December 2009

Report 9a

2058

A History of Government-funded Science 1865–2009

Background report to Report 9: Government-funded Science Under the Microscope

MCGUINNESS INSTITUTE

Report *A History of Government-funded Science from 1865–2009*

Background report to *Government-funded Science under the Microscope*

Updated February 2010
ISBN 978-1-877473-46-3 (paperback)
ISBN 978-1-877473-47-0 (PDF)
This document is available at www.sustainablefuture.info and may be reproduced or cited provided the source is acknowledged.

Prepared by The Sustainable Future Institute, as part of *Project 2058*

Authors Wendy McGuinness, Joe McCarter, Mark Newton and Chris Aitken

External reviewers Dr Jacqueline Rowarth, Dr Steve Thompson and Dr Morgan Williams

About the Institute The Sustainable Future Institute is an independently funded non-partisan think tank. The main work programme of the Institute is *Project 2058*. The strategic aim of this project is to promote integrated long-term thinking, leadership and capacity-building so that New Zealand can effectively seek and create opportunities and explore and manage risks over the next 50 years. It is hoped that *Project 2058* will help develop dialogue among government ministers, policy analysts and members of the public about alternative strategies for the future of New Zealand.

For further information The Sustainable Future Institute
Phone (04) 499 8888
Level 2, 5 Cable Street
PO Box 24222
Wellington 6142
New Zealand

Publishing This publication has been produced by companies applying sustainable practices within their businesses. The body text is printed on ECO100 paper, manufactured from 100% waste paper in a chlorine-free process. The cover is printed on Works Smooth, using vegetable-based offset inks.

Contents

Preface **1**

Executive Summary **2**

1. Purpose **7**

1.1 *Project 2058* 7

1.2 The Sustainable Future Institute 7

2. Methodology **9**

2.1 Method of Analysis 9

2.2 Terminology 9

2.3 Limitations and Boundaries 10

3. Before Government-funded Science **11**

3.1 Māori Knowledge 11

3.2 Western Science 11

4. The First Era: 1865 to 1926 – Gradual Organisation **13**

4.1 The New Zealand Geological Survey 13

4.2 The New Zealand Institute 13

5. The Second Era: 1926 to 1989 – One Dominant Institution **16**

5.1 The Catalyst for Change 16

5.2 The Department of Scientific and Industrial Research 17

5.3 Seeds of Reform 18

6. The Third Era: 1989 to 2009 – The Tri-Institutional Framework **21**

6.1 Shake-up of the Science System 21

6.2 The Tri-Institutional Framework 22

6.3 Emerging Discontent 23

7. Government-funded Science Today **26**

7.1 Policy 26

7.2 Purchase 28

7.3 Provision 31

7.4 Types of Research 37

7.5 Summary 37

8. Observations **38**

Abbreviations **42**

Glossary **43**

References **56**

Tables

Table 1 Observations and Key Questions Relating to Government-funded Science 4
Table 2 Before Government-funded Science 12
Table 3 1865–1926: Gradual Organisation 15
Table 4 1926–1989: One Dominant Institution 20
Table 5 1989–2009: The Tri-Institutional Framework 25
Table 6 The Current Government-funded Science System 27
Table 7 Crown Research Institutes: Return on Assets, 2007/08 31
Table 8 Crown Research Institutes: Comparing 1992 with 2009 33
Table 9 Vote RS&T by Research Funds 2009/10 36
Table 10 Observations and Key Questions Relating to Government-funded Science 39

Figures

Figure 1 Vote RS&T: Allocation to Public Institutions 2009/10 28
Figure 2 Vote RS&T: Recipients Over Time 32
Figure 3 Science and Innovation Profile of New Zealand Compared to the OECD Average 35
Figure 4 Vote RS&T: Research Funding by Type 2007/08 37

Appendices

Appendix 1 About the Authors 44
Appendix 2 Timeline of Legislation and Key Documents 46
Appendix 3 Crown Research Institutes Act 1992 – Principles of Operation 52
Appendix 4 Provision Institutions 53
Appendix 5 Upcoming Government Reviews 55

Preface

We don't have the money so we have to think. – Ernest Rutherford (1871–1937)

December 10, 2008 marked one hundred years since New Zealand's greatest scientist was awarded the Nobel Prize for Chemistry, 'for his investigations into the disintegration of the elements, and the chemistry of radioactive substances'. Ernest Rutherford was certainly one New Zealander who achieved a significant leap in scientific knowledge for the good of humankind, but what of the science system and culture he was born into, and what did he leave behind?

As this report shows, the first era of government-funded science began within years of Ernest Rutherford's birth. However, whereas Rutherford went on to achieve international success within just over ten years, government-funded science in New Zealand progressed more slowly. Rutherford's legacy, in addition to helping place New Zealand on the international map, was the birth of the second era of government-funded science in this country. Notably, during his last visit to New Zealand, in 1925, he called for an institute to be set up in which New Zealand scientists could carry out research that would benefit farmers, a call that assisted in the establishment of the Department of Scientific and Industrial Research (DSIR) in 1926. In 1989 a third era began with the breaking up of the DSIR into three parts, aimed at separating policy, purchase and provision. This model remains in existence today.

This report acknowledges the importance of exceptional scientists like Ernest Rutherford, but tries to look deeper, by attempting to understand the development of the government-funded science industry over time. The reason why this is important is encapsulated in Rutherford's own words: 'We don't have the money so we have to think.' In a small country sitting at the bottom of a resource-scarce, population-loaded planet, 'to think' is the privilege of the government-funded science industry – therefore New Zealanders need not only to understand what 'the industry thinks', but to explore what the industry should be thinking. This report aims to understand the past in order to think about the future. And while the past is summarised here, the future is discussed in Report 9, *Government-funded Science under the Microscope* (SFI, in press).

During the preparation of this package of reports, a number of eminent thinkers have generously offered their time, thoughts and opinions. In particular, we offer our sincere thanks to Dr Jacqueline Rowarth, Dr Steve Thompson and Dr Morgan Williams. Importantly, any opinions expressed in this report do not necessarily represent those of the external reviewers mentioned above, and all errors, omissions and matters of opinion remain those of the authors. Lastly, I wish to acknowledge and thank my co-authors: Joe McCarter, Mark Newton and Chris Aitken, without whom this report would not be possible.

Wendy McGuinness
Chief Executive

Executive Summary

The aim of this report is to research past themes, and the current state of New Zealand's government-funded science system so as to inform the content of a National Sustainable Development Strategy.[1]

The methodology is discussed in Section 2, which includes an outline of the method, a discussion on terminology and a brief statement on the limitations and boundaries of the research. The method adopted during the researching of this report included a literature review, as well as feedback from external reviewers.

In Sections 3, 4, 5 and 6 a review of the history of science in New Zealand is presented. Key eras are identified, and we learn that the science system has undergone periodic systemic reorganisation. Specifically, Section 3 outlines the development of knowledge in New Zealand prior to the establishment of government-funded science in 1865. Section 4 covers the first era of government-funded science, the evolution of science research from 1865 until 1926, culminating in the formation of the Department of Scientific and Industrial Research (DSIR). Section 5 covers the second era, the DSIR's growth until the economic reforms of the late 1980s; and Section 6, covers the third era, the tri-institutional framework and the subsequent evolution of the system. The key characteristics, main themes, drivers of change, major types of research, and lessons learnt from each era are summarised at the end of each subsection.

In Section 7 a picture of the government-funded science system in New Zealand today is presented. The focus is on the tri-institutional separation of policy, purchase and provision and its structure, its operation and the allocation of funding between purchasers, providers and types of research within the system.

This report concludes in Section 8 by summarising key observations and questions about the current government-funded science system in New Zealand. These questions will be addressed in Report 9.

Key findings

The 150 years since the inception of organised Western science in New Zealand have been characterised by the continual evolution of the government-funded science system. This change has been evident throughout all levels of policy, purchase and provision, and has been both gradual (as in the coming together of scientists before the formation of the New Zealand Institute[2]) and abrupt (as demonstrated by the reforms of the late 1980s).

1 For an explanation of what is a National Sustainable Development Strategy, see SFI, 2007: 8-9.

2 Importantly, this organisation is not related to the current New Zealand Institute formed in Auckland in 2004.

Change has been driven by a variety of factors: in the early days, personalities such as James Hector and Ernest Marsden dominated the science scene; however, as demonstrated by the reforms, in recent times science has been structured according to pervasive international theories such as New Public Management and Public Choice Theory (see footnotes 7 and 10 respectively).

Other themes have included the focus on Western thought, which arguably has been at the expense of traditional Māori knowledge, the shift in allegiances from the colonial models to international theories, and the growing importance over the years of the debate about the degree to which the government should influence the provision of science.

The science system today is still governed according to the reforms of the 1980s. This is particularly evident in the focus on economic outcomes, competitive funding and the tri-institutional model of science policy, funding and provision. While this change has provided certain benefits to the New Zealand science sector – such as more economically efficient science provision – overall, the reforms were ill-applied to the sector and have impeded system optimality ever since.

This raises the question, is the current government-funded science system the right framework for the challenges ahead? Researching this broad question has led to eleven key observations about the nature of the government-funded science system in New Zealand. Each observation raises a number of key questions about the future of government-funded science in New Zealand; Table 1 shows the list of the observations and the related questions. These questions will be explored further in Report 9, *Government-funded Science under the Microscope* (SFI, in press), in order to progress the thinking around the optimal direction for the future of government-funded science in New Zealand.

Table 1 Observations and Key Questions Relating to Government-funded Science

Observations – Current System	Key Questions – Future System
1. Science is a long-term process. It requires a similarly long-term dedicated investment.	a. What are the appropriate time scales for optimising investment, for example: one year, three years, twelve years or twenty years? b. Is the government-funded science system adequately oriented towards the appropriate time scales? c. Will the Stable Funding Environment platform based initiative deliver the desired outcome?
2. The focus of science changes over time as new discoveries, new problems and economic changes shift the drivers of science. These changes can come from both international and national sources.	a. Is the capacity of the government-funded science system strong enough to be able to undertake novel streams of research quickly? b. Is the government-funded science system adequately linked to international latest trends and best practice? c. Is the government-funded science system sufficiently flexible and robust to cater for emerging issues facing New Zealand?
3. Government-funded research policy is set by the Minister of Research, Science and Technology and is thus strongly connected to political forces.	a. Are political forces creating any issues, problems or biases in how and what research is conducted? b. Are these political forces evidence-based and transparent?
4. The linkage between the type of research and the research goal is critical to both understanding current performance and shaping future progress.	a. Have we got the type of research right? b. Do we need a better method of evaluation? c. Has the current system delivered benefits to all segments of society in a fair and transparent manner, and if not, what obstacles need to be removed or managed?

Observations – Current System	Key Questions – Future System
5. Government-funded research needs to interact internationally and stand up on the global stage. At the same time, the system must be tailored to meet the unique needs and characteristics of New Zealand.	a. Are international management models appropriate for science in New Zealand? b. Have we got the balance right between international and national research? If not, how best can we manage the conflicting needs? c. Are we capitalising on our formal international science relationships? d. Are we missing opportunities to develop international science relationships?
6. Government-funded research is structured around a company model. As such CRIs are expected to return a dividend to the government each year as well as maximise outcomes from public good science and technology.	a. Is the company model appropriate for a government-funded science system? b. Does assessing performance based on the CRIs dividend overlook and devalue the important returns to New Zealand that are produced by public good science and technology.
7. The contestable funding system run by Foundation for Research, Science and Technology (FRST) and other purchasers creates competition between providers for limited government funds.	a. Is there an easily accessible register of science funds for researchers? b. Does the system allow for fair competition? c. Is the system designed effectively and efficiently to maximise outcomes? d. Is competition between researchers detrimental to quality outputs? e. Is it appropriate for the Stable Funding Environment initiative to retain an element of competitive funding?
8. Science that is government-funded raises the question of whether or not New Zealand taxpayers are getting value for money. Rigorous processes and systems are therefore required to ensure optimal efficiency and transparency.	a. Is the government-funded research system designed effectively and efficiently? b. Is the system sufficiently transparent to enable investment decisions to be assessed? c. Is it clear what value for money means in practice?

Observations – Current System	Key Questions – Future System
9. Crown Research Institutes (CRIs) are becoming less significant and receiving a smaller share of total funding, while more funding is being allocated to universities and business. This is a clear sign that change within the system is already happening.	a. Does New Zealand have an appropriate number of CRIs to achieve its science goals? b. What are the implications of CRIs becoming less significant? c. Are there provision mechanisms other than CRIs that could produce better quality outputs? d. What are the implications of universities and business becoming the front-runners in government-funded research?
10. Science requires a deep and capable pool of researchers for it to operate effectively. Creating a pool like this means retaining researchers and recognising that there is a long lag period between new people entering science education and the time they become productive researchers.	a. Is science valued adequately in the New Zealand education system? b. Does the New Zealand's education system recognise the time-lag between educating scientists and scientists being productive? c. Is science an attractive career choice for New Zealanders?
11. Government-funded research needs government-funded infrastructure, being the fixed assets needed to deliver science that counts.	a. Is there a register of current public good science assets and a list of what is needed? b. Could CRIs, universities and non-government New Zealand organisations share science assets better? c. Does New Zealand have the right science assets in the right hands?

1. Purpose

The purpose of this background report is to research the history of the government-funded science system, and then explore the institutions and methods for progressing this, so as to inform the content of our Report 9, *Government-funded Science under the Microscope* (SFI, in press). This background report forms part of our work programme *Project 2058*.

1.1 *Project 2058*

The strategic aim of *Project 2058* is to promote integrated long-term thinking, leadership and capacity-building so that New Zealand can effectively seek and create opportunities and explore and manage risks over the next 50 years. In order to achieve this aim, the *Project 2058* team are working to:

1. Develop a detailed understanding of the current national planning landscape, and in particular the government's ability to deliver long-term strategic thinking;
2. Develop a good working relationship with all parties that are working for and thinking about the 'long-term view';
3. Recognise the goals of iwi and hapū, and acknowledge te Tiriti o Waitangi;
4. Assess key aspects of New Zealand's society, asset base and economy in order to understand how they may shape the country's long-term future, such as government-funded science, natural and human-generated resources, the state sector and infrastructure;
5. Develop a set of four scenarios to explore and map possible futures;
6. Identify and analyse both New Zealand's future strengths and weaknesses, and potential international opportunities and threats;
7. Develop and describe a desirable sustainable future in detail, and
8. Prepare a *Project 2058* National Sustainable Development Strategy. (SFI, 2009: 3)

This report is designed to help progress the fourth point above.

1.2 The Sustainable Future Institute

Earlier work by Sustainable Future has indicated that New Zealand is well behind on its international obligations to develop and implement a National Sustainable Development Strategy (NSDS) (SFI, 2007). The creation of an NSDS requires consideration of where New Zealanders would like to be as a country and what challenges lie ahead. Dealing with these challenges is often complex and requires large-scale change, much of which may be beyond our control. It involves planning for a desired future, while acknowledging our weaknesses and looking for solutions to the problems we envisage will be encountered along the way. With this in mind, this report is a step towards the Sustainable Future Institute's goal of creating an NSDS for New Zealand, and an integral component of *Project 2058*.

The four authors of the report are Wendy McGuinness, Joe McCarter, Mark Newton and Chris Aitken. Joe was the main author of Sections 3, 4, 5 and 6, the sections that examine the history of science in New Zealand, and Mark was the main author of Section 7, which looks at the system as it is today. Wendy and Chris worked on Section 2, the methodology, and Section 8, the observations and remaining questions, and brought the final report to completion. The authors' backgrounds are outlined in Appendix 1.

2. Methodology

The methodology for this report sits within the wider methodological framework that is discussed in *Project 2058 Methodology: Version 3* (SFI, 2009). Thus, the general methodology of *Project 2058* informs the methodology of Report 9, *Government-funded Science under the Microscope* (SFI, in press), which in turn informs the methodology underlying this background report, Report 9a. This background report seeks to fulfil Objectives 1 and 2 of Report 9:

> **Objective 1:** To review the history of government-funded science in New Zealand (Sections 3, 4, 5 and 6).
>
> **Objective 2:** To provide a snapshot of the science system in 2009 (Section 7). (SFI, in press)

The method adopted during the researching of this report included a literature review, as well as feedback from external reviewers.[3]

Achieving the objectives shown above is important to fulfil the research aim of this report, but also to link the report with the wider strategic purpose of Sustainable Future (as explained in Section 1.1). This report is intended to act as both a stand-alone document and as one of several documents to inform Sustainable Future's perspective on the creation of an NSDS.

2.1 Method of Analysis

The history of government-funded science in New Zealand is examined by breaking it up into four periods, each defined by changes in the organisational structure that occurred at a particular point in time. It is recognised that the science system will not have altered overnight at each change from one period to the next, due to the continuity of individuals, attitudes and knowledge within the system. However, the purpose of this report is to examine the management of science in New Zealand, and these periods, representing significant changes in organisation, provide logical boundaries to help us achieve this purpose.

2.2 Terminology

For the purposes of this report, 'government-funded science' refers to science for which financial support is provided directly by the government. No highly specific definition can be made due to the great changes in the mechanism by which government support has been delivered over the history of science in New Zealand. These mechanisms have ranged from grants made to individual science organisations in the 1860s to the complex Vote RS&T arrangement in existence today. While Vote RS&T currently forms the bulk of government funding for science in New Zealand, smaller amounts also come from Vote Education, Vote Agriculture and Forestry, and Vote Health.

[3] Professor Jacqueline Rowarth, Dr Steve Thompson and Dr Morgan Williams.

Government legislation also enables three industry research levies for heavy engineering, building, dairy, meat and wheat. Although overseen by Ministry of Research, Science and Technology (MoRST), each levy is collected and utilised separately by the relevant industry association (see Appendix 2). The focus of this report is on government funding of MoRST, FRST, CRIs, and other spending through Vote RS&T and thus research levies are not examined further.

The following definition of research and development (R&D) has been taken from Statistics New Zealand (2008), and is based on international best practice:

> Research and experimental development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge. Any activity classified as R&D is characterised by originality. Investigation is a primary objective (Statistics New Zealand, 2008: 1).

For the purposes of this report, the meanings of 'research', 'science' and 'technology' are those used in the Crown Research Institutes Act 1992, Section 2:

> *Research* means scientific research; and includes scientific development and related services,
>
> *Science* includes the physical sciences, the biological sciences, and the social sciences; and also includes *technology*; and scientific has a corresponding meaning. [italics added]

A list of abbreviations and a glossary of commonly used terms have been provided at the end of the report.

2.3 Limitations and Boundaries

The issues addressed in this report are significant in their complexity and scale, and as such provide a starting point for much deeper analysis and discussion. Government-funded science can take many forms, so while this report focuses on New Zealand's major milestones in a developing science sector, other forms of scientific research and advancement have occurred in New Zealand within specific commercial and educational settings. This report does not attempt to discuss or take into consideration privately funded science: for example various, minor institutes, often funded by international directives are not explored within the scope of this report. Arguably, in order to explore the quality of government-funded science in New Zealand, privately funded science and research should also be studied and taken into account.

The history presented in this report is not a detailed analysis of the evolution of New Zealand science, and is intended merely as an overview. Secondary sources have largely been relied upon (aside from examining *The Transactions and Proceedings of the Royal Society of New Zealand 1868–1961* [Bowen, 1868]), thus the inherent limitations of the conclusions drawn are recognised. We would especially like to acknowledge the work of C. M. Palmer (1994), R. Galbreath (1998) and F. L. Reid (2005), from which this report draws significantly.

3. Before Government-funded Science

The history of science in New Zealand is largely documented in terms of the history of Western science, the tenets of which underlie much of our society today. However, in order to understand government-funded science it is important to appreciate that the history of New Zealand science began long before the arrival of non-Māori New Zealanders. This section briefly describes the early foundations of science in New Zealand.

3.1 Māori Knowledge

By the time New Zealand was 'discovered' by European adventurers and scientists, Māori had developed a rich body of knowledge. This knowledge incorporated, among other things, a highly developed pharmacological understanding; an intimate understanding of the uses of local flora and fauna; accurate geological knowledge, and a sophisticated system of navigation capable of spanning huge expanses of ocean in well-designed craft (Howe, 2006; Palmer, 1994). Māori knowledge was informed by a rich cosmology and supported by complex social structures, inherent logic, and customary resource management regimes (Palmer, 1994). This knowledge was essentially very different from the European world view: the early exchanges between the cultures represented tensions 'not just between different ways of thinking, but between Māori and European ways of being' (Salmond, 1997: 33).

Māori were (and still are) significantly under-represented in New Zealand science – for example, there is no reference to Māori members of the New Zealand Institute until 1907, some forty years after its inception (Reid, 2005: 23). In a situation that paralleled development in many areas of the world, there was little room for research with a different epistemological basis, meaning that the utility of the Māori world view in interpreting information and as a means of self-determination was completely disregarded. It is for this reason that the history related here is largely one of Western science. It is important to note, however, that a parallel system of knowledge exists in New Zealand, and is increasingly valid and relevant today.

3.2 Western Science

The speed and efficiency with which the British colonised New Zealand and Europeans colonised scientific thought resulted in the Māori system of knowledge being pushed aside. Furthermore, when government-funded science did begin to emerge in an organised fashion, it was usually along Western modes of thought. One prominent academic put it this way:

> Researchers in Aotearoa/New Zealand have developed a tradition of research that has perpetuated colonial values, thereby undervaluing and belittling Māori knowledge and learning practices and processes in order to enhance those of the colonisers and adherents of neo-colonial paradigms (Bishop, 1998: 200).

However, it was many years after colonisation before there was centralised promotion and organisation of Western science within New Zealand, aside from the many scientific expeditions mounted from Europe and the United States (Andrews, 2007). At this point the pursuit of scientific inquiry was generally undertaken by gentlemen of leisure who could afford the time, as well as individual scientists commissioned by public or private entities. Ernst Dieffenbach, one such scientist, was commissioned by the New Zealand Company to undertake a general survey of navigation, geography, geology, botany and zoology, as well as observing Māori culture (Andrews, 2007; Dick, 1957: 11). Several scientists were employed by local authorities on the hunt for mineral resources, and various philosophical societies were scattered around the country (Galbreath, 1998; Reid, 2005: 23). However, in general, 'science in those dark and distant days had no voice and the finer arts were a dead letter' (Fox, 1868: 13). In a new country with relatively unknown natural capacities and opportunities, science of a sort was occurring on a daily basis as colonists wrested farmland from forest and began to experiment with ways to make it more productive: 'it might almost be said that every colonist in a new and unexplored country is, unconsciously, more or less of a scientific observer' (Bowen, 1868: 4-5).

Table 2 Before Government-funded Science

Key themes

- The Māori world view was pushed aside in the face of Western science
- Organised research capability was not a priority in a new, developing nation

Type of change

- Gradual coalescence

Drivers of change

- The arrival of the Pākehā forcing the decline in importance of Māori knowledge
- Colonial interest in the appropriation of natural resources
- Curiosity of gentlemen of leisure

Types of research undertaken

- Examination of flora and fauna
- Researcher-driven
- Focus on the possibilities of commercial exploitation of natural resources

4. The First Era: 1865 to 1926 – Gradual Organisation

Research carried out in New Zealand during this period was shaped by two institutions: the New Zealand Geological Survey and the New Zealand Institute.

4.1 The New Zealand Geological Survey

In 1865 the government formed the New Zealand Geological Survey, headed by James Hector, in a move aimed at identifying and controlling mineral assets such as gold and coal (Nathan, 2007). The Survey also took control of the Colonial Laboratory and Museum,[4] and until 1892 worked systematically at describing and identifying New Zealand's natural assets (Galbreath, 1998).

4.2 The New Zealand Institute

The creation of the New Zealand Geological Survey was followed in 1867 by the formation of the New Zealand Institute, which aimed to bring together the various research and philosophical societies that had sprung up around the country (Galbreath, 1998). It was responsible for the care of a public museum, library, laboratory and observatory,[5] and through the use of lectures and classes promoted 'the general study and cultivation of the various branches and departments of art, science, literature and philosophy' (Bowen, 1868: 3). The Institute also published the first national journal of scientific writing, *The Transactions and Proceedings of the Royal Society of New Zealand 1868–1961* (hereafter referred to as *Transactions*) (Bowen, 1868).

The formation of the Institute was a seminal event in the history of New Zealand thought, as it enabled communication to take place between the numerous men of science who were undertaking investigations into all aspects of life in New Zealand.[6] Furthermore, it acted as a major focal point for the emerging social sciences, humanities and creative arts (Reid, 2005). When considered in combination, the New Zealand Institute and the New Zealand Geological Survey had the effect of centralising the science research system, and hinted at the growing importance of science to New Zealand.

---

4 Hector's aim was not to make the museum 'an extensive and showy collection' of specimens, but rather a reference museum that illustrated the colony's natural history and mineral resources (Te Papa Tongarewa, 2009).

5 'With the establishment of a standard New Zealand time, an observatory was built in the Wellington Botanic Garden in 1869', writes Phillips (2007); 'The building, on the edge of the Bolton Street cemetery, was demolished in 1906 to allow Prime Minister Richard Seddon to be buried there.'

6 There is evidence of the significant participation of women in New Zealand science – for example, the 1851 rules of the New Zealand Society (a short-lived precursor to the New Zealand Institute) allow participation for women, and women regularly attended meetings with husbands, fathers or brothers. However, women were typically not given speaking rights at meetings, and published no papers in the *Transactions* until 1892 – it may thus safely be assumed that the vast majority of practitioners of science in New Zealand before 1900 were male (Reid, 2005: 23-24).

That said, the establishment of these institutions did not professionalise science in New Zealand to any large degree, and there remained for many years a lack of state-funded scientific investigation. It is also true that during much of this time both the New Zealand Geological Survey and the New Zealand Institute were dominated by upper-class gentlemen rather than working scientists, leading to significant discontent at times (Reid, 2005: 25). The continued lack of growth in New Zealand science had much to do with the fact that science was not yet driving changes within the colony, and thus had limited use politically: '[the] democratic politician does not trouble himself with science; he is generally satisfied to pose as a working man's hero' (Phillips, 1884; cited in Reid, 2005: 27). This led, and has continued to lead, to a chronic underfunding of science research. Interestingly, the principles alluded to by Mr Phillips bear remarkable similarity to the New Public Management ideas that came into vogue during the reforms of the 1980s.[7]

Research carried out in New Zealand during this period was almost entirely in primary industries such as agriculture, and in general occurred in response to problems and commercial imperatives. It was funded by a mixture of government grants and help from Britain, and supported by regional societies and the New Zealand Institute. Some important advances were made in these years, although these were mostly attributable to the skill and perseverance of individual scientists such as B. C. Aston (investigating a common stock illness known as 'bush sickness') and F. W. Hilgendorf (breeding wheat varieties better suited to New Zealand conditions), rather than government organisations or appropriate funding (Galbreath, 1998). In sum, however, despite the fact that scientists believed their work to have a higher significance,[8] funding was in general paltry and sporadic, and staff were few and far between. As a result, scientific research in many areas struggled to get off the ground.

---

7 New Public Management was a movement that became popular throughout the Western world towards the end of the 1970s, and was crucial in the implementation of reforms across the OECD. Its main components were 'hands-on professional management … explicit standards of performance, greater emphasis on output control, increased competition, contracts, devolution, disaggregation of units and private sector management techniques' (Christensen & Laegreid, 2001: 78). Such characteristics were reflected in the development of New Zealand's government-funded science system.

8 The first president of the New Zealand Institute passionately described scientific endeavour as a ladder, 'the base of which rested on the … earth, while its crest [is] lost in the glory of Heaven' (Bowen, 1868: 9).

Attitudes slowly began to change as successive governments realised the importance of research and science to the economic and social growth of the colony. Massey's 1912 Government was supportive of science, particularly with regard to agriculture, and realised the importance of New Zealand becoming a world leader in areas such as grassland science. In general, however, funding was still meagre, and a glance at the *Transactions* in 1912 shows that at this point yearly government funding had not increased from the initial allocation of £500 since 1868. During the next 40 years the figure not only remained the same, but even the £500 annual allocation was often in jeopardy (Cheeseman, 1912: 420). Admittedly, this is only funding to the New Zealand Institute, and does not take into account the various grants from Britain or commercial partnerships; it is, however, indicative of the lack of government interest in, and support for, science research.

Table 3 1865–1926: Gradual Organisation

Key themes

- Emerging recognition of the importance of scientific research to the growth of New Zealand, especially in primary industry
- The emerging importance of consistent funding and support from government
- Continued lack of organisation
- The lack of utility of science to politics

Type of change

- Steady coalescing and increase in research capability

Drivers of change

- Researchers involved
- Economic necessity

Types of research undertaken

- Primary industry – for example, grass, wheat, fertiliser
- Exploration of a new land – classification in zoology and botany
- Problem-solving and commercially focused

5. The Second Era: 1926 to 1989 – One Dominant Institution

Important as much of the research had been, in 1926 New Zealand found itself with no organised science-funding regime or nationally set priorities. This naturally restricted the depth and scope of the research that could take place. Dr Patrick Marshall, a past President of the Royal Society, put it this way:

> it is obvious that scientific research in general must be on a relatively small scale … [because of] the small and insufficient equipment, the small number of workers, and the paucity of available funds, [it is] difficult to add to the progress of knowledge in any important degree. (Marshall, 1927: 1)

Scientists and administrators both called for an increase in funding and the formal organisation of the science system, but were continually frustrated by changing political wills. Marshall notes that in the period following World War I – during which there was a spike of interest in science and technology as a means of national advancement – political attitudes in New Zealand changed 'like a weather-cock' (Marshall, 1927: 2). It was clearly thought that such work was a luxury, and should be most properly undertaken by those countries that were blessed with the most abundant resources (ibid.). However, this was soon to change, as Britain began a push to encourage the Dominions, especially Canada, South Africa, Australia and New Zealand, to form their own institutions and conduct their own scientific research.

5.1 The Catalyst for Change

The catalyst for change was the visit to New Zealand of Sir Frank Heath, the head of the British DSIR (Galbreath, 1998). In 1926 Heath toured the country and delivered a report to Prime Minister Gordon Coates detailing recommendations for the creation of a similar institution in New Zealand. Coates moved quickly to act on the report, and by August 1926 the Scientific and Industrial Research Act had been passed, and the DSIR was born.

The DSIR was a direct descendant of the British institution of the same name, and closely followed the model suggested by Heath (Galbreath, 1998). It assumed responsibility for the administration of science research within New Zealand, and aimed to facilitate greater cooperation between the various bodies and departments carrying out research, as well as private institutions such as the Cawthron Institute (Palmer, 1994).[9] Further, it was intended to facilitate cooperation between industry and scientific research, with provision for the DSIR to match any industry funding with money of its own (Galbreath, 1998). This had the effect of

[9] The Cawthron Institute was established in 1919 from the estate of Thomas Cawthron. Its first director was T. H. Easterfield, and its principal objective was to conduct scientific research into the problems of the primary industries of New Zealand, with particular reference to those of the Nelson district (Rigg, 1966: 2). There were initially three divisions, looking at issues such as problems of insect pests, fungal disease and agricultural chemicals (Rigg, 1966: 1). It is still an important centre of research in New Zealand, and over the years has expanded the scope of its activities significantly – see http://www.cawthron.org.nz.

causing the number of 'associations' between science and industry to increase sharply. However, the forthcoming depression did nothing to encourage industry's growing interest in science (Palmer, 1994). Additional funding was also offered by Britain, and this could be used for all manner of research. For example, in 1928 the Empire Marketing Board, which administered this funding, offered the handsome sum of £2,000 per annum for five years for research into eradicating blackberry and other noxious weeds (Aston, 1928: 42).

The Scientific and Industrial Research Act (1926) was intended to 'make provision for the promotion and organisation of Scientific Research, and for its application to the primary and secondary industries of New Zealand' (Aston, 1928: 37). As it happened, the secondary industries were very secondary in terms of focus, with the vast bulk of funding and research capability being put into primary industry for many years. This had much to do with the necessities of the time, but also hinted at the political climate: as Galbreath notes, 'what was wanted from the DSIR was help for the man on the land' (Galbreath, 1998: 34). Much research therefore went into solving practical problems such as improving wheat output and determining the best mix of clover and ryegrass, as well as general investigations into improving productivity and food security. It was recognised both by Heath and by the new DSIR administration that while New Zealand was expected to follow the example set by the British, New Zealand science came with its own unique constraints and features, given the small income-stream and the reliance of our economy on primary industry.

5.2 The Department of Scientific and Industrial Research

Over the next few years, under the energetic and charming guidance of Ernest Marsden, the DSIR began to grow and prosper. In its first nine years it successfully established several associations and investigations, particularly with regard to the primary industries mentioned above, and specifically, wheat, dairy and leather. In a variation from the purpose for which it had originally been set up, the DSIR also began to undertake its own research. The 1936 establishment of the Plant Research Station marked the point at which the DSIR formally began to carry out its own research (Galbreath, 1998), although the Soil Survey Division had worked from 1933 mapping the soils over most of the country, greatly facilitating efforts to improve agricultural production and increasing our understanding of New Zealand geology (Tonkin, 2009). By 1939 the DSIR had established seven internal research divisions, and its role as a research body was becoming increasingly important. This tendency began to bring it into competition with existing government entities such as the Department of Agriculture, which was carrying out its own research, and it was later to turn the DSIR into the large and unstructured body it became.

The onset of World War II created a sudden need for the expansion of science in New Zealand. The DSIR, while still rather small, was heavily involved from the beginning: the Wheat Research Institute worked on ways to increase wheat yield, and thus self-sufficiency; the Plant Chemistry Laboratories examined new and efficient means of drying fruits for service rations; and grassland scientists examined possible means of creating hardy and tough grasses for runways. A Physical Testing Laboratory was set up to engineer precision devices such as gun-sights, and the famous radar programme (later tested in the South Pacific and used by the Americans) was established (Galbreath, 1998).

Such programmes placed an immense strain on the physical-science infrastructure, and the consequences of the previous almost exclusive focus on primary industry became evident at this point. This lack of capability in secondary industry was still evident some 12 years on, and is hinted at in 1957 in *Science in New Zealand*, a collection of essays edited by F. R. Callaghan: 'it is probably not too inaccurate to say that, at present … secondary industry in New Zealand is … more in need of technologists than of scientists as such' (Dick, 1957: 19). Despite the increased awareness of the importance of secondary industry and the vital need for science in this area, it was still some years before national priorities reflected this.

5.3 Seeds of Reform

The steady evolution of the DSIR into a research provider, as distinct from a separate administrator and facilitator, continued after the war. By 1963, significant conflict with other bodies conducting research had begun to develop, and it was at this time that the National Research Advisory Committee (NRAC) was established. The NRAC was responsible for setting national strategies and departmental budgets, and although there was some effort at coordination between budgets, each department was allowed to set its own priorities (Galbreath, 1998). During the 1960s the NRAC struggled to be effective, and was hampered by a lack of clear political will and understanding of science, as well as a general shortage of resources and capability. Despite its problems it did provide a platform for a more strategic approach, but failed to offer the large-scale strategic vision that was essential to the development of science in New Zealand (Palmer, 1994). Meanwhile, on the level of science provision, the DSIR continued to grow, carrying out more research and adding more staff than ever before. In 1969 the first industry liaison group was added – a move that heralded later shifts towards commercialism (Galbreath, 1998).

By the 1970s, the DSIR had grown into a large organisation with a total staff of 2097, including 1605 scientists and technicians organised into 20 research divisions (Galbreath, 1998). The organisation had now become much more dominant than its British counterpart had ever been. The New Zealand DSIR noted in 1973: 'in few countries is such a wide field [of science] covered by a single state organisation' (DSIR, 1973; cited in Galbreath, 1998). This began to lead to a perception among policy-makers that the DSIR was inefficient. At the same time, a combination of events (including the oil shocks, the entry of the United Kingdom into the European Economic Community (EEC), and growing public environmental and social concerns) began a national conversation on the state of science in New Zealand which led to increasing priority being given to the growth of science investment.

These concerns forced the government to rethink the way science was funded, and resulted in a review in 1974. Subsequently, small increases in the science budget were made, and an increasingly commercial imperative was implemented for the DSIR. Further, the Scientific and Industrial Research Act was rewritten to state what had long been the case in practice: that the prime function of the DSIR was to 'initiate, plan and implement research calculated to promote the national interest in New Zealand' (Galbreath, 1998). This was in stark contrast to the 1926 Act, in which the functions of the DSIR were defined as maintenance, administration and the provision of advice.

Concerns were raised around not only the way in which science was funded, but also the way it was used. As Palmer notes from an OECD report of the time:

> science policy does not only include policy for science – that is the creation of an environment where science can flourish … it also comprises science for policy – affecting the ways that scientific and technical considerations bear on important policy decisions (Palmer, 1994: 8) .

New Zealand had spent over 100 years struggling to create a policy for science, but as Palmer notes, it had now reached a stage where it had to begin 'recognising the need for science for policy' (ibid.).

However, despite the advances in understanding of the science system that occurred during the 1960s and 1970s, the 1970s ended with an economic downturn, a 'sinking lid' on staff numbers, little progress in the manufacturing industries, and with very little industry interest in research and development (R&D) as a means of creating new opportunities (Galbreath, 1998). Even more importantly, emerging ideologies of New Public Management and Public Choice Theory[10] began to influence the way in which public institutions were funded, with huge consequences that became obvious over the next few years.

[10] Public Choice Theory suggests that if public service officials monopolise service delivery, the resulting system will suffer from oversupply and inefficiency. In contrast, it holds that if services are contracted out then the pressures of a competitive market will lead to efficiency gains and improved performance (Boyne, 1998).

Table 4 1926–1989: One Dominant Institution

Key themes

- New Zealand's British heritage, importation of the DSIR model, and steady evolution towards a more global focus
- The need for physical and technical infrastructure to back up scientific enterprise
- The transformation of the DSIR from administrator to provider
- The emerging importance of ideology in system design
- The emerging commercial imperative for science

Type of change

- Paradigm shift in organisation followed by steady growth

Drivers of change

- Overseas models – keeping up with Britain
- War – World War II as a significant driver of technical expansion
- The wider economic environment – i.e. the economic downturns of the 1970s forcing some commercialisation of science
- Institutional refinement – establishing what works and what doesn't

Types of research undertaken

- Continuation of agricultural research
- Increasing amounts of technical research, especially inspired by the war and the post-war boom period
- Emerging focus on manufacturing – and industry-focused research

6. The Third Era: 1989 to 2009 – The Tri-Institutional Framework

The early 1980s found New Zealand harbouring one of the most sheltered economic environments in the world. The myriad of government interventions, regulations and subsidies began to attract criticism from many quarters, and as public debt increased and the economy stagnated the calls for reforms became increasingly vociferous. Concepts such as New Public Management and Public Choice Theory provoked discourse and argument over the degree of government intervention necessary and the optimal institutional make-up (Davenport & Bibby, 2007). Such discourse often centred on the need to separate policy, funding and operational capacity within government to avoid capture of funds by self interested bureaucrats (Winsley, 2003). The 1984 Labour Government applied principles to separate policy, funding and operation across the board in a series of dramatic reforms, which have been noted as some of the most comprehensive and radical carried out anywhere in the world (Evans et al., 1996; Gregory, 1999). The reforms are not dealt with in detail in this report, as they have been the subject of extensive commentary from both local and international authors (see, for example, Cartner & Bollinger, 1997; Evans et al., 1996; MDL, 2005; Walker, 1996).

6.1 Shake-up of the Science System

The science sector was not spared during the reforms. Spurred on by two important reports (Arbuckle, 1988; Beattie, 1986), and enabled by three key pieces of legislation (outlined below), the structure under which research took place in New Zealand was completely reorganised. The 'Arbuckle Report' of 1988, for the Science and Technology Advisory Committee (STAC), was perhaps the most influential factor in determining the direction of the reforms (Palmer, 1994). It adhered to most of the principles of New Public Management and Public Choice Theory, advocating that 'the guiding principle [in designing a new system] is that the role of the government should be minimal' (Arbuckle, 1988: 47). Among its more strident recommendations were the introduction of contestable funding across the board, the creation of clear government objectives, the commercialisation of research institutes, and the separation of (i) policy, (ii) purchase and (iii) operational arms of science research.

This period was one of immense dissatisfaction within scientific circles. Galbreath (1998) notes that the period was marked by difficulties in communication between the various disciplines active in the science sector, especially between scientists and economists. Scientists felt they were being given little trust or recognition for the work they did,[11] while economists viewed scientists as another vested interest group trying to capture funding at the public expense. In this instance, it was the economists' ideas of New Public Management that triumphed, and very few of the scientists' objections were taken into account.

[11] A 1967 paper by Dick, Toynbee and Vignaux (cited in Galbreath, 1998) conservatively estimated a 20% return on investment in RS&T. Throughout much of the 1980s this remained one of the only assessments of the true value of public investment in RS&T, but it was largely disregarded by economists.

Major structural changes followed the Arbuckle Report. These were enabled by three key pieces of legislation that provided a statutory basis for the wide-ranging reforms to follow:

- The State Owned Enterprises Act 1986 provided for the mandatory corporatisation of several government trading organisations, based on the premise that large bureaucracies lacked the business acumen to compete in the marketplace.
- The State Sector Act 1988 was also aimed at inefficiencies and the lack of responsiveness from large bureaucracies, and attempted to ensure that senior managers were accountable for the performance of their departments, and that the public service as a whole was more open to competition.
- The Public Finance Act 1989 carried these same principles through into financial management. One of the key principles was establishing a framework for a contractual relationship between the chief executives and their ministries.

6.2 The Tri-Institutional Framework

The ethic of increasing accountability, defining performance and separating the functions of government also permeated the science reform process, resulting in three forms of institution – what is referred to in this paper as the tri-institutional model. MoRST, which is a government department as defined by the Public Finance Act 1989, was established on 1 October 1989 and commenced effective operations in December that year (MoRST, 2007c). FRST was established by statute in 1990 according to the Foundation for Research, Science, and Technology Act 1990. While MoRST was established to provide policy direction for science to the government, FRST was to distribute and administer government funds. This was followed in 1991/92 by the dissolution of the DSIR and other government research bodies (such as MAF Technology) and their replacement with 10 CRIs (see Table 8), loosely based around the old DSIR divisions (Cartner & Bollinger, 1997). This three-fold structure strictly separated advice (policy), funding allocation (purchase) and the operational faculties of the science sector (provision). The policy, purchase and provision segments of the science sector created by the reforms are outlined below.

6.2.1 Policy

Under the new model, the establishment of policy and priorities was undertaken by the newly created MoRST. Science priorities and associated resource allocations were developed which 'assumed there is a positive relationship between science investment and utilitarian research outcomes, and that this relationship can be planned and managed' (Cartner & Bollinger, 1997: 783). The adjustments to science priorities and allocations were among the most radical and important products of the reforms (Cartner & Bollinger, 1997).

6.2.2 Purchase

Funding was to be contestable under the new model, and administered by the newly created FRST. The adoption of a contestable funding system was another recommendation of the Arbuckle Report. Funding, previously administered by the DSIR and associated bodies, was now put into a single contestable pool, the Public Good Science Fund (PGSF), from which individual researchers and institutions could draw. This was part of a philosophical shift from a focus on input-based funding to the funding of outputs that could be individually contracted, bought and sold as well as assessed and reviewed (New Zealand Association of Scientists, 2005). Under this model, based on the premise that the best results will occur if researchers have to compete for funding, researchers submit 'bids' to the funding agency, which selects projects and length of funding. Decisions are based on the perceived merit of the research, the standing of the researchers, and the application of the research towards the specified science priorities (Cartner & Bollinger, 1997). The PGSF has been joined by various other funds since its inception.

6.2.3 Provision

The CRIs, which are discussed in more detail in Section 7, were created as the operational arm of public good science in New Zealand. From the outset they were intended to be independent science providers, each under the guidance and stewardship of their own board of directors, although directors are appointed by government (MoRST & CCMAU, 2002). Under Section 5 of the Crown Research Institutes Act 1992, CRIs have a responsibility to undertake research 'for the benefit of New Zealand' while also maintaining financial viability.[12] In order to maintain the goals of Section 5 of the Act, the CRIs are also companies under the Public Finance Act 1989 and the later Companies Act 1993. They are expected to have a medium to long-term focus, and balance government funding with commercial investment.

6.3 Emerging Discontent

The reforms were followed by a period of optimism within New Zealand science (Devine, 2003). Despite the enormous disturbance that was felt at the time and the reduced resources, when compared with previous DSIR operating budgets, as the boards of the new CRIs looked at their future directions, there was a real sense that consistent government disregard of the science sector was coming to a close (Palmer, 1994). The structural reforms of the early 1990s were followed in 1995 by a high-level strategic review, which set clear priorities and guidelines for future research (Science Priorities Review Panel, 1995).

[12] Section 5 of the Crown Research Institutes Act 1992, 'Principles of operation', can be found in Appendix 3 of this report.

Accordingly, the system continued to evolve, with universities being allowed access to the PGSF in 1993, the Royal Society of New Zealand and the Health Research Council (HRC) being established as funding agents in conjunction with FRST, and new funds being continually established to cover areas previously not thought of (such as the Marsden Fund (1994), the Technology New Zealand Fund (1997) and the New Economy Research Fund (2000)). In sum, the results appeared encouraging: a complete and thorough set of reforms that created a system that was more streamlined and efficient than its predecessor, and CRIs that did, on the whole, perform well economically (Devine, 2003; MoRST & CCMAU, 2002).

However, views to the contrary have been numerous and strongly expressed. Multiple concerns have been raised about the system, both in independent reviews commissioned by MoRST and FRST (Arnold, 2005; MDL, 2005), and in reviews prepared by MoRST (2009c), the OECD (2007) and a series of respected scientists and analysts (see, for example, Devine, 2003; Edmeades, 2004; Winsley, 2003). These views will be discussed in more detail in Report 9, *Government-funded Science under the Microscope* (SFI, in press). Concerns cover all aspects of the current system, from funding allocations to efficiency and fragmentation. For example, one commentator has stated that there exist 50 sources from which researchers can currently bid for funds. This fragmentation is not only inefficient but suggests system failures in that it may be easier to set up a new fund than adjust an existing incomplete or inefficient fund.

A 'stunning' level of dissatisfaction has been recorded among scientists within CRIs, clearly reflecting a system with some significant shortcomings (Serio & Sommer, 2000; cited in New Zealand Association of Scientists, 2005), while a joint Crown Company Monitoring Agency Unit (CCMAU) and MoRST appraisal of CRIs found that a focus on their economic successes would be misleading, and they should instead be judged by the impact of their operations on the wider public (MoRST & CCMAU, 2002). Furthermore, the closure of the Institute for Social Research in 1995 also raises questions about the capability of a fully commercial model to conduct meaningful social research (Fitzgerald, 2001).

There has been some recognition within MoRST and FRST of the difficulties caused by contestable funding, particularly the problem of financial insecurity over the long-term. To address this issue there have been efforts to create a system of funding less likely to shift in the face of changing priorities and leave researchers without financial backing before a project can reach completion. The Outcome Based Investment (OBI) initiative was trialled for this purpose in 2004/05 supporting the study of natural ecosystems (FRST, 2005). Under the OBI initiative FRST and research providers would agree on specific research outcomes to work towards over a twelve year period. Following one year of operation the OBI initiative was reviewed and subsequently scrapped. The reasons given for the cancellation of the OBI initiative were that it increased rather than decreased competitiveness between researchers, did not increase collaboration, did not develop the skills of the researchers (although the short time frame was acknowledged as a barrier to this) and showed the potential to 'lock out' researchers for longer periods of time if they failed to obtain funding when compared with the normal funding

system. The lessons learned were applied to the development of the Stable Funding Environment (FRST, 2005). The latter initiative is detailed in Section 7.2.

Overall, these views have led the government to question the efficiency of the current system, which has in turn led to a number of reviews on how the system could be improved (see Appendix 5). This implies that a new era could be looming, in which case it is timely to understand how the government-funded science system works today (Section 7) and what are the outstanding questions that are likely to shape the future of the government-funded science industry (Section 8).

Table 5 1989–2009: The Tri-Institutional Framework

Key themes

- Shift in the founding ideology, from following Britain to global economic concepts such as New Public Management and Public Choice Theory
- The debate over the degree to which government should influence the shape of research
- Inappropriateness of the commercial model to fit science

Type of change

- Paradigmatic shift followed by steady growth

Drivers of change

- Wider economic environment
- Imported ideologies
- Structural adjustment – new national economic model
- Evolutionary 'tinkering' with the system created in the reforms – the addition of funds, additional output classes

Types of research undertaken

- Increasing levels of industrial and technical research
- Important and advanced scientific developments across most fields of science

7. Government-funded Science Today

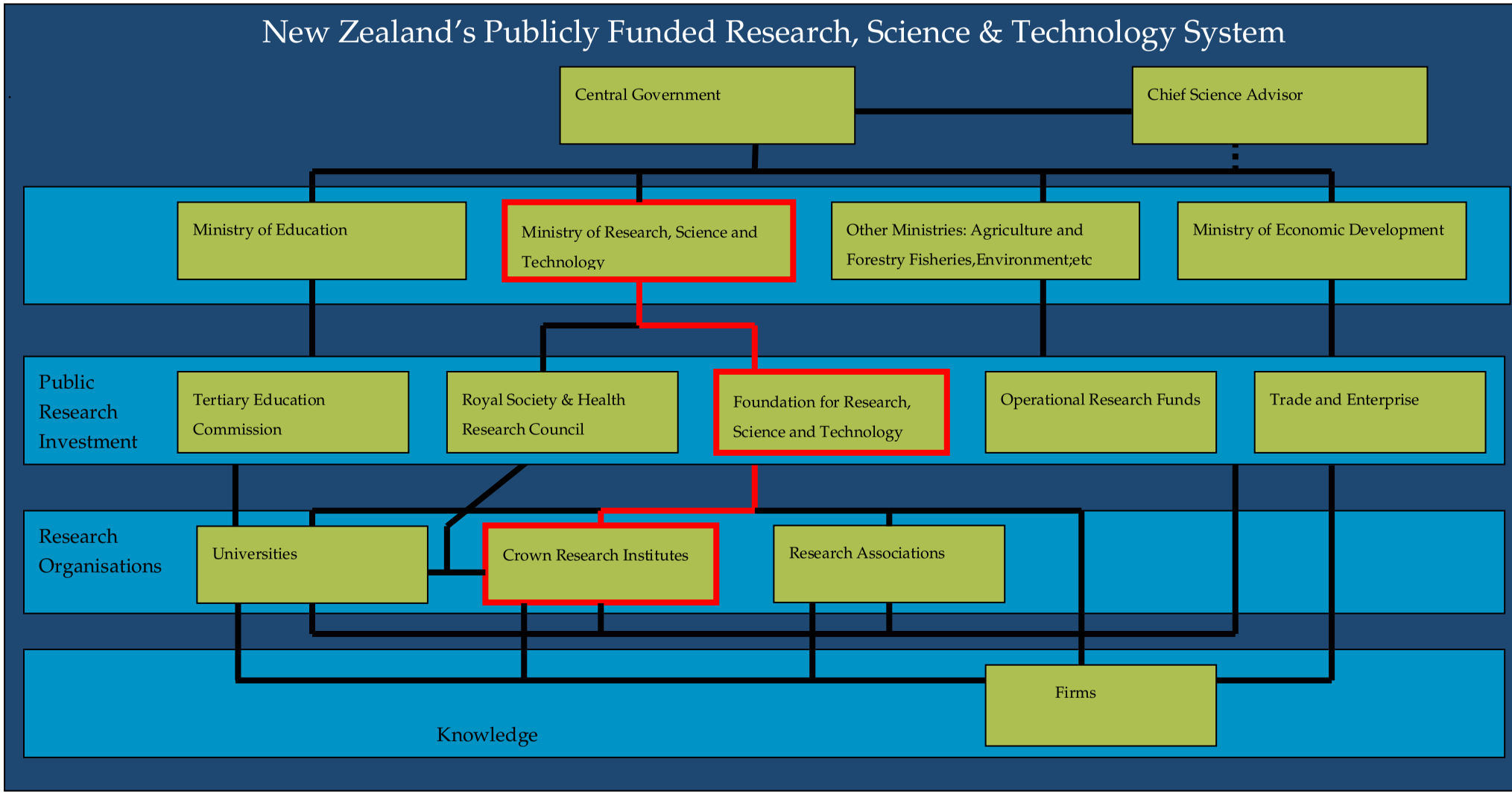
While the previous sections discussed the history of the government-funded science system, this section provides a snapshot of the system as it stands in 2009.[13] In it we discuss each of the three parts of the tri-institutional model: policy, purchase and provision.

7.1 Policy

MoRST is the main agency responsible for science policy in New Zealand. Other government policy agencies are shown in Table 6 and include the Ministry of Education, Ministry of Agriculture and Forestry, Ministry of Economic Development, and Ministry for the Environment. MoRST provides policy advice to the Minister of Research, Science and Technology, and technical support to the government on science-related issues. Further, it strives to allocate funding and set policy to achieve maximum benefit for the public investment dollar, and that knowledge gleaned from scientific research is fed back into the policy cycle. MoRST also allocates the government's $745 million investment in science through Vote RS&T to other bodies, mainly FRST, via 'output expenses' which designate funds to a particular area of research e.g. the environment fund for environmental research. MoRST describes its major outcome as: '[g]etting measurable benefits from New Zealand's investment in research, science and technology' (MoRST, 2009a: 4).

[13] For reasons of brevity, this section does not contain a full list of facts and figures. See the MoRST (www.morst.govt.nz) and FRST (www.frst.govt.nz) websites for more detailed information.

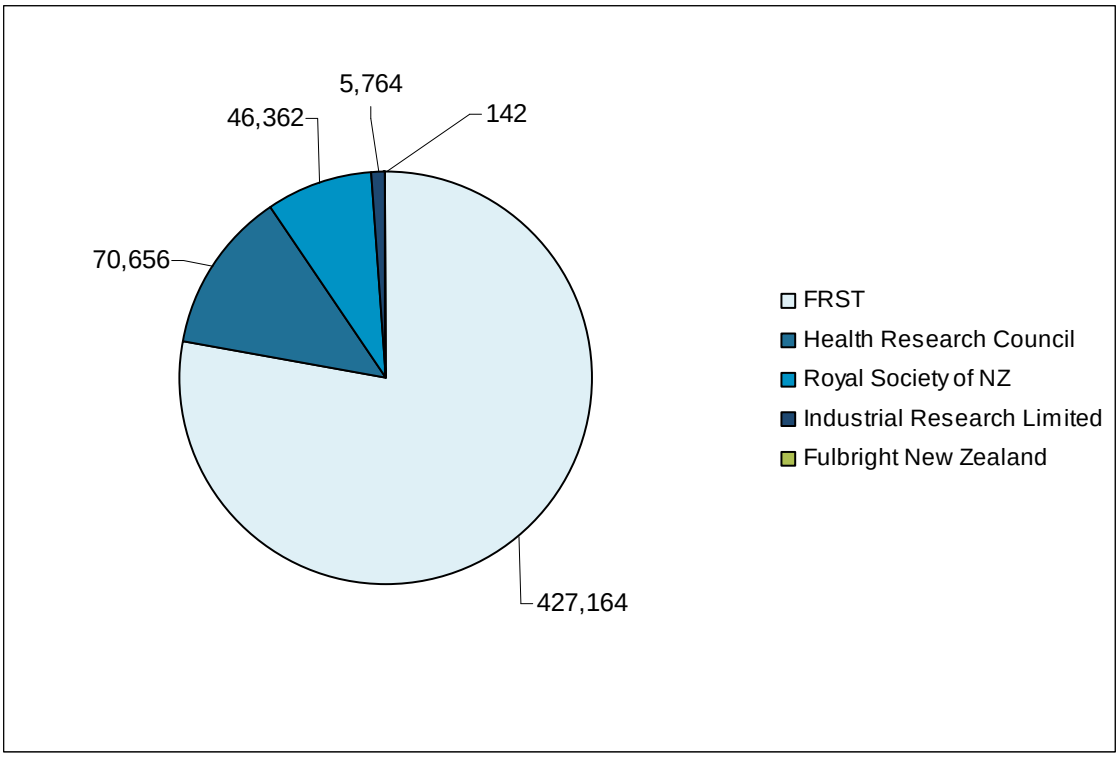
Table 6 The Current Government-funded Science System
Adapted from FRST, 2009a: 1. Note: this table has been updated to include the Chief Science Advisor (CSA), who was appointed in May 2009.



7.2 Purchase

FRST is the largest investor of public science funds in New Zealand. In the investment round of 2009/10, Vote RS&T totalled $745 million. Over $500 million of this will be allocated to science purchasers and FRST will invest over three quarters of that sum (see Figure 1 below) (FRST, 2009a: 1). Where other government ministries are responsible for managing government-funded science, FRST consults and in some cases manages those investments (FRST, 2009a: 1). Due to the prominent position of FRST within the government-funded science system and the non-governmental status of the other purchasers this section will focus upon the Foundation's role only

Figure 1 Vote RS&T: Allocation to Public Institutions 2009/10
Adapted from Treasury (2009a: 185). Values are in $000



The process by which government science funding is allocated can be broken down into three stages: (i) policy development by MoRST, (ii) Portfolio development by FRST and lastly (iii) the investment through a blend of contestable and stable funding by FRST.

When FRST has received both the high level policy goals and the funds (in the form of an 'output expense') from MoRST (being the first stage), the Foundation then establishes a range of portfolios, each of which concerns an area of research required to reach the high level goals. For example, MoRST sets aside funds for the broad area of environmental research, comprising the 'output expense' called the Environment Fund. This is set annually in the budget and allocated to FRST who then breaks down the Environment Fund into four portfolios with more specific

research aims. An example of one of these portfolios is the 'Resilient, Functioning and Restored Ecosystems portfolio' which is 'for research that supports New Zealand's land, freshwater and marine ecosystems to operate, adapt or recover' (FRST, 2009i). The third stage of the funding process is for the funds to then be invested in individual projects through a process whereby researchers apply for contestable funding, as established following the reforms of the 1980s (Section 5). The contestable funding process seeks to raise the quality of scientific outputs in a more efficient manner by adding an element of market competitiveness. The success or failure of each application depends on the merits of their research relative to other applicants. Criteria for success can be based on the expected economic return for shareholders, the quality of the proposal, and the extent to which research outputs will provide public-good outcomes for New Zealand (MoRST, 2006). While the contestable process for funding allocation was widely adopted by many countries as they undertook economic reforms, few went as far as New Zealand. Indeed, Anderson (2006) notes that, following the reforms, the New Zealand science system displays the highest level of contestability in the world.

FRST's structure comprises a management team, and a governance board appointed by the Minister of Research, Science and Technology. Strategic planning is aided by panels of strategy advisors, while funding applications are processed by panels of expert advisors. Advisors may be scientists, policy advisors, research managers and R&D-experienced business people (FRST, 2009b: 1). FRST is currently undergoing changes to the way it is set up, with a view to implementing a new organisational structure (FRST, 2009c: 1).

This alteration of FRST's structure follows a change in government, and is associated with several new initiatives. One of these is to simplify and streamline the investment process to achieve reduced transaction and compliance costs (FRST, 2009d: 1). This will require the devolution of R&D investment decisions to research organisations, simultaneously devolving greater trust and accountability to our scientists and scientific institutions. FRST (2009d: 1) states that other areas for change within the Foundation will include, for example, contracts, and performance management and reviews, and that these changes will affect the entire investment process.

Devolution of funding investments to research organisations was noted as an area in need of consideration by McKinley Douglas Ltd (MDL, 2005: 28), and calls for greater responsibility to be placed in the hands of New Zealand's scientists have also been numerous (cf. National Science Panel, 2008: 9; NZAS, 2005: 80–86). FRST's initiative, therefore, in undertaking its own stakeholder investigation of the shortcomings of the funding and investment mechanisms, and in following through on this initiative with actual change, is to be commended. But will these changes go far enough to resolve the problems associated with FRST's investment processes?

Some scientists we spoke with questioned the process by which FRST allocates funds to projects, pointing out members of the expert panels which evaluate contestable funding applications are not required to be scientists. Naturally, expert panels need not be composed entirely of scientists, as members of other disciplines, such as accountants and lawyers, can

offer different and valuable considerations on a nation's R&D requirements. Yet it is confounding that potential projects may not be subject to scientific peer review before funding approval is granted.

Other commentators have drawn attention to the higher level setting of science priorities through stages 1 and 2, being the establishment of the 'output expenses' and portfolios. Professor Paul Callaghan, in his book *Wool to Weta*, states that, 'no public servant has the prescience needed to make pre-selected allocations or to micro-manage New Zealand's science funding instruments' (Callaghan, 2009: 15). Whilst not impossible it seems doubtful that bureaucrats not actively involved in science in New Zealand can efficiently and effectively allocate funding which contains a high degree of future thinking. If those bureaucrats are involved actively with science then the issue of bias in the funding is raised, i.e. the pre-allocation of funds to 'pet areas'.

Since 2006 MoRST and FRST have been running the Stable Funding Environment (SFE) initiative. The SFE is based upon lessons learned from the earlier OBI initiative (see Section 6.3) and is intended to overcome some of the problems caused by insecurity of funding that has been created by the short term nature of contestable funding and shifting priorities that may result in the loss of funding for any area of research with relatively short notice (FRST, 2008). In an attempt to reduce the insecurities of contestability the SFE removes a portion of the funds allocated by FRST using contestable funding and shifts them to more steady negotiated funding. Negotiated funding allows researchers to work with FRST and determine an agreed mid to long term outcome with funding of a matching length. Currently 30% of funds allocated to the New Economy Research Fund and 40% of funds to Environment Research and Research for Industry are assigned via negotiated funding (MoRST, 2009e). In addition to the allocation of a percentage of the above mentioned three funds to negotiated funding the SFE also allows for the creation of 'platforms' for research funding to address the problem of research areas losing funding due to shifting priorities. Platforms are areas of research interest that cover a specific topic of value. Platforms are then allocated a set amount of funds for a seven to ten year period, to which researchers in the field apply for funding. Contestability still operates as before between researchers applying for funds (FRST, 2008). FRST implemented the first platform of the SFE in August of 2009 (NZ Govt, 2009c), covering natural hazards research; the value of the platform is $140 million over a ten year period (NZ Govt, 2009c).

A review of the SFE was completed in 2009 (MoRST, 2009e). This review found that negotiated funding had failed to achieve the desired stability of funding. Some success had been achieved where the SFE applies to contestable funding and technical review. The review recommended that SFE be changed to incorporate a clearer definition of the goal of stable funding, a number of new changes relating to the design of negotiated funding and the further refinement of contestable funding bidding and technical review.

7.3 Provision

The provision of government-funded science in New Zealand is undertaken by various bodies, of which the primary providers are the CRIs. Other agencies, such as research associations and universities, which provide additional government-funded science research are listed in Appendix 4.

7.3.1 Crown Research Institutes

Crown Research Institutes are the largest providers of scientific research in New Zealand. Ten were established under the Crown Research Institutes Act 1992, of which eight remain in operation today. The CRIs are guided by the principles underlying other economic and institutional reforms of the late 1980s. By subjecting science and research to market forces, the government looked to achieve three principal objectives: accountability, enhanced economic growth, and improved decision-making. Table 7 shows the return on equity for each CRI in the 2007/08 year which is an important indicator of the success of meeting the three principal objectives.

Table 7 Crown Research Institutes: Return on Assets, 2007/08
Source: COMU, 2009a: 1

Crown Research Institute	Total Assets ($m)	Equity ($m)	Revenue (a) ($m)	2007/08 Return on Equity
Crop & Food Research[14]	41.1	23.1	48.1	-5.6%
AgResearch	246.3	193.5	148.6	1.6%
Landcare Research	44.6	26.6	56.1	2.5%
Industrial Research Ltd	38.9	28.6	57.1	2.3%
Scion	32.4	23.6	41.9	4.8%
HortResearch[15]	68.4	54.6	65.4	3.3%
GNS Science	40.3	19.6	54.5	7.1%
Environmental Science and Research	43.4	30.1	51.1	10.1%
National Institute of Water & Atmospheric Research	113.7	120.0	120.0	12.8%
Total	**669.1**	**642.7**	**642.8**	

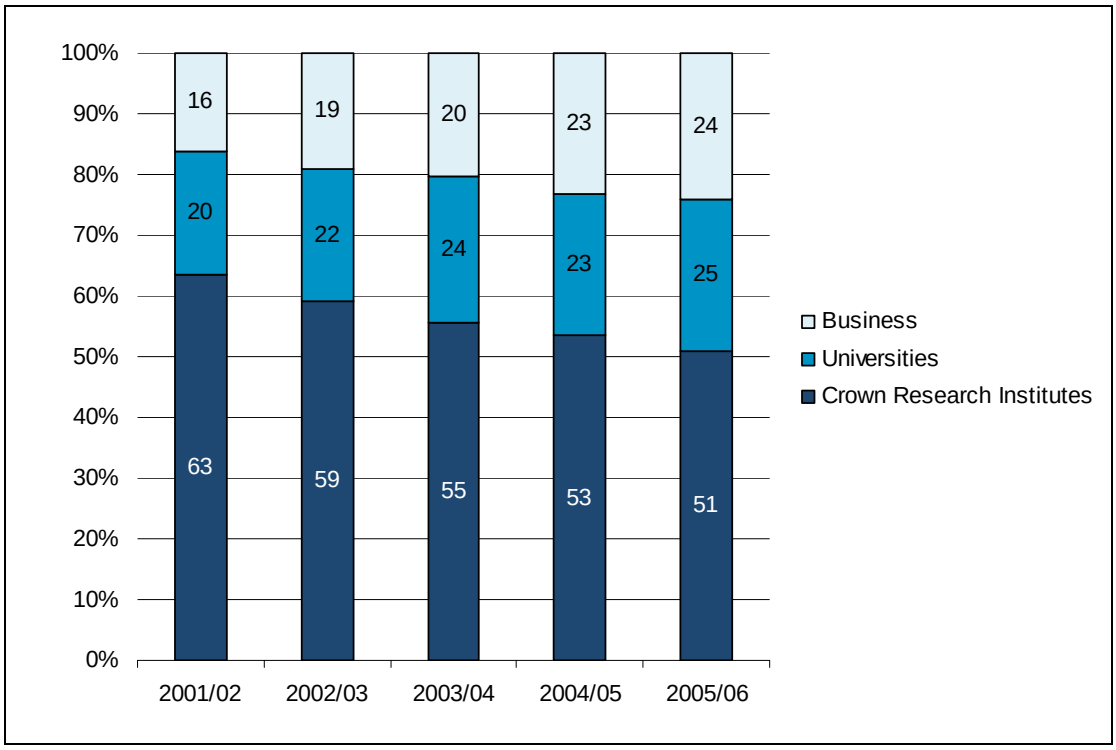
[14] Crop & Food Research and HortResearch were combined to form Plant & Food Research in December 2008.

[15] See above.

Each CRI is matched to a certain sector of the economy or natural resource, and is required to serve government research needs, as well as determine its own research agenda. CRIs are Crown entity companies, and are expected to operate in a financially viable manner under Section 5 of the Crown Research Institutes Act 1992 (see Appendix 3).

Although as a group they are the largest recipient of Vote RS&T, CRIs are experiencing a declining market share. Figure 2 shows that in 2001/02 CRIs received 63% of Vote RS&T, while universities and business received 20% and 16% respectively (MoRST, 2007a: 3). By 2005/06, these figures had changed to 51%, 25% and 24% respectively (ibid.). It seems that the trend shown in Figure 2 is likely to continue. In a 2006 analysis of the science-funding system using mathematical modelling, Weir proposed that the 'market share of CRIs will be reduced from 50% of government funding to 25% in the next 10 years – making CRIs insignificant in the NZ science system' (Weir, 2006: 1).

Figure 2 Vote RS&T: Recipients Over Time
Source: MoRST, 2007a: 3



Crown Research Institutes report research outcomes to FRST. Thus, there is no mandated communication link between the provider (the CRI) and the policy-maker (MoRST). This point is discussed further in Report 9.

Table 8 shows the CRIs that were established in 1992, and compares the situation in 2009.

Table 8 Crown Research Institutes: Comparing 1992 with 2009
Sources: MfE, 1997: 1; Office of the Auditor General, 2009: 10

	CRIs Established in 1992: Entity and Purpose (MfE, 1997: 1)	**CRIs in 2008**	**Full-time Equivalent Employees** (Office of the Auditor General, 2009: 10)
1	**NZ Forest Research Institute Ltd**: Research on profitable and environmentally sound forest and wood products and production processes	**Now Scion:** Purpose – a robust and profitable research and development company enhancing the environmental and economic transformation of New Zealand (Scion, 2008: 2)	**317**
2	**AgResearch (New Zealand Pastoral Agriculture Research Institute Ltd)**: Research on innovative solutions and opportunities for the food, fibre and biotechnology-related industries based on pastoral agriculture	Purpose – to create sustainable wealth in the pastoral and biotechnology sectors through science and technology (AgResearch, 2009)	**934**
3	**Horticulture and Food Research Institute of New Zealand Ltd**: Provides research and development that adds value to fruit, vegetable, crop and food products	**Now Plant & Food Research:**[16] Mission – to generate knowledge and intellectual property that promotes the innovative, efficient and sustainable use of primary plant and seafood-based resources to create value for New Zealand (Plant & Food Research, 2009)	**787**
4	**New Zealand Institute for Crop and Food Research Ltd:** Research on the production and processing of crops and foods for local and overseas processing and manufacturing companies, farmers and growers		
5	**Landcare Research New Zealand Ltd**: Environmental research on management of land resources for conservation and primary production, to benefit land users, resource managers and policy makers	Core purpose – to undertake research and development to protect and enhance New Zealand land environments and enable their sustainable use in economic development (Landcare Research, 2009: 3)	**438**

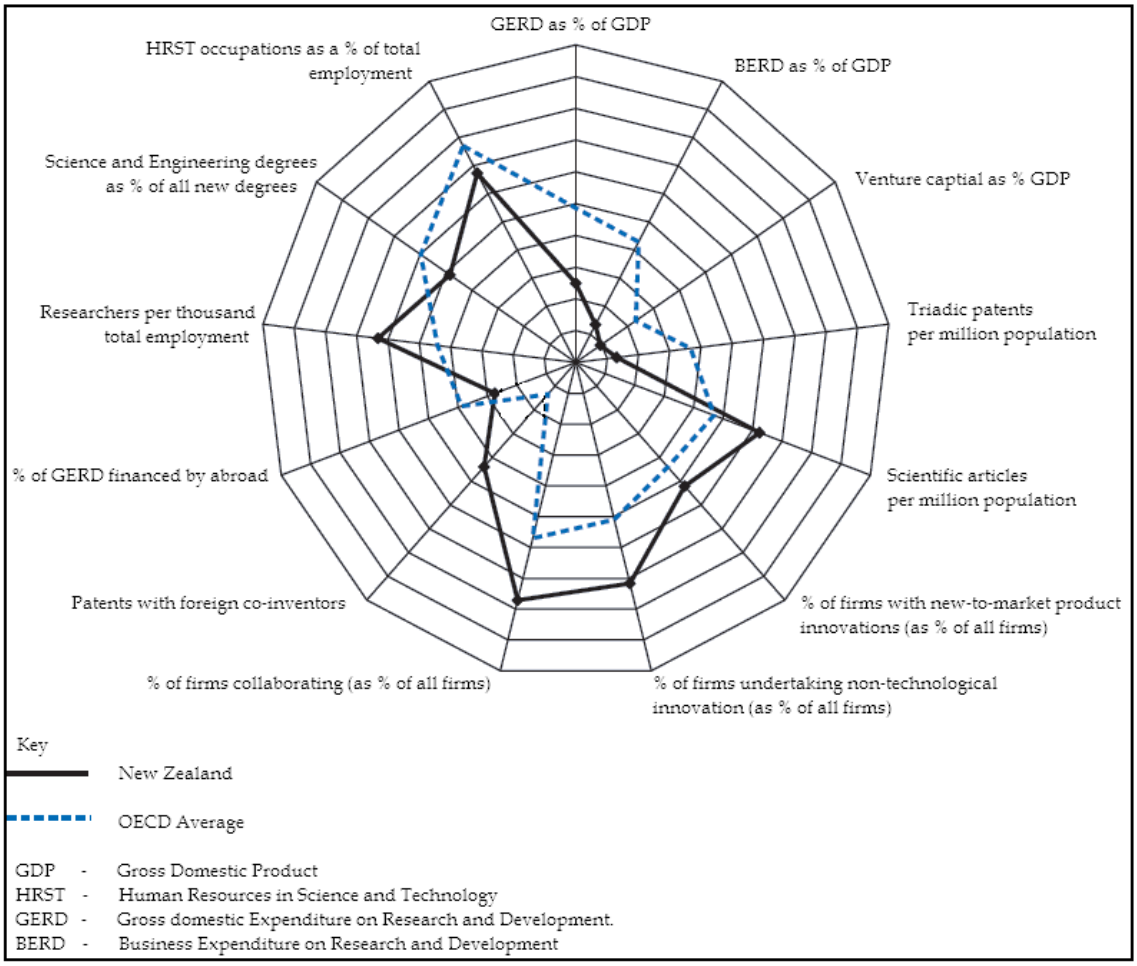
[16] Merged in 2008.

	CRIs Established in 1992: Entity and Purpose (MfE, 1997: 1)	CRIs in 2008	Full-time Equivalent Employees (Office of the Auditor General, 2009: 10)
6	**Institute of Geological and Nuclear Sciences Ltd**: Geo-science and nuclear science expertise to government and industrial organisations involved in geothermal, oil and gas exploration and development, and environmental studies throughout the Asia-Pacific region	**Now GNS Science:** Core purpose – to understand earth systems and technologies and to transform this knowledge into economic, environmental, and social benefits for New Zealand (GNS, 2009: 4)	**334**
7	**Industrial Research Ltd**: Scientific and technological research and development in the processing, manufacturing and energy industries, in partnership with the government	Foundation of their work is – world-class science and engineering to transform industry and add value to the New Zealand economy (IRL, 2008: 3)	**307**
8	**National Institute of Water and Atmospheric Research Ltd**: Research for the sustainable management of New Zealand's atmospheric, marine and freshwater systems and associated resources; environmental consultancy work on a global scale	Mission – [to] conduct leading environmental science to enable the sustainable management of natural resources for New Zealand and the planet (NIWA, 2009)	**726**
9	**Institute of Environmental Science and Research Ltd:** Science-related research, analytical and consulting services in public health, environmental health and forensics within New Zealand and the Asia-Pacific region	Vision – leading provider of specialist science solutions contributing to innovation in New Zealand and to the protection of people and their environment in the Asia-Pacific region (ESR, 2009: 3)	**373**
10	**Institute for Social Research and Development:** Responsible for social research	Disbanded in 1994 (Statistics NZ, 2000)	

The disaggregation of the DSIR into the smaller, isolated business units – CRIs – is the most extreme example of adherence to New Public Management theory in publicly funded science system reforms the world over. New Zealand has a large number of scientific providers (eight CRIs) for its population of four million people. Australia, on the other hand, has one umbrella funder and provider, the Commonwealth Science and Industrial Research Organisation (CSIRO), for its 22 million people (Australian Bureau of Statistics, 2009). The CSIRO, in operation since 1926, is Australia's equivalent of the former DSIR, and survived Australia's

economic reforms of the 1980s. Great Britain, with its population of roughly 61 million (Office for National Statistics, 2009: 1) has seven Research Councils,[17] which administer 90% of public funding for academic research in Britain (Drayson, 2008). Each council purchases R&D from research facilities across Great Britain. No country has followed New Zealand's lead in implementing the CRI system.

Figure 3 Science and Innovation Profile of New Zealand Compared to the OECD Average
Source: OECD, 2008: 143



[17] These Research Councils are Arts and Humanities Research Council; Biotechnology & Biological Science Research Council; Engineering & Physical Sciences Research Council; Economic & Social Research Council; Medical Research Council; Natural Environment Research Council; and the Science and Technology Facilities Council.

Table 9 shows how funds are allocated under Vote RS&T (2009/10).

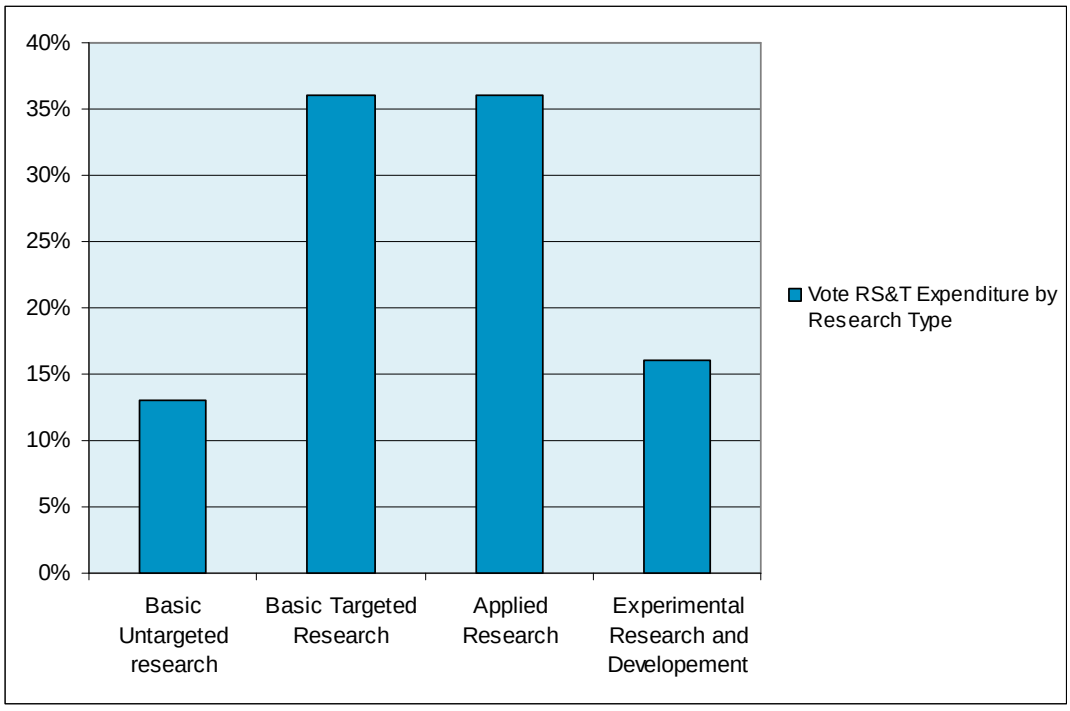
Table 9 Vote RS&T by Research Funds 2009/10
Source: Treasury, 2009a: 149–209

Funds	**2009/10 Budget** (000s)	**Government Funds** (%)
Research for Industry (p. 179)	$214,263	29%
Environment Fund (p. 160)	$102,569	14%
CRI Capability Fund (p. 191)	$60,612	8%
New Economy Research Fund (p. 173)	$73,019	10%
Health Research (p. 165)	$70,955	10%
Technology NZ (p. 205)	$47,405	6%
Marsden Fund (p. 170)	$46,878	6%
Social Research Fund (p. 182)	$5,860	1%
Māori Knowledge and Development Research (p. 168)	$4,867	1%
Other Funds (p. 149-209)	$118,635	16%
Total	**$745,063**	**100**%

7.4 Types of Research

The government invested 13% in basic untargeted research through Vote RS&T in 2007/08 (MoRST, 2008a: 2). This investment is mostly distributed through the Marsden Fund, which sees an extraordinarily high proportion of applicants fail. Of the 934 proposals received in 2009, only 109 (just under 12%), succeeded in securing funding (Royal Society of New Zealand, 2009: 1). This low success rate highlights the wealth of foregone research outputs due to low investment, and the large amount of time wasted by our scientists in preparing unsuccessful applications.

Figure 4 Vote RS&T: Research Funding by Type 2007/08
Adapted from: MoRST, 2008a: 2



7.5 Summary

New Zealand's government-funded science system is dominated by the tri-institutional set-up created following the reforms of the early 1980s. Under this arrangement, policy, purchase and provision of science are determined by multiple actors at each level, but the dominant actors are MoRST for policy, FRST for purchase and the eight CRIs for provision. Under this system the direction of government-funded science is determined at the broadest level by policy set by MoRST. Funding for individual science projects is determined by FRST, with the aim of allocating funds on a contestable basis to ensure that only the highest quality research receives funding. In addition to high quality research outcomes, CRIs are also expected to operate on a commercial basis and return a dividend to the government each year.

The background information discussed above led to a number of interesting observations and outstanding questions, the most significant of which are identified in Section 8.

8. Observations

There is little doubt that the outputs of the current system have been useful, and important in establishing New Zealand's niche in the scientific world order, and the resulting outcomes have been influential in shaping New Zealand as it is today. The crux of the problem, however, is whether greater success could have been achieved and can still be achieved: essentially, should the current system be improved or redesigned, and if so, how could an NSDS contribute to optimising the government-funded science system?

Having explored the history of government-funded research in New Zealand, there are eleven key observations which stand out. These observations encompass clear issues and themes that have recurred during the structuring of New Zealand's publicly funded science in the past, and thus are likely to occur again. In acknowledging these and discussing them, we can consider the ways in which they could shape an efficient system for government-funded research in the future. Our observations are presented below in conjunction with the subsequent questions that arise from them. We do this with a view to improving the government-funded research system that exists today and introducing the concepts and questions which will be addressed in Report 9, *Government-funded Science under the Microscope* (SFI, in press).

Table 10 Observations and Key Questions Relating to Government-funded Science

Observations – Current System	Key Questions – Future System
1. Science is a long-term process. It requires a similarly long-term dedicated investment.	a. What are the appropriate time scales for optimising investment, for example: one year, three years, twelve years or twenty years? b. Is the government-funded science system adequately oriented towards the appropriate time scales? c. Will the Stable Funding Environment platform based initiative deliver the desired outcome?
2. The focus of science changes over time as new discoveries, new problems and economic changes shift the drivers of science. These changes can come from both international and national sources.	a. Is the capacity of the government-funded science system strong enough to be able to undertake novel streams of research quickly? b. Is the government-funded science system adequately linked to international latest trends and best practice? c. Is the government-funded science system sufficiently flexible and robust to cater for emerging issues facing New Zealand?
3. Government-funded research policy is set by the Minister of Research, Science and Technology and is thus strongly connected to political forces.	a. Are political forces creating any issues, problems or biases in how and what research is conducted? b. Are these political forces evidence-based and transparent?
4. The linkage between the type of research and the research goal is critical to both understanding current performance and shaping future progress.	a. Have we got the type of research right? b. Do we need a better method of evaluation? c. Has the current system delivered benefits to all segments of society in a fair and transparent manner, and if not, what obstacles need to be removed or managed?

Observations – Current System	Key Questions – Future System
5. Government-funded research needs to interact internationally and stand up on the global stage. At the same time, the system must be tailored to meet the unique needs and characteristics of New Zealand.	a. Are international management models appropriate for science in New Zealand? b. Have we got the balance right between international and national research? If not, how best can we manage the conflicting needs? c. Are we capitalising on our formal international science relationships? d. Are we missing opportunities to develop international science relationships?
6. Government-funded research is structured around a company model. As such CRIs are expected to return a dividend to the government each year as well as maximise outcomes from public good science and technology.	a. Is the company model appropriate for a government-funded science system? b. Does assessing performance based on the CRIs dividend overlook and devalue the important returns to New Zealand that are produced by public good science and technology.
7. The contestable funding system run by Foundation for Research, Science and Technology (FRST) and other purchasers creates competition between providers for limited government funds.	a. Is there an easily accessible register of science funds for researchers? b. Does the system allow for fair competition? c. Is the system designed effectively and efficiently to maximise outcomes? d. Is competition between researchers detrimental to quality outputs? e. Is it appropriate for the Stable Funding Environment initiative to retain an element of competitive funding?
8. Science that is government-funded raises the question of whether or not New Zealand taxpayers are getting value for money. Rigorous processes and systems are therefore required to ensure optimal efficiency and transparency.	a. Is the government-funded research system designed effectively and efficiently? b. Is the system sufficiently transparent to enable investment decisions to be assessed? c. Is it clear what value for money means in practice?

Observations – Current System	Key Questions – Future System
9. Crown Research Institutes (CRIs) are becoming less significant and receiving a smaller share of total funding, while more funding is being allocated to universities and business. This is a clear sign that change within the system is already happening.	a. Does New Zealand have an appropriate number of CRIs to achieve its science goals? b. What are the implications of CRIs becoming less significant? c. Are there provision mechanisms other than CRIs that could produce better quality outputs? d. What are the implications of universities and business becoming the front-runners in government-funded research?
10. Science requires a deep and capable pool of researchers for it to operate effectively. Creating a pool like this means retaining researchers and recognising that there is a long lag period between new people entering science education and the time they become productive researchers.	a. Is science valued adequately in the New Zealand education system? b. Does the New Zealand's education system recognise the time-lag between educating scientists and scientists being productive? c. Is science an attractive career choice for New Zealanders?
11. Government-funded research needs government-funded infrastructure, being the fixed assets needed to deliver science that counts.	a. Is there a register of current public good science assets and a list of what is needed? b. Could CRIs, universities and non-government New Zealand organisations share science assets better? c. Does New Zealand have the right science assets in the right hands?

Abbreviations

CCMAU	Crown Company Monitoring Advisory Unit (renamed Crown Ownership Monitoring Unit (COMU) 23/11/2009)
COMU	Crown Ownership Monitoring Unit
CRI	Crown Research Institute
CSA	Chief Science Advisor
CSIRO	Commonwealth Science and Industrial Research Organisation (Australia)
DSIR	Department of Scientific and Industrial Research
FRST	Foundation for Research, Science and Technology
GDP	Gross Domestic Product
HRC	Health Research Council of New Zealand
MAF	Ministry of Agriculture and Forestry
MED	Ministry of Economic Development
MfE	Ministry for the Environment
MoRST	Ministry of Research, Science and Technology
NERF	New Economy Research Fund
NIWA	National Institute of Water & Atmospheric Research
NSDS	National Sustainable Development Strategy
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
RS&T	Research, Science and Technology (as in Vote RS&T)
SFE	Stable Funding Environment
RSNZ	The Royal Society of New Zealand
TEC	Tertiary Education Commission

Glossary

Term	Definition
Applied research	Original investigation undertaken in order to acquire new knowledge, but directed primarily towards a specific practical aim or objective (OECD, 2002: 78)
Basic research	Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view (OECD, 2002: 30)
Basic untargeted research	Experimental or theoretical research undertaken to acquire new knowledge with no particular application in mind (FRST, 2009e: 1)
Centres of Research Excellence (CoREs)	Primarily, but not exclusively, inter-institutional research networks, with researchers working together on a commonly agreed work programme. Each CoRE is hosted by a university and comprises a number of partner organisations, which may include other universities, CRIs and wānanga (TEC, 2009)
Experimental development	Systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, installing new processes, systems and services, or improving substantially those already produced or installed (OECD, 2002: 30)
Research and experimental development (R&D)	Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications (OECD, 2002: 30).
Wānanga	Tertiary institutions that were established under Section 162 of the Education Act 1989; the Act defines a wānanga as 'characterised by teaching and research that maintains, advances, and disseminates knowledge and develops intellectual independence, and assists the application of knowledge regarding ahuatanga Māori (Māori tradition) according to tikanga Māori (Māori custom)'(Education Act, 1989).

Appendix 1 About the Authors

Wendy McGuinness
Wendy McGuinness is the founder and Chief Executive of the Sustainable Future Institute. Wendy was born in 1958 in Te Kuiti, and grew up on a farm in the King Country. She attended Hamilton Girls High School and Edgewater College, Pakuranga before going on to study at Manukau Technical Institute, Otara (NZCC), Auckland University (BCom), Otago University (MBA), as well as completing a number of papers in Environmental Ethics and Philosophy from Massey University.

As a chartered accountant specialising in risk management, Wendy has worked in both the public and private sectors. She worked on contract for Treasury during the reforms of the 1980s, and wrote the report *Implementation of Accrual Accounting in Government Departments* (McGuinness, 1988). She also acted as Chief Financial Officer for the DSIR for three months, and worked on contract for the Ministry of Energy during its break-up into two separate units, both in the late 1980s. Wendy was appointed as an independent advisor to FRST twice in early 2000, as part of what is now called a proposal advisory group. She also applied to MoRST for assistance in establishing *Project 2058* but was advised that the project was better suited to FRST funding. However, following a decision to progress *Project 2058* independently and outside of government, no application was ever made to FRST. Wendy has extensive knowledge of the genetic modification debate in New Zealand, as indicated in two published reports in early 2008 (SFI, 2008a, 2008b). She has also attended two World Futures Conferences in Washington DC (2008) and Chicago (2009). In addition, she has visited over eight think tanks based in the US and the UK, many of which have studied science, and whose publications now sit in the James Duncan Reference Library in the Sustainable Future Institute's Wellington offices.

In 2004 Wendy established the Sustainable Future Institute as a way to contribute to creating a space in which to consider New Zealand's long-term future. She remains a member of the Royal Society, the New Zealand Institute of Chartered Accountants (of which she was a councillor from 2005 to 2007) and NZ Bio. For more information on the Sustainable Future Institute, see www.sustainablefuture.info.

Mark Newton
Mark Newton works as a research analyst at the Sustainable Future Institute, having completed his Master of Environmental Studies degree at Victoria University of Wellington in early 2009. Mark completed a BSc in Geography and Environmental Studies in 2005, and the following year studied Environmental Management at the Christian Albrecht's University of Kiel, Germany.

Mark's work experience includes tutoring Environmental Studies students at Victoria University in 2007, and work as a field technician for Wildland Consultants in 2007, which involved gathering scientific data on the damage deer are doing to New Zealand's native forest.

Joe McCarter

Joe McCarter was born in England and moved to New Zealand in 1984. He has lived in several towns and cities in this country, but did most of his growing up in the central North Island and now has his deepest roots in Wellington. He completed his BSc/BA in Biology, Classics and Religious Studies at Victoria University of Wellington in 2005, and returned to complete his Post-Graduate Diploma in Environmental Studies in 2007. Since 2008, Joe has been working between Vanuatu and Wellington, researching change in traditional environmental knowledge and resource management on Malekula Island, and facilitating the establishment of locally based 'custom schools' as a means of increasing the intergenerational transmission of knowledge. This research will form the bulk of a PhD thesis, which Joe is hoping to submit in March 2011.

Chris Aitken

Chris Aitken grew up in Levin, moving to Wellington to study at Victoria University, where he completed a BSc in Geography and Environmental Studies. He then undertook postgraduate research, completing a Master of Environmental Studies in 2009 by writing a thesis examining behaviour and attitudes towards climate change.

Appendix 2 Timeline of Legislation and Key Documents

Below is a timeline of relevant dates, with the aim of providing a brief overview of past events.

1865 New Zealand Geological Survey established
A central government initiative to ensure the maintenance of control over gold and coal discoveries. The Survey was led by James Hector, who suggested it be organised as a museum-type establishment which would report on all natural sciences in New Zealand (Nathan, 2007).

1867 The New Zealand Institute Act
The New Zealand Institute aimed to bring together the various research and philosophical societies that had sprung up around the country (Galbreath, 1998). It was responsible for care of a public museum, library, laboratory and observatory, and through the use of lectures and classes promoted 'the general study and cultivation of the various branches and departments of art, science, literature and philosophy' (Bowen, 1868). In 1933 the New Zealand Institute became the Royal Society of New Zealand under the Royal Society of New Zealand Act 1933.

1926 Scientific and Industrial Research Act
An Act intended to 'make provision for the promotion and organisation of Scientific Research, and for its application to the primary and secondary industries of New Zealand' (Aston, 1928: 37). The Department of Scientific and Industrial Research (DSIR) was formed as a result and assumed responsibility for the administration of science research within New Zealand. The DSIR aimed to facilitate greater cooperation between the various bodies and departments carrying out research, as well as private institutions.

1933 The Royal Society of New Zealand Act 1933
The purpose of the Royal Society of New Zealand Act 1933 was 'to abolish the New Zealand Institute but for their work as a body for the promotion of science to continue as the Royal Society of New Zealand' (Royal Society of New Zealand Act, 1933).

1963 National Research Advisory Committee (NRAC) established
A committee responsible for setting national strategies and departmental budgets. This committee appears to have been disbanded in 1986 (Pickens, 1990).

1969 First industry-liaison group added to the DSIR (Galbreath, 1998)

1969 Building Research Levy Act 1969

The Building Research Levy Act 1969 was 'an Act to authorise the levying of building contractors to provide money for research into improved techniques and materials for use in the building industry' (Building Research Levy Act, 1969).

1974 Government Review of Science Funding

This review resulted in small increases in the science budget being made, and an increasingly commercial imperative being implemented for the DSIR. Further, the Scientific and Industrial Research Act was rewritten to state what had long been the case in practice: that the prime function of the DSIR was to 'initiate, plan and implement research calculated to promote the national interest in New Zealand' (Galbreath, 1998), a variation from the 1926 version of the Act.

1978 Heavy Engineering Research Levies Act 1978

The Heavy Engineering Research Levies Act 1978 was 'an Act to authorise the levying of persons engaged in heavy engineering manufacture and related industries to provide funds for research into heavy engineering, administered by MoRST' (Heavy Engineering Research Levies Act, 1978).

1986 State Owned Enterprise Act 1986

An Act focusing on the improvement of government performance in trading activities, which provided for the mandatory corporatisation of several government trading organisations, based on the premise that large bureaucracies lacked the business acumen to compete in the marketplace (State Owned Enterprise Act, 1986).

1988 State Sector Act 1988

An Act aimed at inefficiencies and the lack of responsiveness from large bureaucracies, which attempted to ensure that senior managers were accountable for the performance of their departments, and that the public service as a whole was more open to competition (State Sector Act, 1988).

1988 The 'Arbuckle Report'

A report prepared for the Science and Technology Advisory Committee (STAC). The Arbuckle Report followed the principles of New Public Management and Public Choice Theory. Among the recommendations included in the report were the introduction of contestable funding across the board, the creation of clear government objectives, the commercialisation of research institutes, and the separation of (i) policy, (ii) purchase and (iii) operational arms of science research (Arbuckle, 1988).

1989 Ministry of Research, Science and Technology (MoRST) established

A government department formed to oversee the performance of New Zealand's RS&T systems and where necessary strengthen these systems for the benefit of New Zealanders. MoRST administers government investment through Vote RS&T, and creates links to the international science committee (MoRST, 2009d). It is the agency responsible for science policy. MoRST is a government department as defined by the Public Finance Act 1989 (MoRST, 2007d).

1989 Public Finance Act 1989

An Act governing the use of public finances and:

a) Providing a framework to assess management of the Crown's assets and liabilities

b) Creating government responsibility with regard to public finances

c) Ensuring effective and efficient use of public finances in departments and Crown entities

d) Specifying minimum financial reporting obligations

e) Safeguarding of public assets (Public Finance Act, 1989).

1989 Wheat Industry Research Levies Act 1989

An Act 'to provide money for research into the growing of wheat and the manufacture of wheat into flour, bread, and other products by imposing levies on persons and organisations engaged in wheat growing, flour milling, baking, and related industries' (Wheat Industry Research Levies Act, 1989).

1990 Vote RS&T implemented

The appropriation of money from the Government budget for research, science and technology in New Zealand, which is then administered by MoRST and FRST. Vote RS&T was established by an Order in Council on December 18, 1989 (Galbreath, 1998).

1990 Health Research Council Act 1990

An Act 'to establish and then define the powers and functions of a health research council in New Zealand as well as dissolve the Medical Research Council of New Zealand' (Health Research Council Act, 1990).

1990 Foundation for Science, Research and Technology Act 1990

An Act 'to establish the Foundation for Science, Research and Technology and define its functions and powers'. The functions of the Foundation are defined under the Act as:

(a) To allocate funds for the production of outputs relating to public good science and technology

(b) To allocate funds pursuant to ministerial schemes

(c) To provide independent policy advice to the Minister on matters relating to research, science, and technology, including advice on national priorities for those matters (Foundation for Research, Science and Technology Act, 1990).

1991 Foundation for Research, Science and Technology (FRST) established

A foundation whose mission is to invest for results from research, science and technology to deliver greater prosperity, security and opportunities to all New Zealanders (FRST, 2009f).

1991–1992 Disestablishment of the DSIR

This period included the disestablishment of several government departments. Funding which was previously managed by the DSIR was put into a single contestable pool, the Public Good Science Fund (PGSF) (Galbreath, 1998).

1992 Crown Research Institutes Act 1992

An Act which established 10 CRIs out of former government departments: the Department of Scientific and Industrial Research (DSIR), MAF Technology (part of the Ministry of Agriculture and Fisheries), the Forest Research Institute (Ministry of Forestry), part of the Meteorological Service (a division of the Ministry of Transport) and Health Service Laboratories (Ministry of Health) (COMU, 2009b). The eight CRIs still in operation are:

f) AgResearch Ltd (AgResearch).

g) Industrial Research Ltd (IRL).

h) Institute of Environmental Science & Research Ltd (ESR).

i) Institute of Geological & Nuclear Sciences Ltd (GNS Science).

j) Landcare Research New Zealand Ltd (Landcare Research).

k) National Institute of Water & Atmospheric Research Ltd (NIWA).

l) New Zealand Forest Research Institute Ltd (trading as Scion)

The New Zealand Institute for Plant & Food Research Ltd (Plant & Food Research) (Crown Research Institutes Act, 1992).

1993 Review of the Foundation for Research, Science and Technology Act 1990 (1st)
Required under the Foundation for Research, Science and Technology Act 1990 (Personal communication, R. Marks, 10 December 2009).

1993 Health Research Council established
The agency responsible for public health research policy and investment in New Zealand (HRC, 2009).

1993 The Companies Act 1993
The Companies Act 1993 was an Act to reform the law relating to companies, and, in particular:

(a) to reaffirm the value of the company as a means of achieving economic and social benefits through the aggregation of capital for productive purposes, the spreading of economic risk, and the taking of business risks; and

(b) to provide basic and adaptable requirements for the incorporation, organisation, and operation of companies; and

(c) to define the relationships between companies and their directors, shareholders, and creditors; and

(d) to encourage efficient and responsible management of companies by allowing directors a wide discretion in matters of business judgment while at the same time providing protection for shareholders and creditors against the abuse of management power; and

(e) to provide straightforward and fair procedures for realising and distributing the assets of insolvent companies (Companies Act, 1993).

1994 Marsden Fund established
A fund intended to be used for excellent fundamental research in science, and administered by the Royal Society of New Zealand (Marsden Fund, 2009).

1995 Institute for Social Research closed
The Institute was one of the initial 10 CRIs formed in 1992; it was closed due to its failure to establish commercial viability (COMU, 2009b).

1997 Technology New Zealand (TechNZ) Fund established
A fund intended for FRST's business investment programme, which supports firms or individuals involved in research with the purpose of generating new products, processes or services. The fund is administered by FRST (FRST, 2009g).

2000 **New Economy Research Fund established**
A fund specifically intended for the research area of 'developing new technology platforms to support the creation of new industries or sectors' (FRST, 2009h).

2004 **Review of the Foundation for Research, Science and Technology Act (2nd)**
Required under the Foundation for Research, Science and Technology Act 1990 (MoRST, 2009c).

2004 **The Crown Entities Act 2004**
An Act which reformed the law relating to Crown entities, providing a robust framework for their establishment, governance and operation as well as accountability (Treasury, 2009b). Section 7 of the Act outlines the five categories of Crown entity, which are summarised below:

(a) Statutory entities – bodies corporate established through legislation;

(b) Crown entity companies – often previously known as Crown-owned companies;

(c) Crown entity subsidiaries – companies that are controlled by Crown entities;

(d) School boards of trustees – as constituted under the Education Act 1989, and

Tertiary education institutes – polytechnics, universities and wānanga (Crown Entities Act, 2004).

2007 **OECD Review of Innovation Policy: New Zealand** (OECD, 2007)

2008 The New Zealand Institute for Crop & Food Research Ltd and the Horticulture & Food Research Institute of New Zealand are merged to form the New Zealand Institute for Plant & Food Research Ltd.

2009 **Review of the Foundation for Research, Science and Technology Act (3rd)**
Required under the Foundation for Research, Science and Technology Act 1990 (MoRST, 2009c).

Appendix 3 Crown Research Institutes Act 1992 – Principles of Operation

The following Principles of Operation are set out in Section 5 of the Crown Research Institutes Act 1992.

(1) Every Crown Research Institute shall, in fulfilling its purpose, operate in accordance with the following principles:

(a) That research undertaken by a Crown Research Institute should be undertaken for the benefit of New Zealand:

(b) That a Crown Research Institute should pursue excellence in all its activities:

(c) That in carrying out its activities a Crown Research Institute should comply with any applicable ethical standards:

(d) That a Crown Research Institute should promote and facilitate the application of—

(i) The results of research; and
(ii) Technological developments:

(e) That a Crown Research Institute should be a good employer as required by Section 118 of the Crown Entities Act 2004:

(f) That a Crown Research Institute should be an organisation that exhibits a sense of social responsibility by having regard to the interests of the community in which it operates and by endeavouring to accommodate or encourage those interests when able to do so.

(2) Every Crown Research Institute shall, in fulfilling its purpose, operate in a financially responsible manner so that it maintains its financial viability.

(3) For the purposes of subsection (2) of this section, a Crown Research Institute is financially viable if—

(a) Regardless of whether or not it is required to pay dividends to the Crown, the activities of the Crown Research Institute generate, on the basis of generally accepted accounting principles, an adequate rate of return on shareholders' funds; and

(b) The Crown Research Institute is operating as a successful going concern.

Appendix 4 Provision Institutions

In addition to Crown Research Institutes (CRIs), which are discussed in Section 7.3 above, a variety of other institutions provide research in New Zealand.

i) Universities

New Zealand has eight universities, all of which are active providers of research, science and technology. Universities receive public funding both from FRST, through Vote RS&T, and from the Tertiary Education Commission (TEC), through the Performance-Based Research Fund. Universities undertake around 30% of New Zealand's government-funded R&D (MoRST, 2008a). One of the primary functions of universities is to train postgraduate students, which means they are well adapted to providing basic research. It is estimated that 51% of all basic research undertaken in New Zealand is done at universities (MoE, 2007).

ii) Research Consortia

Research Consortia provide medium- to long-term research through collaboration between at least two private-sector providers and one CRI provider. This creates a pooling of knowledge, resources, skills and administration (Davis, 2006: 30). Private research partners must provide 50% of the cash for each research project, which must be of three to seven years' duration (FRST, 2006a: 12).

iii) Centres of Research Excellence

The government established the Centres of Research Excellence Fund to promote and undertake world-class research that contributes to New Zealand's economic development and incorporates knowledge transfer into training. The Centres of Research Excellence[18] (CoREs) are all physically hosted within universities, but they have various partnership linkages with other institutions, particularly CRIs and other universities (MoRST, 2007b). In this way, CoREs are a successful model of collaboration between research organisations. CoREs are funded by the TEC through Vote Education, by FRST through Vote RS&T, through private investment, and anywhere they can find funding (MoRST, 2008a). In 2008/09, CoREs received $36 million in public funds from the Centres of Research Excellence Fund through Vote Education (MoRST, 2008a: 21).

iv) Research Associations

Research associations also provide RS&T in New Zealand. These non-government, industry-linked organisations provide research primarily for industry, and have a strong ability to

[18] Seven CoREs have been established. They are concerned with: molecular ecology and evolution, at Massey University; molecular biodiscovery, at the University of Auckland; mathematics and its applications, at the University of Auckland; Māori development and advancement, at the University of Auckland; advanced materials and nanotechnology, at Victoria University of Wellington; human and animal growth and development, at the University of Auckland, and advanced bio-protection technologies at Lincoln University (MoRST, 2007b).

facilitate research and technology transfer. Research associations receive the majority of their funding through commercial income and industry levies; however they also receive public monies from contestable funds (FRST, 2006b). These research associations include the Building Research Association of New Zealand (BRANZ), DairyNZ, and the Heavy Engineering Research Association. A second type of research association relies on funds from corporate, charitable and contestable government sources. Similar types of research emerge from these associations, in that they focus on specific areas of science and health research. Research associations of this type include the Malaghan Institute and the Cawthron Institute (FRST, 2006b).

v) Whare Wānanga

Whare wānanga are government-funded Māori tertiary education institutions. The purpose of the three whare wānanga is to create a significant entrance point for Māori into the tertiary education system. In addition to this the whare wānanga provide an environment within which research with a Māori focus is conducted. Whare wānanga have close relationships with iwi, hapū and whanau, as well as with research institutions such as universities (MoRST, 2008b).

Appendix 5 Upcoming Government Reviews

The government is currently conducting three initiatives to assess areas of relevance to science funding in New Zealand, all of which are intended to be completed in time to feed into the 2010 Budget. These are briefly discussed below:

(i) Government Research, Science and Technology initiative: feedback on investment priorities

The Minister of Research, Science and Technology, Wayne Mapp, has advised that he will be seeking the input of key stakeholders including Science NZ, the Royal Society, the business sector – particularly Business NZ and the Capitalising on Research and Development Action Group – and the Chief Science Advisor to the Prime Minister, in order to provide a specific policy direction to Cabinet by the beginning of December 2009.[19] In a speech in August 2009 he stated that the aim of collecting feedback is:

> – improving the ability to migrate science from the lab to the market through better interaction across sectors
>
> – creating more certainty in the public good and 'enabling' science space through longer-term funding, encouraging collaboration and improving the flow of ideas both into and out of the system
>
> – boosting the results of growth-orientated research by examining the funding balance and sharpening the requirements around intended outcomes, time horizons and success gates
>
> – simplifying the system to allow efficiencies for the users and clarity for everyone. (NZ Govt, 2009a)

(ii) Government Research, Science and Technology initiative: assessing options for improving business research and development performance

A MoRST initiative to help improve business funding of science in New Zealand. This will feed into Budget 2010 and will not be released to the public as a separate report.

(iii) Taskforce to Review Crown Research Institutes

Cabinet has approved the setting up of a taskforce to determine how New Zealand can derive better national good from public investment in Crown Research Institutes (CRIs).[20] The taskforce will examine the purpose, governance and funding of CRIs. It will report to the two CRI shareholding ministers, Finance Minister Bill English and Dr Mapp, by the end of December 2009 (NZ Govt, 2009b). This report will be released to the public at a future date.

---

[19] This feedback has been sought through a number of mechanisms; see, for example, *New Zealand's research, science and technology priorities: Feedback document* (MoRST, 2009b). Feedback was requested by 18 November 2009.

[20] See Terms of Reference at http://www.morst.govt.nz/current-work/CRI-Taskforce/CRI-Taskforce-Terms-of-Reference/. The members of the taskforce include Neville Jordan, Dr Ron Sandland, John McKenzie and Dr Rod Carr, as well as the chief executives of the Department of the Prime Minister and Cabinet, Treasury, the Ministry of Research, Science and Technology and the Foundation for Research, Science and Technology.

References

AgResearch (2009). *Company profile: Farming, food and health. First*. Retrieved August 18, 2009 from http://www.agresearch.co.nz/publications/corpprofile-text.asp

Anderson, H. (2006, June 5). Getting the best out of our research science. *New Zealand Herald*.

Andrews, J. (2007). European discovery of plants and animals. *Te Ara: The Encyclopedia of New Zealand*. Retrieved January 15, 2008 from http://www.TeAra.govt.nz/TheBush/UnderstandingTheNaturalWorld/EuropeanDiscoveryOfPlantsAndAnimals/en

Arbuckle, R. H. (1988). *Science and technology review: A new deal*. Wellington: Science and Technology Advisory Committee.

Arnold, E. (2005). *Reflections on devolving funding in Vote RS&T: A view from abroad for MoRST New Zealand.* Brighton: Technopolis.

Aston, B. C. (1928). Presidential address. *Transactions and Proceedings of the Royal Society of New Zealand, 58.* Retrieved October 2, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_58/rsnz_58_00_000350.html

Australian Bureau of Statistics (2009*). Population clock*. Retrieved November 20, 2009 from http://www.abs.gov.au/ausstats/abs@.nsf/94713ad445ff1425ca25682000192af2/1647509ef7e25faaca2568a900154b63?opendocument

Beattie, D. (1986). *Key to prosperity: Science and technology. Report of the Ministerial Working Party on Science and Technology*. Wellington: Ministerial Working Party on Science and Technology.

Bishop, R. (1998). Freeing ourselves from neo-colonial domination in research: A Māori approach to creating knowledge. *International Journal of Qualitative Studies in Education, 11*(2), 199–219.

Bowen, G. (1868). Inaugural address of Governor Sir George Ferguson Bowen, G.C.M.G., to the New Zealand Institute, as its first President. *Transactions and Proceedings of the Royal Society of New Zealand 1868-1961*, *1*. Retrieved October 8, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_01/rsnz_01_00_000300.html

Boyne, G. (1998). Bureaucratic theory meets reality: Public choice theory and service contracting in US local government. *Public Administration Review*, *58*(6), 43–61.

Building Research Levy Act (1969). Retrieved December 8, 2009 from http://www.legislation.govt.nz/act/public/1969/0023/latest/DLM391231.html?search=ts_act_research_resel&p=1&sr=1

Callaghan, P. (2009). *Wool to Weta. Transforming New Zealand's culture & economy*. Auckland: Auckland University Press.

Cartner, M., & Bollinger, T. (1997). Science policy reforms: The New Zealand experience. *Social Studies of Science, 27*(5), 775–803.

Cheeseman, T. F. (1912). Presidential address. *Transactions and Proceedings of the Royal Society of New Zealand 1868-1961, 45*. Retrieved October 8, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_45/rsnz_45_00_004420.html

Christensen, T., & Laegreid, P. (2001). New Public Management: The effects of contractualism and devolution on political control. *Public Management Review, 3*(1), 73–94.

Companies Act (1993). Retrieved December 22, 2009 from http://legislation.govt.nz/act/public/1993/0105/latest/DLM319570.html

Crown Entities Act (2004). Retrieved December 7, 2009 from http://www.legislation.govt.nz/act/public/2004/0115/latest/DLM329631.html

Crown Ownership Monitoring Unit (COMU) (2009a). *Analysis of CRI 2007/08 financial performance.* Retrieved December 1, 2009 from http://www.comu.govt.nz/2007087-financial-performance.html

Crown Ownership Monitoring Unit (COMU) (2009b). *Crown company overview*. Retrieved December 7, 2009 from http://www.comu.govt.nz/crown-research-institutes.html

Crown Research Institutes Act (1992). *Interpretation.* Retrieved October 2, 2009 from http://www.legislation.govt.nz/act/public/1992/0047/latest/DLM264292.html

Davenport, S., & Bibby, D. (2007). Contestability and contested stability: Life and times of CSIRO's New Zealand cousins, the Crown Research Institutes. *Innovation: Management, Policy & Practice*, *9*(2), 181–191.

Davis, N. (2006). *Business R&D, innovation and economic growth: An evidence-based synthesis of the policy issues*. Wellington: Ministry of Economic Development. Retrieved December 17, 2007 from http://www.med.govt.nz/upload/40878/med-op-06-08.pdf

Devine, S. (2003). A systems look at the science reforms. *New Zealand Science Review, 60*(2–3), 70–74.

Dick, D. (1957). Historical introduction to New Zealand science. In F. R. Callaghan (Ed.), *Science in New Zealand* (pp. 11–19). Wellington: Reed.

Drayson, P. (2008). *Speech to the British Venture Capital Association*. Retrieved July 6, 2009 from http://www.dius.gov.uk/news_and_speeches/speeches/lord_drayson/venture

Edmeades, D. (2004). Is the commercial model appropriate for science? *New Zealand Science Review*, *61*(3–4), 85–92.

Education Act (1989, s 162). *Establishment of institutions*. Retrieved November 23, 2009 from http://www.legislation.govt.nz/act/public/1989/0080/latest/DLM183668.html?search=sw_096be8ed8049746a_wananga&p=1#DLM183668

Evans, L., Grimes, A., Wilkinson, B., & Teece, D. (1996). Economic reform in New Zealand 1984–95: The pursuit of efficiency. *Journal of Economic Literature, 34*(4), 1856–1902.

Fitzgerald, G. (2001). Social impact assessment in New Zealand resource management institutions. In A. Dale, N. Taylor, et al. (Eds.), *Social assessment in natural resource management institutions*. Sydney: CSIRO Publishing.

Foundation for Research, Science and Technology Act (1990). Retrieved December 7, 2009 from http://www.legislation.govt.nz/act/public/1990/0072/latest/DLM213379.html

Foundation for Research, Science and Technology (FRST) (2005). *Outcome-based Investment Pilo*t. Retrieved December 16, 2009 from http://www.frst.govt.nz/library/evaluations/investment-processes/obipilot

Foundation for Research, Science and Technology (FRST) (2006a). *Request for proposals and applicant instructions for research consortia*. Retrieved December 17, 2007 from http://www.frst.govt.nz/research/downloads/consortia/Research_Consortia_RFP_and_Applicant_Instructions.pdf

Foundation for Research, Science and Technology (FRST) (2006b). *Setting future directions: Summary of initiatives 2006–2009*. Wellington: Foundation for Research, Science and Technology.

Foundation for Research, Science and Technology (FRST) (2007). *Guidelines for advisory groups and other independent experts.* Retrieved July 28, 2009 from http://www.frst.govt.nz/files/Guidelines%20for%20Advisory%20Groups%20and%20Other%20Independent%20Experts.pdf

Foundation for Research, Science and Technology (FRST) (2008). *Stable Funding Environment Consultation Document April 2008 Moving into Phase 2*. Wellington: Foundation for Research, Science and Technology.

Foundation for Research, Science and Technology (FRST) (2009a). *Foundation for Research, Science and Technology.* Retrieved October 8, 2009 from http://www.frst.govt.nz/about-us/our-place

Foundation for Research, Science and Technology (FRST) (2009b). *Advisers.* Retrieved December 1, 2009 from http://www.frst.govt.nz/about-us/advisers

Foundation for Research, Science and Technology (FRST) (2009c). *Organisation.* Retrieved December 1, 2009 from http://www.frst.govt.nz/about-us/our-organisation

Foundation for Research, Science and Technology (FRST) (2009d). *New initiatives.* Retrieved December 1, 2009 from http://www.frst.govt.nz/about-us/newinitiatives

Foundation for Research, Science and Technology (FRST) (2009e). *Glossary.* Retrieved December 1, 2009 from http://www.frst.govt.nz/glossary/term/393

Foundation for Research, Science and Technology (FRST) (2009f). *About us*. Retrieved December 7, 2009 from http://www.frst.govt.nz/about-us

Foundation for Research, Science and Technology (FRST) (2009g). *Current funding available for business: TechNZ.* Retrieved December 7, 2009 from http://www.frst.govt.nz/funding/business

Foundation for Research, Science and Technology (FRST) (2009h). *New Economy Research Fund (NERF)*. Retrieved December 7, 2009 from http://www.frst.govt.nz/investframe/areas/research/newtech

Foundation for Research, Science and Technology (FRST) (2009i). *Environmental Research*. Retrieved February 2, 2010 from http://www.frst.govt.nz/investframe/areas/research/enviro

Fox, M. (1868). Proceedings of the New Zealand Institute, session of 1868: Minutes of the meetings. *Transactions and Proceedings of the Royal Society of New Zealand 1868-1961, 1.* Retrieved October 12, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_01/rsnz_01_00_000310.html

Galbreath, R. (1998). *DSIR: Making science work for New Zealand*: *Themes from the history of the Department of Scientific and Industrial Research, 1926–1992*. Wellington: Victoria University Press.

Gregory, R. (1999). Social capital theory and administrative reform: Maintaining ethical probity in public service. *Public Administration Review, 59*(1), 63–75.

Health Research Council (HRC) (2009). *About the Health Research Council of New Zealand*. Retrieved December 7, 2009 from http://www.hrc.govt.nz/root/About%20the%20HRC/About_the_HRC.html

Health Research Council Act (1990). Retrieved December 7, 2009 from http://www.legislation.govt.nz/act/public/1990/0068/latest/DLM213017.html

Heavy Engineering Research Levy Act (1978). Retrieved December 8, 2009 from http://www.legislation.govt.nz/act/public/1978/0081/latest/DLM25391.html?search=ts_act_research_resel&p=1&sr=1

Howe, K. R. (Ed.) (2006). *Vaka moana: Voyages of the ancestors: The discovery and settlement of the Pacific.* Auckland: David Bateman.

Industrial Research Limited (IRL) (2008). *Annual report 2008.* Retrieved August 18, 2009 from http://www.irl.cri.nz/repository/files/IRL-Annual-Report-08-web.pdf

Institute of Environmental Science Research (ESR) (2009). *Statement of corporate intent for the financial year ending 30 June 2010*. Retrieved August 18, 2009 from http://www.esr.cri.nz/SiteCollectionDocuments/ESR/Corporate/PDF/SCI2010.pdf

Institute of Geological and Nuclear Sciences (GNS) (2009). *Statement of corporate intent 2009–2010.* Retrieved August 18, 2009 from http://www.gns.cri.nz/who/images/09_10_statement_ofintent.pdf

Landcare Research (2009). *Statement of corporate intent 2009–2010*. Retrieved August 18, 2009 from http://www.landcareresearch.co.nz/about/documents/sci0910.pdf

Marsden Fund (2009). *The Marsden Fund: Marsden Fund overview*. Retrieved December 7, 2009 from http://marsden.rsnz.org/about/

Marshall, P. (1927). Presidential address. *Transactions and Proceedings of the Royal Society of New Zealand 1868-1961, 57*. Retrieved October 8, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_57/rsnz_57_00_000090.html

McGuinness, W. L. (1988). *Implementation of accrual accounting for government departments.* Available from Sustainable Future Institute.

McKinley Douglas Ltd (MDL) (2005). *Devolution: A think piece*. Tauranga: McKinley Douglas Ltd.

Ministry for the Environment (MfE) (1997). *Science reforms 1989–1996*. Retrieved March 4, 2008 from http://www.mfe.govt.nz/publications/ser/ser1997/html/chapter4.8.html

Ministry of Education (MoE) (2007). *Profiles & trends 2006: New Zealand's tertiary education sector.* Retrieved February 8, 2008 from http://www.educationcounts.govt.nz/indicators/quality_education_providers/2027

Ministry of Research, Science & Technology (MoRST) (2006). *Science for New Zealand: An overview of the RS&T system 2006*. Retrieved December 19, 2007 from http://www.morst.govt.nz/Documents/publications/policy/MoRST-Science-for-NZ.pdf

Ministry of Research, Science & Technology (MoRST) (2007a). *Research, Science and Technology scorecard.* Retrieved October 10, 2009 from http://www.morst.govt.nz/publications/a-z/r/scorecard/scorecard-2007

Ministry of Research, Science & Technology (MoRST) (2007b). *New Zealand new ideas: An introduction to the New Zealand Research, Science and Technology system*. Retrieved December 1, 2009 from http://www.morst.govt.nz/Documents/work/international/NZ-New-Ideas.pdf

Ministry of Research, Science & Technology (MoRST) (2007c). *Statement of intent 2007–2010: Part Three: Financial information. Statement of underlying assumptions.* Retrieved December 8, 2009 from http://www.morst.govt.nz/publications/corporate-reports/soi/2007-2010/part-3/

Ministry of Research, Science and Technology (MoRST) (2007d). *Statement of accounting policies for the year ending 30 June 2008*. Retrieved December 8, 2009 from http://www.morst.govt.nz/publications/corporate-reports/soi/2007-2010/part-3/

Ministry of Research, Science & Technology (MoRST) (2008a). *New Zealand RS&T scorecard 2008.* Retrieved May 21, 2009 from http://www.morst.govt.nz/Documents/publications/statistics/MoRST-RST-Scorecard-2008.pdf

Ministry of Research, Science & Technology (MoRST) (2008b). *New Zealand tertiary sector*. Retrieved August 18, 2009 from http://www.morst.govt.nz/rst-links/nz-tertiary-sector/

Ministry of Research, Science & Technology (MoRST) (2009a). *Statement of intent 2009–2012*. Retrieved October 12, 2009 from http://www.morst.govt.nz/publications/corporate-reports/soi/SoI-2009-2012/

Ministry of Research, Science & Technology (MoRST) (2009b). *New Zealand's research, science and technology priorities: Feedback document.* Retrieved October 12, 2009 from http://www.morst.govt.nz/current-work/NZ-RST-priorities-feedback/.

Ministry of Research, Science and Technology (MoRST) (2009c). *Review of the Foundation for Research, Science, and Technology Act (1990).* Retrieved December 1, 2009 from http://www.morst.govt.nz/publications/a-z/r/review-foundation-act-2009/

Ministry of Research, Science and Technology (MoRST) (2009d). *What we do*. Retrieved December 7, 2009 from http://www.morst.govt.nz/about/what-we-do/

Ministry of Research, Science and Technology (MoRST) (2009e). *Evaluation of the Stable Funding Environment (2009).* Wellington: Ministry of Research, Science and Technology

Ministry of Research, Science & Technology & Crown Company Monitoring Advisory Unit (MoRST & CCMAU) (2002). *An appraisal of Crown Research Institutes, 1992–2002.* Retrieved July 6, 2009 from http://www.morst.govt.nz/Documents/publications/discussions/CRI-Appraisal-1992-2002-report.pdf

Nathan, S. (2007). Geological exploration. *Te Ara: The Encyclopedia of New Zealand*. Retrieved January 15, 2008 from http://www.TeAra.govt.nz/EarthSeaAndSky/Geology/GeologicalExploration/en

National Institute of Water & Atmospheric Research (NIWA) (2009). *Our mission*. Retrieved August 18, 2009 from http://www.niwa.co.nz/about-niwa/our-mission

National Science Panel (2008). *A science manifesto or plan for the recovery of New Zealand Science.* Retrieved October 10, 2009 from http://www.psa.org.nz/Libraries/Media_releases/MANIFESTO_New.sflb.ashx

New Zealand Association of Scientists (NZAS) (2005). There is a better way: Eight recommendations on the science system in New Zealand. *New Zealand Science Review*, *62*(3), 80–86.

New Zealand Government (NZ Govt) (2009a). Speech 12 August, 2009, *Mapp: Research, Science and Technology Priorities*. Hon Dr Wayne Mapp, Minister of Research, Science and Technology. Retrieved December 6, 2009 from http://beehive.govt.nz/speech/research+science+and+technology+priorities

New Zealand Government (NZ Govt) (2009b). Press release 28 October 2009, *Taskforce to review Crown Research Institutes*. Hon Dr Wayne Mapp, Minister of Research, Science and Technology. Retrieved December 6, 2009 from http://www.beehive.govt.nz/release/taskforce+review+crown+research+institutes

New Zealand Government (NZ Govt) (2009c). Press release 28 October 2009, *Funding boost for natural hazards research*. Hon Dr Wayne Mapp, Minister of Research, Science and Technology. Retrieved December 15, 2009 from http://www.beehive.govt.nz/release/funding+boost+natural+hazards+research

Nobel Prize (2009). *Biography: Ernest Rutherford*. Retrieved October 18, 2009 from http://nobelprize.org/nobel_prizes/chemistry/laureates/1908/rutherford-bio.html

Office for National Statistics (2009). *Population.* Retrieved December 1, 2009 from http://www.statistics.gov.uk/cci/nugget.asp?ID=6

Office of the Auditor General (2009). *Workforce planning in Crown Research Institutes.* Wellington: Office of the Auditor General.

Organisation for Economic Development and Co-operation (OECD) (2002). *Frascati manual: Proposed standard practice for surveys on research and experimental development.* Retrieved March 5, 2008 from http://browse.oecdbookshop.org/oecd/pdfs/browseit/9202081E.PDF

Organisation for Economic Development and Co-operation (OECD) (2007). *OECD reviews of innovation policy: New Zealand.* Paris, OECD Publishing. Retrieved July 6, 2009 from http://213.253.134.43/oecd/pdfs/browseit/9207071E.PDF

Organisation for Economic Development and Co-operation (OECD) (2008). *OECD science, technology and industry outlook 2008.* Paris: OECD Publishing.

Palmer, C. M. (1994). *The reform of the public science system in New Zealand: A history of the background and implementation of the restructuring of the science system 1988–1993*. Wellington: Ministry of Research, Science and Technology.

Phillips, J. (2007). Timekeeping. *Te ara: The encyclopedia of New Zealand*. Retrieved January 17, 2008 from http://www.TeAra.govt.nz/EarthSeaAndSky/Astronomy/Timekeeping/en

Pickens, K. (1990). Computer-based information services for education and the social sciences in New Zealand: A review of recent developments. *Journal of Documentation*, *46*(2): 102–112.

Plant & Food Research (2009). *Annual report 2009.* Retrieved October 30, 2009 from http://www.plantandfood.co.nz/corporate/2009-annual-report.pdf

Public Finance Act (1989). Retrieved December 7, 2009 from http://www.legislation.govt.nz/act/public/1989/0044/latest/DLM160809.html?search=ts_act_public+finance_resel&p=1&sr=1

Reid, F. L. (2005). 'The democratic politician does not trouble himself with science': Class and professionalism in the New Zealand Institute, 1867–1903. *Tuhinga, 16*, 21–31.

Rigg, T. (1966). Cawthron Institute. *Te ara: The encyclopedia of New Zealand.* Retrieved October 2, 2009 from http://www.teara.govt.nz/en/1966/cawthron-institute/1

Royal Society of New Zealand (2009). *The Marsden Fund*. Retrieved October 28, 2009 from http://marsden.rsnz.org/

Royal Society of New Zealand Act (1933). Retrieved December 7, 2009 from http://rsnz.natlib.govt.nz/volume/rsnz_64/rsnz_64_00_005190.pdf

Salmond, A. (1997). *Between worlds: Early exchanges between Māori and Europeans 1773–1815*. Auckland: Penguin.

Science Priorities Review Panel (1995). *Priorities for 2001: Public good science investment*. Wellington: Ministry of Research, Science and Technology.

Scion (2008). *Statement of corporate intent 1 July 2008–30 June 2011*. Retrieved August 18, 2009 from http://www.scion.net.nz/Portals/0/FINALSCI-2008-Signed.pdf

State Owned Enterprise Act (1986). Retrieved December 22, 2009 from http://www.legislation.govt.nz/act/public/1986/0124/latest/DLM97377.html

State Sector Act (1988). Retrieved December 22, 2009 from http://legislation.govt.nz/act/public/1988/0020/latest/DLM129110.html

Statistics New Zealand (2000). *New Zealand official yearbook 2000.* Auckland: David Bateman.

Statistics New Zealand (2008). *Research and development survey 2008*. Retrieved November 20, 2009 from http://www.stats.govt.nz/browse_for_stats/businesses/research_and_development/ResearchandDevelopmentSurvey_HOTP2008/Commentary.aspx

Sustainable Future Institute (SFI) (2007). *A National Sustainable Development Strategy: How New Zealand measures up against international commitments.* Report 1. Retrieved October 12, 2009 from http://www.sustainablefuture.info/Site/Publications/Project_Reports.aspx

Sustainable Future Institute (SFI) (2008a). *The history of genetic modification in New Zealand*. Retrieved November 15, 2009 from http://www.sustainablefuture.info/Site/Publications/Project_Reports.aspx

Sustainable Future Institute (SFI) (2008b). *The review of the forty-nine recommendations of the Royal Commission on Genetic Modification*. Retrieved November 15, 2009 from http://www.sustainablefuture.info/Site/Publications/Project_Reports.aspx

Sustainable Future Institute (SFI) (2009). *Project 2058 methodology: Version 3*. Retrieved November 15, 2009 from http://www.sustainablefuture.info/Site/Publications/Project_Reports.aspx

Sustainable Future Institute (SFI) (in press). *Government-funded science under the microscope*. Report 9. Wellington: Sustainable Future Institute.

Te Papa Tongarewa Museum of New Zealand (2009). *Colonial Museum*. Retrieved December 6, 2009 from http://collections.tepapa.govt.nz/exhibitions/jameshector/segment.aspx?irn=105

Tertiary Education Commission (TEC) (2009). *Centres of Research Excellence.* Retrieved October 5, 2009 from http://www.tec.govt.nz/templates/standard.aspx?id=586

Tonkin, P. J. (2009). Soil investigation. *Te ara: The encyclopedia of New Zealand*. Retrieved October 7, 2009 from http://www.TeAra.govt.nz/TheBush/UnderstandingTheNaturalWorld/SoilInvestigation/en,

Treasury (2009a). *Performance information for appropriations: Vote Research, Science and Technology.* Retrieved May 18, 2009 from http://www.treasury.govt.nz/budget/2009/ise/v2/ise09-v2-pia-ressci.pdf

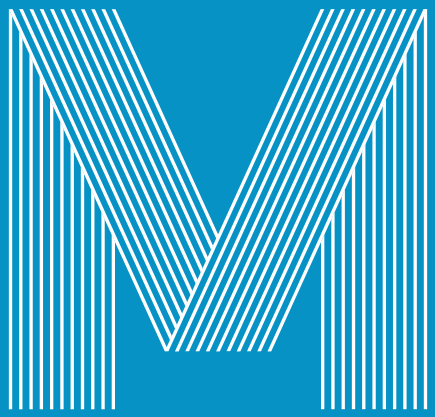
Treasury (2009b). *Crown entities*. Retrieved December 7, 2009 from http://www.treasury.govt.nz/statesector/crownentities

Walker, B. (1996). Reforming the public sector for leaner government and improved performance: The New Zealand experience. *Public Administration and Development, 16*(4), 353–375.

Weir, G. (2006). Declining importance of Crown Research Institutes in New Zealand's present science funding system. *New Zealand Science Review*, *63*(1), 2–4.

Wheat Industry Research Levies Act (1989). Retrieved December 8, 2009 from http://www.legislation.govt.nz/act/public/1989/0064/latest/DLM167917.html?search=ts_act_research_resel&p=1&sr=1

Winsley, P. (2003). How we can improve the performance of New Zealand's science system. *New Zealand Science Review, 60*(2–3), 75–80.



MCGUINNESS INSTITUTE