rated 'A'.

[13] Each portfolio submitted for assessment in the PBRF was assigned to a research subject area. The subject areas were grouped for assessment purposes by panels of experts that were responsible for assessment of a group of similar subject areas.

FIGURE 5.2: PERFORMANCE-BASED RESEARCH FUND 2003 QUALITY EVALUATION RESULTS – NUMBER OF FTE STAFF IN EACH QUALITY CATEGORY AND AVERAGE QUALITY SCORE FOR EACH SUBJECT PANEL

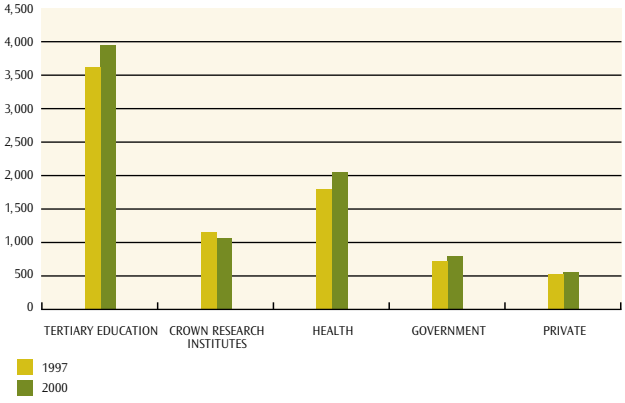


Source: Tertiary Education Commission.

The *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research*[14] notes that research papers from the New Zealand tertiary education sector published in 1997 were cited on average 6.1 times each over the period 1997 to 2001, an increase from 1996 (5.8 citations per paper) and 1986 (4.2 citations per paper). The rate of citation of tertiary education sector publications was similar to that of papers internationally, given the journals that they are published in.

The report also notes that the tertiary education sector is responsible for the largest share of the research output of the country. Over the period covered by the report, the tertiary education sector was responsible for 66 percent of indexed research papers produced in New Zealand. This represents a gain on the figure for 1997 (51 percent). Figure 5.3 shows the relative size of the research sectors in 1997 and 2000[15].

FIGURE 5.3: NEW ZEALAND'S INDEXED SCIENTIFIC RESEARCH PUBLICATION OUTPUT DISTRIBUTION BY RESEARCH SECTOR 1997 AND 2000



Source: Ministry of Research, Science and Technology.

While the information above is primarily concerned with research conducted by the universities, other tertiary education institutions were also active in research, albeit on a smaller scale.

The polytechnic sub-sector produces a modest[16] but increasing volume of reported research output, primarily focused in the area of applied research. Two of the largest producers of research output are UNITEC Institute of Technology and the Waikato Institute of Technology, which reported 842 and 612 research outputs respectively in 2003.

[14] MoRST, FRST, HRC, RSNZ, *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research, 2003.*

[15] The definition of research outputs used in the PBRF is broader than that used in bibliometric studies, which are focused on research publications.

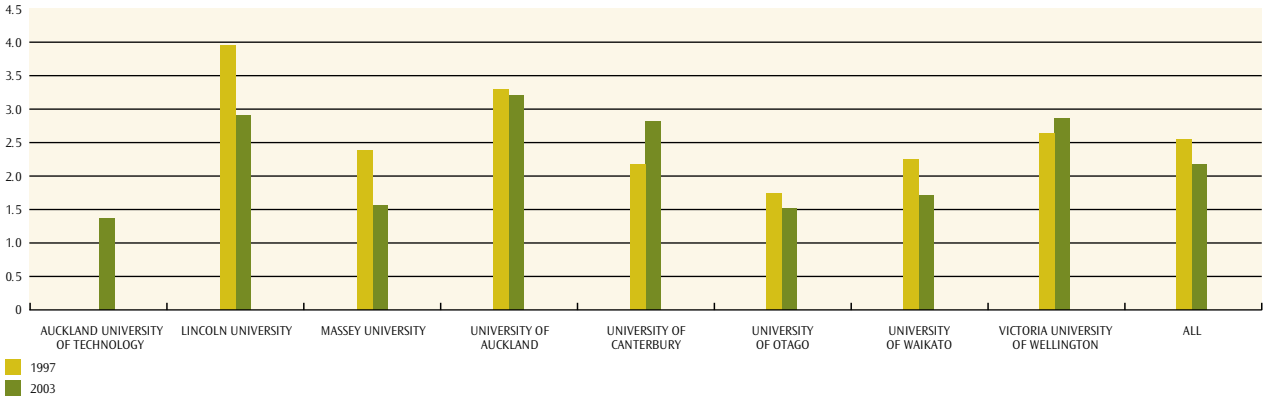
[16] Only two polytechnics chose to participate in the PBRF.

A Statistics New Zealand survey of business practices in 2003[17] found that 14 percent of New Zealand businesses that were classified as innovators considered universities an important or very important source of information for innovation. This compared with 72 percent who found their suppliers an important or very important source of innovation information, 53 percent for other New Zealand businesses in the same industry, 60 percent for books, journals, conferences and shows and 28 percent for research institutes.

RESEARCH PRODUCTIVITY

One measure of research productivity is the number of research outputs for each academic staff member. In 2003, there were 2.2 publications per full-time equivalent academic staff member (FTE) in New Zealand universities. This compares with 2.5 in 2002 and 2.5 in 1997. Figure 5.4 below shows the number of publications per FTE in each of the universities in 1997 and 2002.

FIGURE 5.4: PUBLICATIONS PER FULL-TIME EQUIVALENT ACADEMIC STAFF MEMBER PRODUCED IN NEW ZEALAND UNIVERSITIES IN 1997 AND 2003



Notes:

[1] The Auckland University of Technology (AUT) was granted university status in 2000. No count is included of publications of its predecessor institution, AIT.

[2] There may be substantial lags between research activity and the resulting research output.

[3] Universities have different approaches to recording research outputs in their annual reports. As a result, there is some inconsistency between the ratios shown in the graph above.

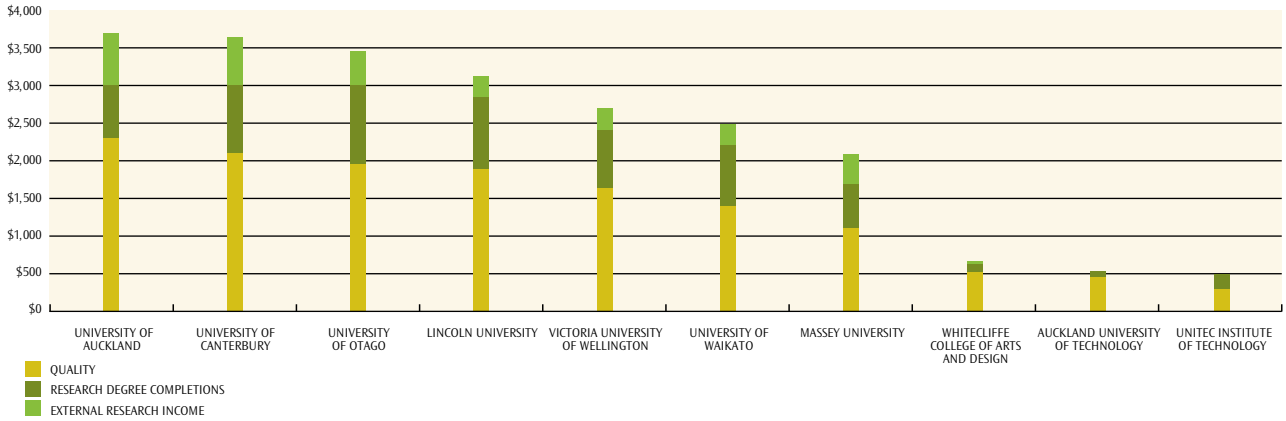
Source: Annual reports of universities.

The key measure of the research productivity of tertiary education organisations is the amount of PBRF funding generated per full-time equivalent staff member eligible for consideration under the PBRF. This indicator takes account of the quality and significance of the research produced as it includes the quality evaluation scores. It also takes account of the research degree completions and the external research earnings of the organisation, which broaden the picture of research activity in the organisation. Figure 5.5 displays the results of the initial 2003 evaluation for the eight universities in earning funding from the $18.2 million available for distribution[18].

[17] Statistics New Zealand, *Innovation in New Zealand 2003*, page 21.

[18] The sum of $18.2 million was the amount of contestable funding available under the initial PBRF distribution. The sum reflects the gradual phase-in of the PBRF over the years 2004 to 2007. The final amount available for distribution under the PBRF is expected to be of the order of $170 million. In interpreting Figure 5.5, it is important to note that the dollar sums are being used as an index of performance only, so it is the relative (rather than the absolute) size of the allocation that matters.

FIGURE 5.5: PBRF FUNDING GENERATED PER FULL-TIME EQUIVALENT PBRF-ELIGIBLE STAFF MEMBER – THE 2003 PBRF ROUND



Note: This graph shows only the 10 tertiary education organisations that scored highest of the 22 participating organisations.

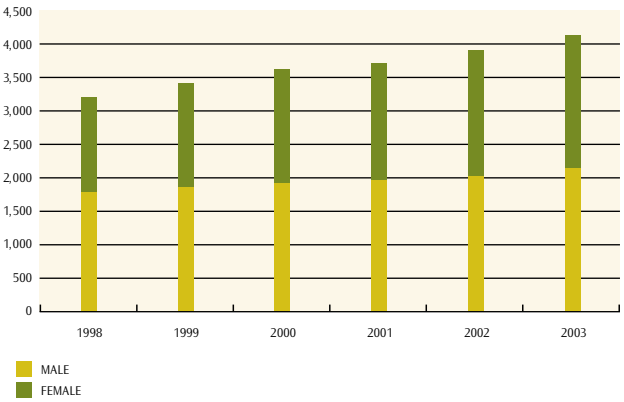
Source: Tertiary Education Commission.

In addition to the eight universities, 14 other tertiary education organisations participated in the 2003 PBRF round. Whitecliffe College of Arts and Design was ranked eighth ($673 per FTE), UNITEC Institute of Technology ($492 per FTE) was 10th, Carey Baptist College ($388 per FTE) was 11th and Anamata ($334) was 12th.

TRAINING OF RESEARCHERS

Formal training in research is mainly carried out through postgraduate research degrees. Between 1998 and 2003, enrolments in doctoral studies in the eight universities increased by 30 percent, from 3,202 to 4,152. Growth between 2002 and 2003 was 6 percent.

FIGURE 5.6: DOCTORAL DEGREE ENROLMENTS BY GENDER 1998-2003



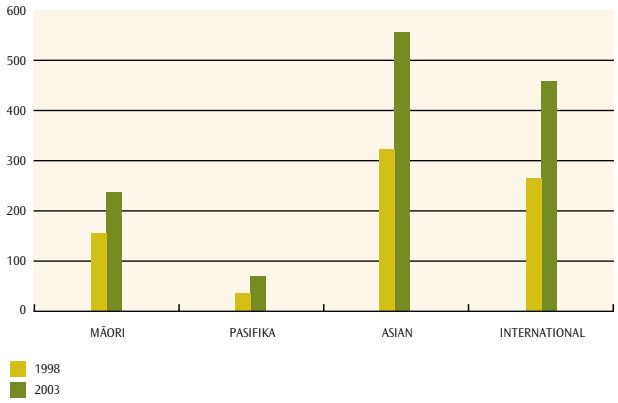
Women and Māori remain under-represented in enrolments in research degrees, but the trends are positive. In 2003, while women represented 57 percent of all formal enrolments in tertiary education, they constituted only 48 percent of doctoral enrolments. The corresponding figure for 1998 was 44 percent and there has been an increase in the percentage of women each year since then. Enrolments by women in doctoral degrees grew by 42 percent over the last six years while doctoral enrolments as a whole grew by 30 percent.

In 2003, Māori made up 6.3 percent of all Doctor of Philosophy (PhD) enrolments by domestic students, whereas Māori constituted more than 20 percent of all enrolments in tertiary education. The rate of participation of Māori in postgraduate study in 2003 was little more than half the rate of non-Māori – 0.6 percent of the population over the age of 15, compared with 0.9 percent for non-Māori. While these statistics show that Māori are still not engaging in postgraduate study to the same extent as the whole population, Māori enrolments in postgraduate qualifications have grown faster than for the whole population. The proportion of domestic PhD students who were Māori in 1998 was 5.2 percent.

The trend is similar for Pasifika peoples. Pasifika students constitute only 1.9 percent of doctoral enrolments, but 5.5 percent of all tertiary enrolments. At the doctoral level, Pasifika enrolments rose by 91 percent (from 37 to 71) over the period 1998 to 2003, while those for the doctoral enrolments grew by 26 percent among domestic students as a whole. The rate of participation by Pasifika peoples in postgraduate study was low; only 0.4 percent of the Pasifika population aged 15 or over was enrolled in postgraduate study on 31 July 2002. The rate for the population as a whole was twice that – 0.8 percent.

Enrolments in doctoral programmes by international students grew by 28 percent in 2003 and by 74 percent over the six years from 1998 to 2003, a rate higher than the population as a whole. International students now constitute 11 percent of all PhD students in the universities, compared with 8.2 percent in 1998. International doctoral students make a particular contribution to the research culture in the institutions in which they work.

FIGURE 5.7: NUMBER OF DOCTORAL ENROLMENTS BY SELECTED GROUPS 1998 AND 2003



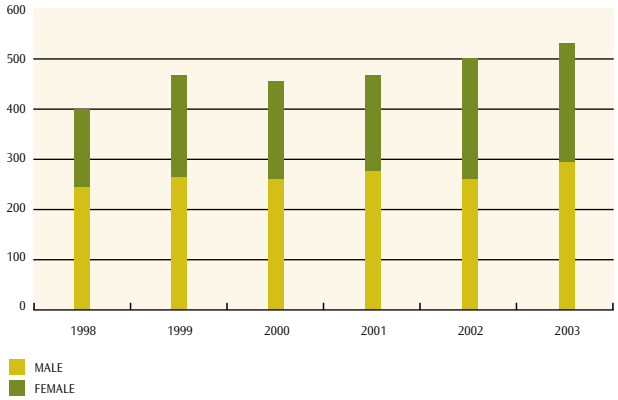
Notes:

[1] Each student is shown in each ethnic group he/she identifies with.

[2] Pasifika and Asian enrolments include domestic and international students of those ethnicities.

The number of PhD degrees awarded by New Zealand tertiary education institutions rose by 6.6 percent between 2002 and 2003. The number of awards has risen by 33 percent since 1998.

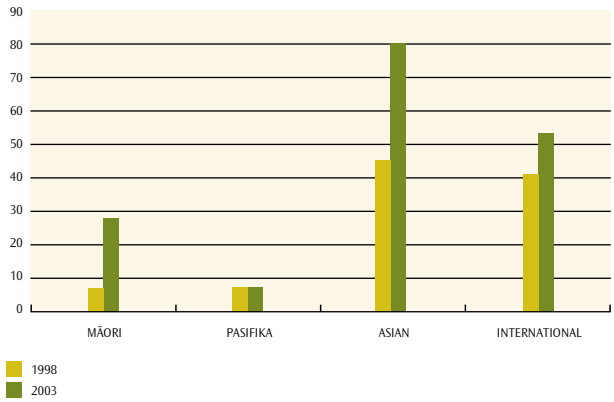
FIGURE 5.8: DOCTOR OF PHILOSOPHY DEGREE COMPLETIONS BY GENDER 1998-2003



The number of women awarded PhD degrees in 2003 as a proportion of all those earning doctoral qualifications was 45 percent, compared with 48 percent in 2002 and 39 percent in 1998. The gradually increasing representation of women among those awarded doctoral qualifications reflects the enrolment trends. It is not out of line with other countries. OECD data[19] shows that the proportion of women among advanced research degree graduates in 2002 in New Zealand was 47 percent. This was more than in Australia (44 percent), more than in the United Kingdom (42 percent) and roughly the same as in the United States (46 percent). The mean for all OECD countries was 40 percent.

The number of Māori awarded PhD degrees is very low in relation to the number of Māori completing all qualifications, but has risen sharply since 1998. In 2003, there were 28 PhD degrees awarded to Māori, up from 21 in 2002 and from only seven in 1998. The share of domestic students earning doctoral qualifications who were Māori was 5.8 percent in 2003, compared with 2 percent in 1998. The number of Pasifika students awarded PhD degrees is also low – seven in 2003, four in 2002 and seven in 1998.

FIGURE 5.9: NUMBER OF DOCTOR OF PHILOSOPHY DEGREE COMPLETIONS BY SELECTED GROUPS 1998 AND 2003



Notes:

[1] Each student is shown in each ethnic group he/she identifies with.

[2] Pasifika and Asian enrolments include domestic and international students of those ethnicities.

[19] OECD, *Education at a Glance, OECD Indicators 2004*, Table A4.2, page 84.

The most common broad areas of study for doctoral degrees completed over the period 1998 to 2003 were the social sciences (19 percent), the biological sciences (20 percent), the physical sciences (16 percent) and the humanities (11 percent). These four areas collectively represented two thirds of all doctoral completions from New Zealand tertiary education institutions over those six years. Medicine and health-related sciences constituted 9 percent of the doctoral completions, while engineering/architecture represented 8 percent of the total. Other fields with significant shares of the total were agriculture, horticulture, forestry and environment (4 percent), mathematics and information/computer science (6 percent) and law, business and commerce (7 percent).

FIGURE 5.10: DISTRIBUTION OF DOCTORAL DEGREE COMPLETIONS BY FIELD OF STUDY 2003

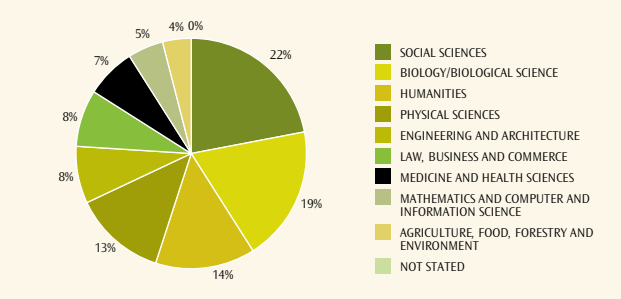
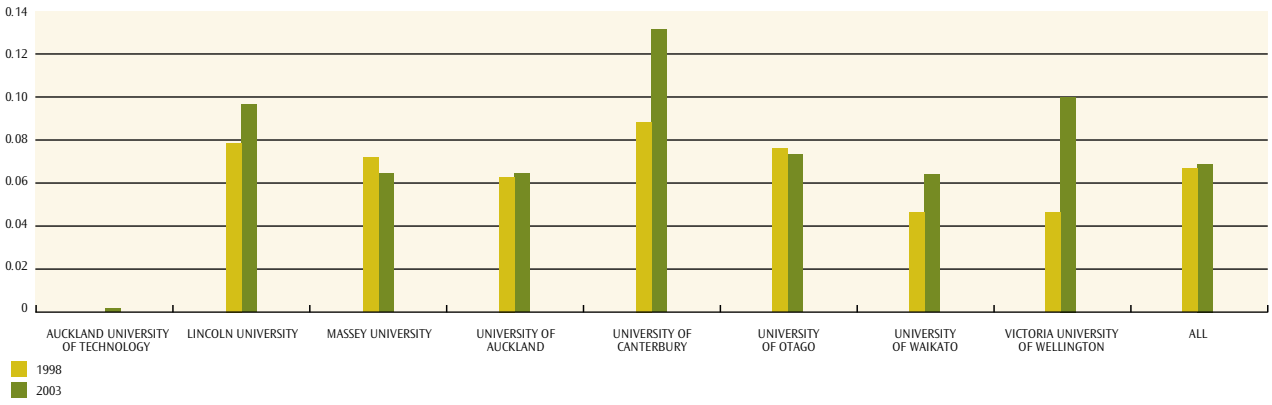


Figure 5.11 below gives an idea of the work of the universities in producing PhD graduates by comparing the number of doctoral graduates with the number of academic staff in each university.

An examination of the rate of completion of doctoral students shows that, of domestic students who started a doctorate in 1998, 23 percent had completed successfully by 2003. The long-term completion rate for doctoral students is estimated at between 54 and 57 percent[20]. That rate is similar to estimates of long-term completion rates for doctoral degrees in Australia[21].

In 2002, New Zealand ranked 14th out of 27 OECD countries for the graduation rates of advanced research programmes[22]. The OECD reports that in New Zealand, the proportion of the population at the expected age of graduation that holds advanced research degrees is 0.9 percent, compared with 1.3 percent in Australia and the United States, 1.6 percent in the United Kingdom and 2.7 percent in Sweden. The mean of OECD countries on this indicator was 1.1 percent. The corresponding ranking for New Zealand in 1999 was 14th of 23 countries.

FIGURE 5.11: DOCTORAL DEGREE COMPLETIONS PER FULL-TIME EQUIVALENT ACADEMIC STAFF MEMBER BY UNIVERSITY 1998 AND 2003



[20] Refer to Scott, David, *Retention, Completion and Progression in Tertiary Education, 2003*, Ministry of Education, page 13.

[21] Martin, Yew, Maureen Maclachlan and Tom Karmel *Postgraduate Completion Rates*, Occasional Paper Series, Higher Education Division, Department of Education, Training and Youth Affairs, Canberra.

[22] OECD, *Education at a Glance: OECD Indicators 2004*, page 69.

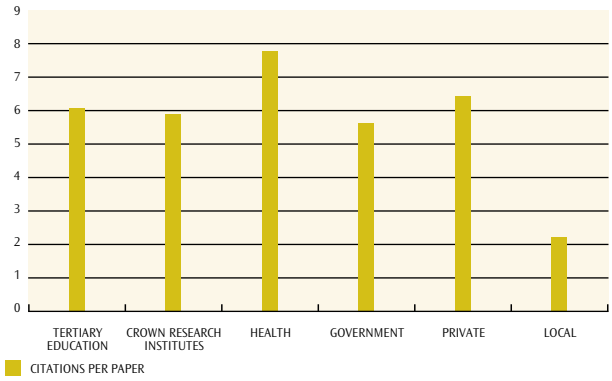
THE IMPACT OF TERTIARY EDUCATION SECTOR RESEARCH

The most common means of analysing the impact of research is through measuring citation rates – that is, the number of times a research paper has been cited or referred to in subsequent research publications. The *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research* reports on citation rates for recent New Zealand research publications, updating earlier studies of citation rates for 1986 and 1996[23]. However, the calculation of citation rates is never absolutely precise. Further, the number of citations is, at best, only a proxy measure for the impact of research. Trends in citation rates, however, are a well-accepted indicator of the extent to which a research community is building its research impact, and thus its research quality.

The probability of a paper being cited is dependent on a number of factors and, in particular, on the journal or other publication in which the paper appears and on the field of research. The *National Bibliometric Report* notes that tertiary education sector research publications that appeared in 1997 were cited during the period from 1997 to 2001 on average 6.1 times. This is roughly the number of citations expected, given the fields of research concerned and the journals used[24].

The citation rate for tertiary sector publications of 6.1 citations per paper in 2001 compares with 5.8 in 1996 and 4.2 in 1986. The 2001 citation rate for the Crown Research Institutes was 5.9 citations per paper, while there were 7.8 citations per paper produced by the health sector in 2001. The corresponding rates for the government and private research sectors were 5.7 and 6.4 respectively.

FIGURE 5.12: CITATIONS PER PAPER BY RESEARCH SECTOR 2001



Source: Ministry of Research, Science and Technology.

MoRST data shows that the amount of patenting by New Zealand universities is increasing, although their share of domestic patenting has been stable since 1992 at around 2 to 3 percent per annum. Between 1993 and 1997, Auckland Uniservices Ltd (a subsidiary of the University of Auckland that manages the university's research contracts) ranked second in the list of New Zealand's top patenting organisations. Most university patents are in biotechnology and scientific instruments[25].

The Statistics New Zealand survey of innovative businesses conducted in 2003[26] asked innovative businesses about the types of organisation they had collaborative or cooperative arrangements with. Around 20 percent reported that they had collaborative arrangements with a university, institute of technology or polytechnic. This was about the same as reported collaborations with a CRI or other public research provider. Nearly 70 percent of respondents claimed to have collaborations with suppliers of equipment, components or software.

[23] Refer also to MoRST, *A Bibliometric Profile of the New Zealand Science System* 2001, which contains data on the 1996 bibliometric analysis.

[24] The ratio of actual citations to expected citations for university publications in this study was 1.03. This means that the number of citations of New Zealand tertiary education sector research publications was 1.03 times the number of citations made of other publications in the same journals. The corresponding ratios for other research sub-sectors were: CRIs, 1.13; health sector, 1.12; government, 1.08; private, 1.06.

[25] Source: MoRST (June 2000), *Options for Funding Tertiary Research,* page 11.

[26] Statistics New Zealand, *Innovation in New Zealand 2003,* page 42.

CASE STUDY

BUSINESS/TERTIARY COLLABORATION: AUCKLAND UNISERVICES LIMITED

The mission of Auckland UniServices Limited is to apply the research and expertise of the University of Auckland to the needs of clients and business. Uniservices was established as a wholly-owned subsidiary by the University of Auckland 15 years ago. Its 2003 performance review confirmed a record year, with revenues of $63 million, a gain of 12 percent over the 2002 year. Of this total, $56 million was from research and consulting and a further $6 million from intellectual property. UniServices' revenue constituted 13 percent of the University of Auckland's annual income in 2003 and 57 percent of its external research revenue.

In addition to the University of Auckland staff working on UniServices research projects, a further 549 research staff were employed directly by Uniservices, 306 full-time. Uniservices is now reputed to be the biggest single organisation in either New Zealand or Australia engaged in commercialising university research. Of its annual revenue, 81 percent comes from New Zealand clients. Along with managing and developing a wide range of commercial research, the company specialises in securing patents appropriately and ensuring that licensing agreements are in place to protect the financial future of marketable research. UniServices has launched a number of new companies to realise the commercial potential of its research.

In 2003 UniServices made 43 new patent filings. This level of activity is well ahead of nearly all other Australasian universities and is comparable with the number of patent applications filed by the University of Cambridge and other leading European universities.

During 2003 UniServices was able to:

- conclude a 10-year collaboration arrangement with global partners for research at the university's Auckland Cancer Society Research Centre
- complete a phase I clinical trial for a new anti-cancer drug, DMXAA, for UK-based AntiSoma plc
- continue cardiac MRI collaboration with Siemens, and
- collaborate with Australian biotech company Metabolic Pharmaceuticals in developing a potential treatment for osteoporosis.

The organisation began 820 new projects during the year.

UniServices aims to commercialise technology developed through University of Auckland research projects. Examples where UniServices worked to realise the commercial potential of research findings during 2003 included:

- the development of proprietary technology for the breeding and maturation of zebra fish, which are a major gene expression research tool, with the goal of selling services to research institutions throughout the world
- commercialising new software systems for predicting demand and water flows for the hydro-electricity industry, and
- commercialising new technology related to management of biological fluids.

In addition to expanding the commercial potential in those three areas, UniServices handled some very important pieces of research work during the year.

- New Zealand's expanding primary sector markets have required growing research. One trial, conducted with Dairy Goat Cooperative (NZ) Ltd and organised by UniServices, compared the first commercialised goat milk infant formula with the nutritional properties of cow milk formulae.
- Four years of important research into improving literacy in low-income schools was reported on in 2003. The research indicates that while the mechanics are complex, the results show that, if teachers put aside traditional low expectations of pupils in low-decile schools and are given intensive professional support, their pupils make strong sustained gains in literacy.
- For the fourth year running, the University of Auckland Business School survey on banking attitudes has produced a customer service benchmark for all New Zealand banks.

The Faculty of Medical and Health Sciences of the University of Auckland is developing a patented new molecule that could transform current ideas of effective vaccine protection. This is expected to be able to eliminate the need for booster shots and increase protection from existing vaccines. UniServices is working with commercial partners in these

developments as it has potential applications that include new treatments for hepatitis B, some cancers, multiple sclerosis and HIV/AIDS. The potential for large global markets for such products is very significant.

UniServices is an excellent example of the benefits that can come from the tertiary education sector working closely with business, using the expertise of the sector to create knowledge that can be used to meet the needs of business.

THE FINANCING OF RESEARCH IN TERTIARY EDUCATION PROVIDERS

Tertiary education providers in New Zealand fund their research activities from a variety of sources. Part of the funding allocated to providers that award degree-level qualifications recognises the costs of research activities. In addition, many providers are active in seeking external funding for their research work, through winning research contracts and grants. Part of that research contract and grant funding is provided by the government as part of its funding for the national research, science and technology effort. This section looks at the revenue generated by tertiary education providers – and especially the universities – from those sources.

GOVERNMENT FUNDING FOR RESEARCH IN TERTIARY EDUCATION

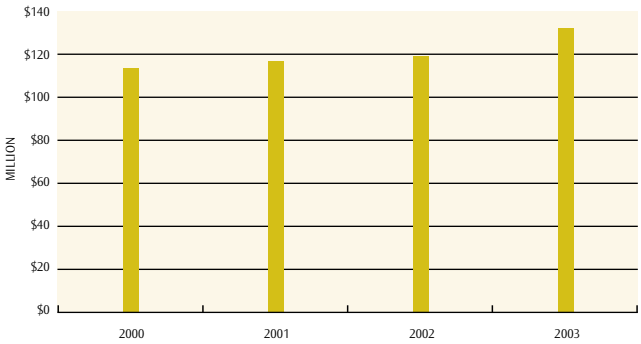
Since 2000, part of the government's tuition subsidy for enrolments at degree level in tertiary education has been designated a 'research top-up', recognising the statutory responsibility of institutions that teach at degree level to be active in research. The distribution of the research top-up funding among providers is determined by the number of enrolments at degree level. The research top-up funding has been the government's principal means of funding research in tertiary education. With the introduction of the PBRF from 2004, the research top-ups are to be phased out, with the money being reallocated to the PBRF for distribution to providers on the basis of their research performance.

The level of funding is related to the number of enrolments at degree level and higher, with the amount of the top-up funding depending on:

- the course classification and hence the funding category for enrolments in that field of study, and
- the level of the study, with lower top-up rates being paid for undergraduate degree enrolments and higher rates for enrolments in taught postgraduate courses and for research degree enrolments.

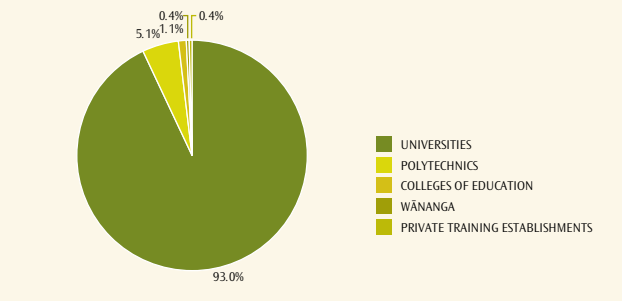
The value of the research top-ups in 2003 was $132.6 million, compared with $121.0 million in 2002 and $113.6 million in 2000. The 17 percent increase over that four-year period reflects both the expansion of enrolments at degree level since 2000 and also the increases in funding rates over that time. In addition to the research top-ups, there is a subsidy for international, wholly-research student enrolments intended to reflect the benefits to New Zealand that the research in these programmes can create. In 2003, this funding represented $2.1 million ($1.5 million in 2002).

FIGURE 5.13: RESEARCH TOP-UP FUNDING 2000-2003



Of the 2003 research top-up funding, 93 percent was allocated to the universities, 5 percent to the polytechnics, 1 percent to colleges of education, 0.4 percent to wānanga and 0.4 percent to PTEs.

FIGURE 5.14: RESEARCH TOP-UP FUNDING BY SUB-SECTOR 2003



Research top-up funding represented 9 percent of all tuition subsidy funding in the tertiary education institutions (TEIs) in 2003 and 4 percent of all TEI income. For the universities, the sub-sector with the largest involvement in research, the corresponding figures were 16 percent of funding and 6 percent of income.

Table 5.1 below shows the proportions of research funding in the years 2000 to 2003 generated by enrolments at each level of study. While around 85 percent of all enrolments generating research top-ups are at the undergraduate level, those enrolments generate relatively lower levels of research top-up funding than the enrolments of research students. Around 22 percent of the funding typically has been generated by undergraduate enrolments.

TABLE 5.1: PERCENTAGE OF RESEARCH TOP-UP FUNDING GENERATED BY ENROLMENTS AT VARIOUS LEVELS 2000 AND 2003

Level of qualification		Percentage of research top-up funding 2000	2003
2	Undergraduate Degree	21.4%	22.7%
3	Taught Postgraduate	19.1%	21.1%
4	Postgraduate Research	59.5%	56.3%

Table 5.2 divides the 2000 and 2003 research funding by funding category. An increasing share of the funding has been generated by enrolments in more highly funded categories.

TABLE 5.2: PERCENTAGE OF RESEARCH TOP-UP FUNDING GENERATED BY ENROLMENTS IN VARIOUS FUNDING CATEGORIES 2000 AND 2003

Field of study	Funding categories	Percentage of research top-up funding 2000	2003
Lower Cost	A, I	29.1%	28.8%
Higher Cost	B, C, G, H	70.9%	71.2%

About 28 percent of the research top-up funding is earned by enrolments in courses that are funded at lower rates. Around one third is earned by the natural sciences, while about one fifth derives from arts, humanities and social sciences, and about one tenth from each of health sciences; engineering, technology and architecture; and business[27].

One way of considering the impact of the PBRF on the allocation of research funding is to look at the percentage of the contestable PBRF funding won by each of the sub-sectors and then compare that with the percentage of research top-up funding earned in 2003.

TABLE 5.3: PERCENTAGE OF CONTESTABLE PBRF FUNDING BY SUB-SECTOR IN 2004 COMPARED WITH RESEARCH TOP-UP FUNDING IN 2003[28]

	2004 PBRF Contestable Fund allocation	Percentage of total 2004 PBRF Contestable Fund	Percentage of 2003 research top-up funding
All universities	$17,905,240	98.4%	93.1%
All polytechnics	$204,385	1.1%	5.0%
All colleges	$57,184	0.3%	1.1%
All wānanga	$9,213	0.05%	0.4%
All PTEs	**$23,978**	**0.1%**	**0.4%**

Note: Percentages may not add up to 100 because of rounding.

Source: Tertiary Education Commission.

[27] Note that, while the funding is allocated according to enrolments in different fields of study, providers are not constrained to spend the funding according to those fields.

[28] In comparing these percentages, it is important to note that the injection of new funding by the government in Budgets 2002 and 2003 means that the size of the total funding for research will grow over the next few years.

If the PBRF had been implemented completely in 2004 (ie without a phase-in) **and** with the same level of funding as provided in 2003 through the research top-ups[29], **and** with the same pattern of TEO participation as in 2003[30], then, compared with the funding provided in 2003 through the research top-ups:

- the **universities** would have *gained* about $7 million, representing 0.9 percent of their total funding and about 0.4 percent of total income
- the **polytechnics** would have *lost* about $5 million, representing 1.1 percent of their total funding and about 0.6 percent of total income
- the **colleges of education** would have *lost* about $1 million, representing 1.8 percent of their total funding and about 0.8 percent of total income, and
- the **wānanga** would have *lost* about $0.5 million, representing 0.3 percent of their total funding and about 0.2 percent of total income.

While the universities as a group gained a larger share of the funding from the 2004 PBRF contestable pool than from the 2003 research top-ups, in fact only three universities increased their shares – in order of the scale of increase, Otago, Lincoln and Auckland. The University of Waikato maintained its share. The other four universities experienced drops in share. Nearly all other providers that participated in all dimensions of the PBRF experienced a fall in share – the exception being Te Wānanga o Aotearoa where there was a small gain.

Implementing the PBRF without a phase-in would also have resulted in a shift of funding generated by courses funded at lower rates to activities funded at higher rates. The shift is illustrated in Table 5.4.

TABLE 5.4: PERCENTAGE OF CONTESTABLE PBRF FUNDING BY FUNDING CATEGORY IN 2004 COMPARED WITH RESEARCH TOP-UP FUNDING IN 2003

Field of study	Funding categories	Percentage of research funding	
		2003 research top-ups	2004 PBRF contestable funding
Lower Cost	A, I	28.8%	23.5%
Higher Cost	B, C, G, H	71.2%	76.5%

In part, this shift is attributable to the fact that student:staff ratios are higher in the lower cost areas. Research top-up funding was determined by student numbers, while PBRF funding is dependent on staff research performance and hence is influenced by the number of staff. The shift is also a reflection of the fact that some of the science disciplines scored highly in the PBRF.

OTHER SOURCES OF RESEARCH REVENUE

Providers also use student fees and other revenue to fund the costs of research. In addition, researchers in tertiary education providers bid for research contract funding from research funds and from private sponsors of research.

Research contract funding is a good proxy measure of research quality as it is usually won through competitive bidding and is often subjected to rigorous peer review[31]. Research contract income has grown substantially in the last six years, both in absolute terms and as a proportion of institutional income. In 2003, research contracts in universities constituted $264 million, compared with $235 million in 2002 and $131 million in 1997. This rise between 2002 and 2003 was 13 percent. Since 1997, research contract revenue has grown by 101 percent. Research contract income accounted for 13.6 percent of all university revenue in 2003, compared with 13.1 percent in 2002, 12.8 percent in 2000 and 11.1 percent in 1997.

The following graph shows the growth in total research contract income in the universities from 1997 to 2003.

[29] Note that the total amount of funding to be allocated through the PBRF, once the phase-in has occurred, will exceed that allocated under the research top-ups system.

[30] It is to be expected (given the nature of the PBRF) that the universities have increased their share of the whole, while the other sub-sectors have experienced a fall in their share. It needs to be noted, however, that in only two sub-sectors – the universities and the colleges – did all degree-awarding providers participate in all of the PBRF measures. In the polytechnics, for instance, only two providers participated. Those two providers together earned 1.99 percent of the research top-up funding in 2003 and 1.12 percent of the PBRF contestable funding in 2004.

[31] In this context, it needs to be noted that some research funding is commissioned by industry or by public sector agencies and hence is not won in competitive tender. The capacity of providers to maintain income from these sources over time depends on their reputation for delivery of research of high quality. It also needs to be noted that the main public research funds are oriented towards certain types of disciplines or outcomes. This limits the extent to which external research earnings can be used as a measure of research quality.

FIGURE 5.15: RESEARCH CONTRACT INCOME IN UNIVERSITIES 1997-2003

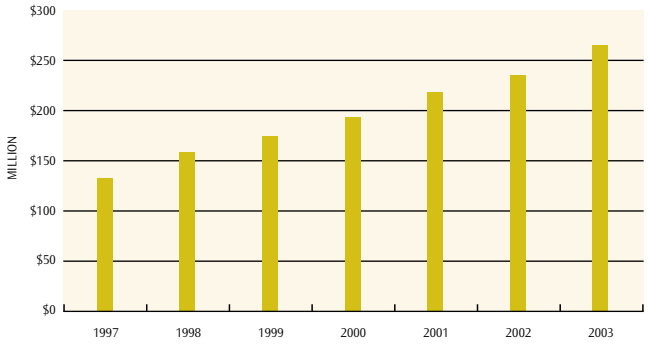
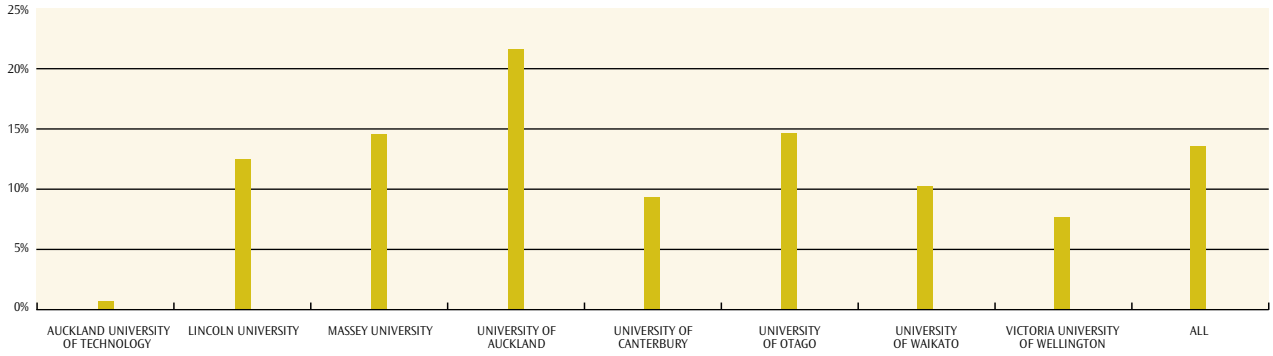


Figure 5.16 below shows the research contract income as a percentage of all income at each of the eight universities in 2003[32].

FIGURE 5.16: RESEARCH CONTRACT INCOME AS A PERCENTAGE OF ALL UNIVERSITY INCOME 2003

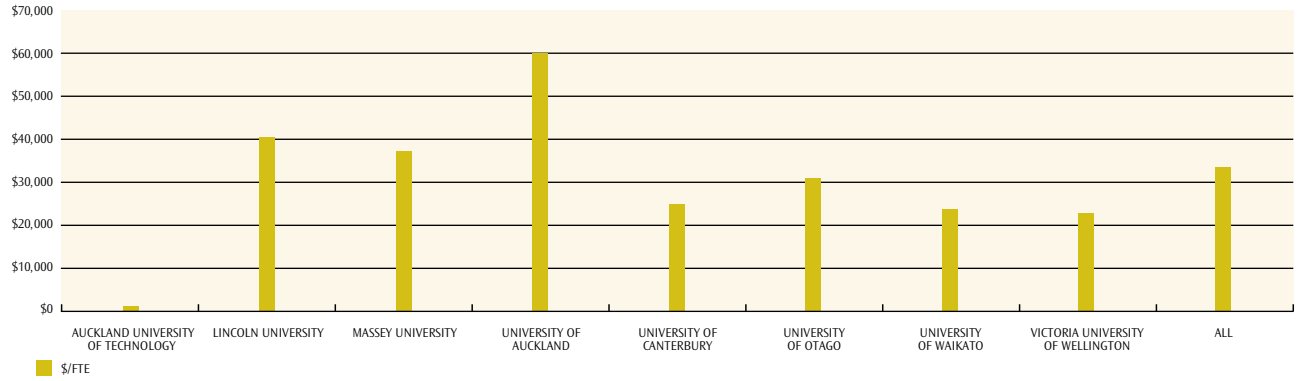


While the information above relates to universities, some other TEIs reported research contract earnings in 2003. The Auckland College of Education reported external research contract income of $190,000, Dunedin College of Education $78,000, Waikato Institute of Technology $106,000, Telford Rural Polytechnic $54,000, and UNITEC Institute of Technology $992,000.

A measure of the research productivity of academic staff in the universities is the research contract income for each academic staff member. In 2003, the average research contract earnings per FTE academic staff member in the universities was $33,797, compared with $32,130 in 2002 and $29,597 in 2000. Figure 5.17 which follows shows the research income per FTE in each of the eight universities in 2003.

[32] The term 'research contract income' is subject to the same imprecision as other definitions in tertiary education research. It should be noted, in interpreting this graph and the preceding one, that AUT was established as a university only in 2000. Its performance in this analysis reflects this fact. It should also be noted that there are large research funds (such as those managed by the Health Research Council) devoted to health research, a field of research dominated in New Zealand by the two universities with medical schools – Otago and Auckland.

FIGURE 5.17: RESEARCH CONTRACT INCOME PER FULL-TIME EQUIVALENT ACADEMIC STAFF MEMBER IN NEW ZEALAND UNIVERSITIES 2003



In addition to funding university research through the research top-ups, the government supplies much of the funding for contestable research funds. The principal Crown funding for research is allocated on behalf of the Ministry of Research, Science and Technology by research purchase agents – the Royal Society of New Zealand, the Health Research Council and the Foundation for Research, Science and Technology. Thus, a substantial proportion of university research contract income comes from these contestable Crown research funds.

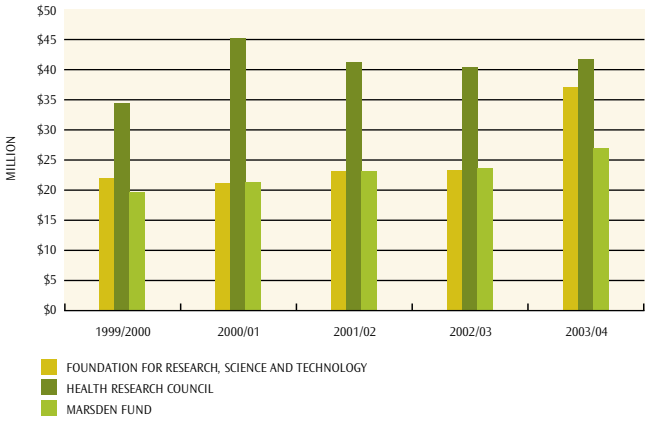
In the 2003/04 fiscal year, TEIs were expected to receive $105 million from these funds, including:

- $37 million direct research contract funding from the Foundation for Research, Science and Technology (FRST), compared with $23 million in the previous year
- $27 million from the Marsden Fund, compared with $23 million the year before, and
- $42 million from the Health Research Council (HRC) ($40 million in 2002/03).

These amounts represent an increase between 1999/2000 and 2003/04 of 39 percent.

The amounts exclude funding earned through sub-contracts in FRST contracts. Sub-contracts are valued at about a further $6 million per annum.

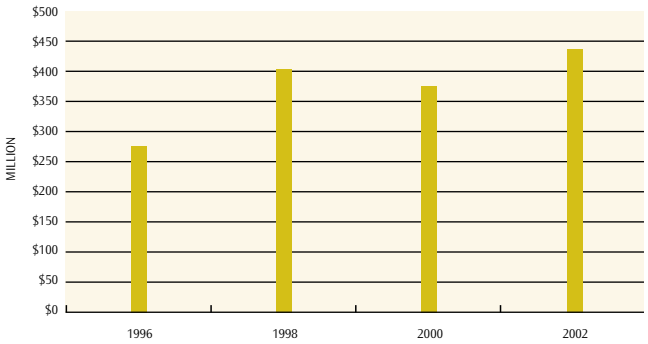
FIGURE 5.18: UNIVERSITY RESEARCH FUNDING FROM VOTE RESEARCH, SCIENCE AND TECHNOLOGY 1999/2000-2003/04



RESEARCH EXPENDITURE

In its 2002 biennial survey of research in New Zealand, the Ministry of Research, Science and Technology (MoRST) and Statistics New Zealand (SNZ) reported that universities estimated[33] they spent $435.8 million on research in 2002. This represented an increase of 16.5 percent on 2000 and 59.4 percent on 1996.

FIGURE 5.19: ESTIMATED EXPENDITURE ON RESEARCH BY UNIVERSITIES 1996-2002

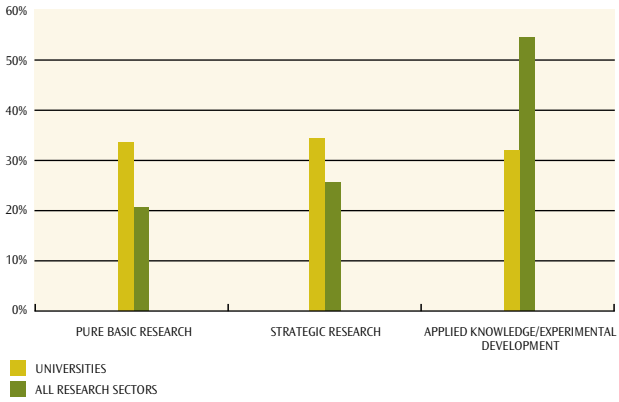


Source: Statistics New Zealand and the Ministry of Research, Science and Technology.

The 2002 research expenditure in the universities represented 0.35 percent of gross domestic product, compared with 0.33 percent in 2000. The average for all OECD countries in 2001 was 0.40 percent[34]. MoRST and SNZ report that universities accounted for 33 percent of all New Zealand research and development expenditure in 2002, compared with 34 percent in 2000.

Higher education research expenditure is divided roughly equally between basic research, strategic research and applied knowledge/experimental development. Compared with other research sectors, research in higher education is heavily weighted towards basic and strategic research.

FIGURE 5.20: PERCENTAGE OF UNIVERSITY RESEARCH EXPENDITURE COMPARED WITH OTHER SECTORS BY RESEARCH TYPE 2002



Source: Statistics New Zealand and the Ministry of Research, Science and Technology.

The *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research* notes the cost-effectiveness of the New Zealand research sector. New Zealand ranked first of the 20 countries assessed in terms of the number of papers for every million dollars of research investment (normalised for variations in purchasing power).

THE TERTIARY EDUCATION RESEARCH WORKFORCE

As part of the participation in the PBRF, providers now supply to the Tertiary Education Commission information about their research staff on a periodic basis. This census gives a first view on the make-up of the research workforce in tertiary education organisations.

There were 8,017 people employed by organisations participating in the 2003 PBRF quality evaluation whose responsibilities included research[35]. Those people equated to 7,414 full-time equivalent (FTE) staff members. On an FTE basis, 41 percent were women. Of those with a declared ethnic group[36], 74 percent were of European ethnicity, 6.1 percent Māori, 1.2 percent Pasifika and 6.4 percent Asian.

[33] The figures in this section are based on expenditure reported by the universities in response to the MoRST/SNZ biennial surveys of university research expenditure. Because the survey required an estimate of the proportion of each staff member's time devoted to research, the figures cannot be regarded as precise. In addition, there was a change in the methodology in 2002, meaning that caution needs to be exercised in comparing the 2002 result with the data for previous years.

[34] This figure is cited in the MoRST and SNZ biennial report *Research and Development in New Zealand 2002.*

[35] The conditions that make a staff member eligible for consideration for the PBRF are set out in *Performance-Based Research Fund: Evaluating Research Excellence – the 2003 Assessment,* Tertiary Education Commission, 2004, page 17. To be eligible, a staff member must hold a position that is expected to make a contribution to the research activity of the organisation and/or to its degree teaching.

[36] Around a quarter of PBRF-eligible staff did not declare their ethnicity in the PBRF staff census.

The proportions of staff with a declared ethnic group and gender receiving the various quality categories in the 2003 PBRF quality evaluation are set out in the table below.

TABLE 5.5: PERCENTAGE OF PBRF-ELIGIBLE STAFFING ASSIGNED VARIOUS QUALITY CATEGORIES IN THE 2003 PBRF QUALITY EVALUATION

	Number of FTE staff	Percentage of staff who scored 'A'	'B'	'C'
Female	3,007.6	2.2%	15.3%	29.8%
Male	4,379.1	8.2%	28.6%	32.5%
European	4,101.4	6.1%	24.2%	28.7%
Māori	336.5	2.9%	14.1%	25.7%
Pasifika	68.0	2.9%	10.4%	23.2%
Asian	356.4	3.4%	22.8%	36.5%
Total	**7,414.4**	**5.7%**	**23.2%**	**31.3%**

Notes:

[1] Not all staff declared an ethnicity or a gender. The proportion with no declared ethnic group was 25.4 percent while 0.4 percent made no declaration of gender.

[2] The ethnic data is prepared on the basis of each respondent's primary ethnic group.

Source: Tertiary Education Commission.

Men tended to score better than women in the quality evaluation, with 69 percent of men being awarded an 'A', 'B' or 'C' quality category, compared with 60 percent for all those participating. While those belonging to the European ethnic group had a high proportion of staff in the 'A' category, the ethnic group with the highest proportion in the three categories was the Asian group, where 63 percent scored 'A', 'B' or 'C', compared with 59 percent for Europeans and 60 percent overall.

Based on responses to their 2002 survey, MoRST and SNZ estimate that the universities' research effort represented 2,516 FTE researchers[37] plus 1,110 FTE technical and other staff in the academic year 2002. In addition, the survey reports 6,139 full-time equivalent postgraduate students working in the sector during 2002. Ignoring the postgraduate students, the tertiary education sector's researchers constituted 36 percent of the total research and development staff equivalents in New Zealand, compared with an OECD average of around 40 percent[38].

[37] Note that this figure was derived by estimates of the percentage of staff time devoted to research. That estimate is, therefore, not precisely comparable across the universities. This figure is not that used in other indicators in this chapter where a person's FTE count depends on the nature of the employment, rather than the extent of time devoted to research. Thus a full-time staff member devoting 25 percent of her time to research would be counted as 1.0 FTE in the PBRF but as 0.25 FTE in the MoRST and SNZ survey.

[38] This figure is cited in the MoRST and SNZ report *Research and Development in New Zealand 2002*.

COLLABORATION AND INTERACTION WITHIN THE INNOVATION SYSTEM

One of the key themes underpinning the Tertiary Education Strategy 2002/07 is the importance of enhancing collaboration both within the tertiary education sector and between the sector and other groups. The 'change' messages that describe the government's expectations for the sector include 'greater collaboration ... within the sector' and 'stronger linkages with business and other external stakeholders'. Objective 3 of the Strategy calls for 'greater collaboration with the research sector ...' while objective 32 calls for 'a more focused tertiary research investment through world-class clusters and networks of specialisation'.

Collaboration is of particular importance in research. The *National Bibliometric Report, 1997 to 2001: International Benchmarking of New Zealand Research* notes that research papers that result from collaboration between authors receive significantly more citations on average than those with a single author. Co-authored papers produced by New Zealand researchers in 1997 received 6.7 citations on average over the period 1997 to 2001, compared with 2.2 for sole-authored publications.

That report shows that papers produced in the tertiary education sector were more likely to have involved collaboration than those produced in other parts of the national research system. The report states that, in 2001, 52 percent of university publications were the result of collaborations, compared with the 59 percent reported for publications in 1996 and 32 percent in 1986. More than 70 percent of these collaborations were with overseas bodies (against 67 percent in 1996[39]). International collaborations in papers produced by universities were more likely than in papers produced in other parts of the research system. For instance, around 60 percent of Crown Research Institute (CRI) papers that involved collaboration and about 50 percent of collaboratively produced health research papers involved collaboration overseas. Nearly 10 percent of collaborations on university papers were with CRIs. Only 5 percent were with other domestic universities, compared with 8 percent in 1996. Thus, while there is extensive collaboration between researchers in New Zealand universities and their colleagues overseas, there is relatively low propensity to collaborate between the New Zealand universities in research.

[39] This means that around 35 percent of all university papers in 2000 involved international collaborations, compared with 40 percent in 1996.

While the level of collaboration between universities in New Zealand in research has not been high, the Centres of Research Excellence (CoREs) are now encouraging a high level of domestic collaboration, both between the universities and between the universities and CRIs.

The seven CoREs have been established to support world-class research that will contribute to New Zealand's development as a knowledge society. The CoREs are designed to encourage a concentration of intellectual and financial research resources in the tertiary education sector and to facilitate greater networking. The CoREs are inter-institutional research networks with researchers working together on a commonly agreed research plan.

The initial funding allocation was $40.6 million over four years with a $20 million capital contingency fund available to purchase strategic research assets. A further $27 million over three years, plus an additional $40 million in capital expenditure, was committed in Budget 2002 to provide for the creation of additional CoREs.

All of the CoREs are hosted by universities; five out of the seven CoREs involve formal partner institutions, including universities and research organisations, while one other involves a cluster of multidisciplinary research teams across one institution. For instance, Nga Pae o te Maramatanga – The National Institute of Research Excellence for Māori Development and Advancement is hosted by the University of Auckland. This CoRE involves the participation of two wānanga (Te Whare Wānanga o Awanuiarangi and Te Wānanga o Aotearoa), four universities (Victoria University of Wellington, the University of Otago and the University of Waikato, in addition to the University of Auckland) and one CRI (Landcare Research).

The following CoREs have been established:

- **The Allan Wilson Centre for Molecular Ecology and Evolution** – Host institution: Massey University. Partners: the University of Canterbury, the University of Auckland, the University of Otago, and Victoria University of Wellington.
- **The Centre for Molecular Biodiscovery** – Host institution: the University of Auckland.
- **New Zealand Institute of Mathematics and its Applications** – Host institution: the University of Auckland. Partner: New Zealand Mathematics Research Institute.
- **Nga Pae o te Maramatanga (Horizons of Insight) – The National Institute of Research Excellence for Māori Development and Advancement** – Host institution: the University of Auckland. Partners: Te Whare Wānanga o Awanuiarangi, Te Wānanga o Aotearoa, Victoria University of Wellington, the University of Otago, the University of Waikato, and Landcare Research.
- **The MacDiarmid Institute for Advanced Materials and Nanotechnology** – Host institution: Victoria University of Wellington. Partners: the University of Canterbury, Industrial Research Limited and the Institute of Geological and Nuclear Sciences.
- **The National Centre for Advanced Bio-Protection Technologies** – Host institution: Lincoln University. Partners: Massey University, New Zealand Crop and Food Research Ltd and AgResearch Ltd.
- **The National Centre for Growth and Development** – Host institution: the University of Auckland. Partners: Massey University and the University of Otago, with contributions from AgResearch Ltd.

CASE STUDY

THE NATIONAL CENTRE FOR ADVANCED BIO-PROTECTION TECHNOLOGIES

The National Centre for Advanced Bio-Protection Technologies was established as one of the seven Centres of Research Excellence (CoREs) established by the government over 2002 and 2003. The CoREs have been established to support world-class research that will contribute to New Zealand's development as a knowledge society. CoREs are intended to encourage a concentration of intellectual and financial research resources in the tertiary sector and encourage greater networking. The CoREs are inter-institutional research networks with researchers working together on a commonly agreed research plan. Each centre is hosted by a tertiary education institution and was selected on the basis of demonstrated excellence in research and on the basis of collaboration with other research providers.

The initial allocation was worth $40.6 million over four years with a $20 million capital contingency fund available to purchase strategic research assets. A further $27 million over three years, plus an additional $40 million in capital expenditure, was committed in Budget 2002.

The National Centre for Advanced Bio-Protection Technologies was established in February 2003. Its goal is to conduct internationally recognised research into the management of New Zealand's weeds, plant pests and diseases and to develop systems for improved biosecurity.

It is hosted by Lincoln University and is directed by Professor Alison Stewart. It comprises four partner organisations – Lincoln University, Massey University, AgResearch and Crop and Food Research. Eight other research and academic institutes are Centre collaborators, providing staff to the Centre's research programmes (The University of Auckland, the University of Canterbury, Auckland University of Technology, Te Whare Wānanga o Awanuiarangi, Landcare Research, Hort Research, the Forest Research Institute and Canesis).

Most of the staff, postdoctoral fellows and postgraduate students of the Centre are based in the Canterbury region, with other staff located at research institutes throughout New Zealand. The laboratories are complemented by extensive field facilities (including vineyards managed to industry standards and a commercial organic cropping farm).

The Centre also manages the Biotron, a purpose-built plant growth facility that enables observation and measurement of plant microbe and physical interactions above and below the ground.

The research conducted by the Centre is divided into four major themes.

Biosecurity: detecting unwanted organisms at the border using sensor technology and molecular diagnostics, and developing intelligent computing systems to predict the potential of new organisms to become pests.

> **Progress to date:** This area of research uses the Biotron, which is able to provide answers to questions about the likely host range of invasive species, their ability to tolerate diurnal and seasonal extremes and likely damage potential. With research in this area, the Centre should be able to provide significant research information for biosecurity agencies in New Zealand and overseas. Staff working in this theme area produced three publications and 11 conference/workshop presentations in 2003.

Biocontrol: managing weeds, pests and diseases using environmentally friendly biocontrol agents that are an alternative to chemical pesticides. The applied research is underpinned by studies that examine the specific interaction between biocontrol agents and their hosts/prey.

> **Progress to date:** In the past, there has been little success using this kind of approach. The new approach being adopted looks to be far more promising. The scientists in this theme area are adopting a cross-disciplinary approach to enhancing biocontrol. For example, in the work in vineyards, plant pathologists are working with insect ecologists to understand the role of insects called thrips as initiators of Botrytis infections in grape bunches. Similarly, biocontrol researchers are working closely with the Mātauranga Māori Bio-Protection Theme to enhance pest management in Māori cropping systems. There were 15 publications from this group and 26 conference presentations in 2003.

Agri-Biotechnology: investigating the molecular basis of plant microbe interactions and developing advanced biotechnologies to confer resistance to pests or pathogens.

Progress to date: This biotechnology research was initiated when there was considerable scrutiny because of the moratorium on the release of genetically-modified organisms. Scientists working in this theme area produced 26 conference presentations and two publications in 2003.

Mātauranga Māori Bio-Protection: researching bio-protection techniques that are acceptable to Māori growers by incorporating Māori perspectives and tikanga into bio-protection strategies. Māori knowledge of horticulture has been developed over the past 1,000 years in the many and varied soil types and climates of New Zealand and therefore inclusion of this knowledge and tikanga, where appropriate, will add value to existing scientific research into the management of pests and diseases.

Progress to date: A network of Māori growers from throughout New Zealand has been established to identify case study groups. This includes selected growers from a broad range of crop production systems, from 'traditional' crops such as kumara and taewa (Māori potato) through to more contemporary crops. This activity uses varied production methods and philosophies such as organic, sprayfree and conventional.

Development of relevant databases on Māori in the agriculture/horticulture sector provides important baseline information for ongoing research. The information to date has identified gaps in the knowledge bases as well as issues and problems associated with crop production and protection. There are also issues around decision-making for Māori land with multiple owners and other collective assets and around product development and marketing of crops produced by Māori growers. There is emerging a diverse range of views within the Māori community as to what constitutes Māori horticulture and a recognition of the importance of both Mātauranga Māori and western science in developing the industry.

In 2003 there were two publications and 20 presentations associated with this theme.

While the development of this research centre is at an early stage it is clear that its research is critical to the delivery of safe food from New Zealand's biologically driven economy.