May 2010

Report 10A

2058

Designing a Framework to Monitor New Zealand's Resources

MCGUINNESS INSTITUTE

Report 10a

Designing a Framework to Monitor New Zealand's Resources

Version 1

May 2010

Report name	*Designing a Framework to Monitor New Zealand's Resources: Version 1*
Background paper to	Report 10: *The State of New Zealand's Resources*
Published	 ISBN 978-1-877473-52-4 (paperback) ISBN 978-1-877473-53-1 (PDF)
Prepared by	Sustainable Future, as part of *Project 2058*
Authors	Wendy McGuinness and Jean-Charles Perquin
In addition to the report's main authors, the research team included	Jessica Prendergast
External reviewers	Dr Beat Huser, Stephen Oakley, Wayne Silver, Dr Sean Weaver and Dr Morgan Williams
For further information	Sustainable Future Phone (04) 499 8888 Level 2, 5 Cable Street PO Box 24222 Wellington 6142 New Zealand www.sustainablefuture.info
Disclaimer	
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

Tables

Figures

Appendices

Preface

We measure what we value, and we manage what we measure.

Throughout time societies have been completely reliant upon the state of their natural resources. Both the resources themselves, and their health, have a major influence on the prosperity and well-being of any nation. Hence, it is of primary importance to 'measure what we value' in a way that respects the efforts of past New Zealanders, meets the needs of the present, while at the same time protecting resources for the use and enjoyment of future New Zealanders, thus maximising New Zealand's long-term prospects.

Comprehensive reporting on the state of resources and the natural environment is a difficult exercise due to both the scale of the task and its complexity. However the desire to measure and manage resources continues to generate a number of insightful reports that add to the wider debate on New Zealand's long term future.

The Ministry for the Environment's report *Environment New Zealand 2007* (first published in 1997) uses a set of indicators to report on key aspects of New Zealand's environment and to track how these aspects have changed over time. Other reports, such as *Measuring New Zealand's Progress Using a Sustainable Development Approach: 2008*, published by Statistics New Zealand (2009), present an overarching view of New Zealand's environmental, economic and social progress, and an assessment of whether progress has been consistent with sustainable development. A recent review by the Parliamentary Commissioner for the Environment (2010), *How Clean Is New Zealand? Measuring and reporting on the health of our environment*, investigates the way the 'state of the environment' is assessed by councils in New Zealand, and recommends changes that will improve the quality and usefulness of the process. It also confirms conclusions drawn in the reports mentioned above regarding issues around the reliability and consistency of available information in order to describe and evaluate New Zealand's environment successfully. Similarly, the *Environmental Performance Review of New Zealand,* released by the OECD (2007), was published to 'help member countries improve their individual and collective performances in environmental management'. The review considered the quality of New Zealand's national monitoring system and made 38 recommendations that could contribute to further environmental progress in New Zealand, many of which focus on establishing more effective standards and useful indicators to measure progress.

Although all the above reports increase our understanding of the challenges ahead, none of the four contain a comprehensive stocktake of New Zealand's resources over time. This report and the resulting datasets attempts to meet this purpose.

The authors would like to thank the external reviewers, in particular Dr Beat Huser, Stephen Oakley, Wayne Silver, Dr Sean Weaver and Dr Morgan Williams, for reading the early drafts of this methodology and providing considerable guidance throughout the process. Naturally, any errors or matters of opinion remain the responsibility of the authors.

Wendy McGuinness
Chief Executive

Executive Summary

The purpose of this report is to explain the methodology the Institute has developed to inform Report 10, *The State of New Zealand's Resources*. The fundamental proposition underlying Report 10 is that 'we measure what we value'. The purpose of the report is two-fold. Firstly, it will help Sustainable Future develop a National Sustainable Development Strategy (NSDS) for New Zealand in late 2011.[1] Secondly, it will provide interested parties with comprehensive data on the state of New Zealand's resources, enabling them to consider, reflect upon and manage those resources effectively for our shared future.

This report explains how four models were explored: (i) traditional science-based approaches; (ii) an eco-systems approach; (iii) the accounting systems approach, and (iv) the frameworks to measure the progress of societies (Section 3). From this, we go on to develop what we consider the optimal framework (Section 4). Figure 1 lists the 11 datasets we have compiled, and shows how they are used to provide a comprehensive framework across all resources. Section 5 explains where data was collected from, and Section 6 explains how this information will be used to contribute to the development of an NSDS. Finally, the framework is presented in Appendix 1.

Importantly, this report is version 1 of the methodology. The Institute has no desire to duplicate the work of other organisations; we welcome feedback on this version in order to ensure the resulting data is both accurate and useful.

It is our hope that this work will help to progress New Zealand's reporting on resources in the future, particularly in terms of enabling New Zealanders to benchmark progress over time.

[1] For further information about our work programme, see *Project 2058 Methodology: Version 3* (SFI, 2009).

Figure 1 The Eleven Datasets and their Indicators

TYPE I – Natural Resources

1 Land
1.1 Land use – general
1.2 Land cover
1.3 Land use – specific (agriculture and forestry)

2 Minerals
2.1 Production of metals (including rocks, aggregate, limestone, etc.)
2.2 Production of non-metals

3 Energy
a Non-renewable energy
3a.1 Energy production
3a.2 Energy consumption

b Renewable energy
3b.1 Energy production
3b.2 Energy consumption

c Electricity
3c.1 Electricity generation non-renewables
3c.2 Electricity generation renewables
3c.3 Electricity consumption

4 Water Supply
4.1 Freshwater inflow volumes
4.2 Freshwater outflow volumes
4.3 Change in storage volumes
4.4 Abstraction volumes
4.5 Discharge volumes
4.6 Groundwater stock volumes

5 Fisheries and Aquaculture
5.1 Fish capture quantity
5.2 Aquaculture production quantity & trade value
5.3 Fish exports quantity & trade value
5.4 Fish imports quantity & trade value
5.5 Fish stock assessment

6 Biodiversity
6.1 Number of known native species
6.2 Number of threatened species
6.3 Land area under pest management
6.4 Protected natural areas – terrestrial
6.5 Protected natural areas – marine

7 Forestry[2]
a Natural forest
7a.1 Removals & production[3]

[2] Forestry is the only dataset that is split between two types of resources, natural and human-generated; see also 7b.1 to 7b.7.

[3] Removals refer to the quantity of wood harvested per year.

TYPE II – Human-generated Resources

7 Forestry

b Planted forest

7b.1 Area & standing volume
7b.2 Exotic planting
7b.3 Exotic harvesting
7b.4 Area by species
7b.5 Production & consumption
7b.6 Exports of forestry products
7b.7 Imports of forestry products

8 Livestock and Crops

a Livestock

8a.1 Livestock numbers
8a.2 Meat production
8a.3 Milk production
8a.4 Exports

b Crops

8b.1 Production of cereals
8b.2 Production of vegetables (outdoor)
8b.3 Production of vegetables (indoor)
8b.4 Production of fruits
8b.5 Fertiliser use
8b.6 Exports

TYPE III – Whole System Resources

9 Atmosphere

9.1 Air quality
9.2 Greenhouse gas emissions & removals
9.3 Stratospheric ozone level

10 Water quality

10.1 Freshwater quality
10.2 Seawater quality

11 Soil

11.1 Soil health
11.2 Proportion of soils not meeting target range by soil health indicator
11.3 Number of identified contaminated sites by management category
11.4 Erosion-prone soil area

1. Purpose

The purpose of this report is to explain the methodology behind the 11 datasets, which together aim to measure New Zealand's resources over time. The information from these datasets will inform Report 10, *The State of New Zealand's Resources* (SFI, in press [a]). Our approach has been to create a comprehensive framework using publicly available data. This attempt differs from existing frameworks as it proposes to create a comprehensive stocktake of New Zealand's resources. Notably, this project differs in scope from the Ministry for the Environment's *Environment New Zealand 2007* report, in that the primary focus is on the quality and quantity of resources, rather than assessing New Zealand's environmental health.[4]

With this framework agreed, it will be possible to: (i) insert statistical data into each of the datasets; (ii) analyse the data within the datasets, and (iii) report on the implications. Step (i), the datasets, will be published online on our website. Step (ii), the data analysis, will be published as 11 separate working papers. Finally, step (iii), reporting on the implications, will be published in Report 10.

Our resources and how they are managed will be a key determinant of New Zealand's future, and understanding these resources is a vital step in progressing the Sustainable Future Institute's *Project 2058*.

1.1 The Sustainable Future Institute

The Institute is an independently funded think tank based in Wellington, New Zealand. 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). It is the aim of *Project 2058* to help inform ministers, policy analysts and members of the public about key events and trends in New Zealand's past, and alternative strategies for the future. With this in mind, this report is a step towards Sustainable Future's goal of preparing an NSDS for New Zealand in 2011.

1.2 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 is working to:

---

4 '*Environment New Zealand 2007* uses a set of environmental indicators to report on key aspects of the New Zealand environment and to track how these aspects have changed over time. This report will:
– provide useable and constructive information to foster informed decision-making on matters that affect the environment and encourage appropriate management approaches
– increase New Zealanders' understanding about the state of, and pressures on, our environment
– highlight the aspects of the environment that have come under particular pressure and those that require priority attention
– motivate all New Zealanders to take action to protect and conserve the environment.' (MfE, 2007: 4)

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 hap□, 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)

The culmination of *Project 2058*, the development of a National Sustainable Development Strategy (NSDS), depends on having an accurate assessment of key aspects of New Zealand society. Earlier reports have dealt in particular with points 1, 3, 5 and 6 above,[5] and this report is designed to help progress the fourth point: '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 …'. Specifically, this report explains the purpose and methodology underlying Report 10.

[5] For a detailed list of published and upcoming reports, see *Project 2058 Methodology: Version 3* (SFI, 2009: 7).

2. Methodology

To form a useful framework, the datasets must be organised in such a way that they are relevant, logical, easy to understand and able to stand the test of time. Datasets will be generated from currently published information, and when completed will be made available on the Sustainable Future Institute website.[6] In particular, the data will need to be well referenced so that policy-makers and the wider community are able to have confidence in the datasets, and the resulting analysis.

2.1 Position Statement

Wendy McGuinness is the founder and chief executive of the Sustainable Future Institute. She holds a BCom from the University of Auckland and an MBA from Otago University. In 2009 Wendy was conferred a Fellowship by the New Zealand Institute of Chartered Accountants for her contribution to the accountancy profession.

Jean-Charles Perquin is originally from Brittany, France. After completing a BSc at Rennes University, Lannion and the University of Littoral Côte d'Opale, Calais, he gained a Masters in Environmental Science at the University of Paul Cézanne, Marseille.

Jessica Prendergast holds a BA, with a double major in Criminology and Psychology, from Victoria University of Wellington. Before joining the Sustainable Future team she worked for the Ministry for the Environment, and has recently returned from an expedition in South America.

2.2 Terminology

One of the more significant challenges the research team faced was deciding what definition was to be used for the term 'resources'. Our research encompassed three types of resources: natural resources, human-generated resources and whole system resources. We have defined 'natural resources' broadly to include all resources naturally existing in the environment, without human intervention, i.e. water, air, forest, biodiversity. In contrast, 'human-generated resources' refer to resources that do not exist in their current form without human intervention, i.e. livestock, crops, planted forest. Lastly, 'whole system resources' refers to the system as a type of resource that must be monitored and managed because of its influences on natural and human-generated resources. Whole system resources include the atmosphere, water and soil. The term 'whole system' also implies that the three related datasets focus on measuring the quality of the environment (within which sit the previously mentioned resources) rather than the quantity of outputs stored or harvested. For further discussion, see Section 4.1.

[6] See www.sustainablefuture.info

Another term we use throughout this report is 'dataset'. In this project, a dataset defines a grouping of indicators that report on a specific resource such as land. Eleven datasets were defined: land, minerals, energy, water supply, fisheries and aquaculture, biodiversity, forestry, livestock and crops, atmosphere, water quality and soil.

2.3 Information Collection

The figures used to build up our database were gathered from various national agencies, ministries and Crown Research Institutes, along with international organisations. We support the free availability of data relating to environmental statistics. With this in mind, we deliberately used openly accessible data so that we were able to report on this availability and identify potential gaps. This in turn enables us to report on the implications and draw up recommendations for an improvement of current statistics on resources. Section 5.1 explains the specific sources used for each dataset.

2.4 Limitations and Boundaries

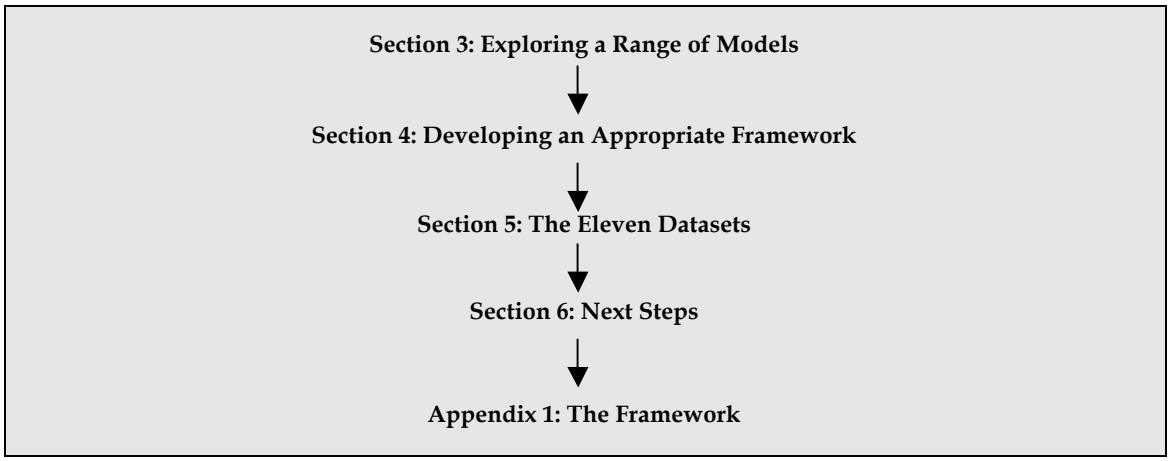
There are a number of limitations in the process of agreeing upon a framework. Firstly, the framework that has been adopted was developed by the research team, although where possible, was informed by international best practice. Further, as the aim was to create a comprehensive framework, this meant that the framework was designed first and then the data was collected. This resulted in some gaps in data within the datasets. Lastly, there remain concerns with data quality. Such concerns can be further broken down into: 'its source, purpose and method of collection and analysis' (Cofinas & Creighton, 2001).

2.5 Method of Analysis

Figure 2 sets out the steps undertaken to develop the list of datasets found at the end of this report. The process began with a review of other frameworks currently in use. These included traditional science-based systems of classification such as the biological kingdoms and the spheres in Earth Systems science, as well as the ecosystem services approach used by the Millennium Ecosystem Assessment (MA), and accounting systems approaches like the System of National Accounts (SNA) and the System of integrated Environmental and Economic Accounts (SEEA). The OECD's Framework to Measure the Progress of Societies has also been considered.

From here, we began to develop our own framework, combining elements from each of the above. A summary of the final framework is included in Section 4. Section 5 lists the 11 different datasets, and the related indicators, which sit within this framework, as well as the sources of the data.

Figure 2 The Method



The detailed datasets will be available on the Sustainable Future Institute website. The folder will contain Excel copies of original documents together with PDFs containing full data sources. On completion of the datasets, a group of working papers will be completed, followed by a high-level overview of the state of New Zealand's resources, published as Report 10 of *Project 2058*.

3. Exploring a Range of Models

Four types of model were reviewed. The first group could be categorised as traditional science-based systems. They have been in existence for a long period of time, and include models based on biological kingdoms (i.e. animal, vegetable and mineral) and Earth System spheres (lithosphere, atmosphere, hydrosphere and biosphere). The second and third groups we reviewed are systems based on recent developments in resource classification: the ecosystem services approach developed by the Millennium Ecosystem Assessment (MA), and accounting systems approaches, that is, SNA and SEEA. The fourth group reviewed – the OECD's Framework to Measure the Progress of Societies – is a model aimed at providing a comprehensive picture of how well-being is evolving. The review did not include a detailed assessment of each model; rather, the models were explored in terms of our aim of developing a useful framework for our review of New Zealand's resources. The four broad approaches are each discussed briefly below.

3.1 Traditional Science-based Approaches

Ancient knowledge of nature was founded on natural elements described as the basic constituents of the Earth: air, water, earth and fire. Over time, the development of science brought a better understanding of natural processes. In order to incorporate the notion of humans and their activities as part of a global system, it was necessary to design a template that combined the Biological Kingdoms and the Earth System spheres (lithosphere, atmosphere, hydrosphere and biosphere).

3.1.1 Biological kingdoms

Taxonomy as a system of classification was developed by the Swedish naturalist Carl Linnaeus in the eighteenth century, and it is the internationally accepted system of classifying all living species. The system enables all living organisms to be placed within a hierarchy, as part of a group from kingdom to species. An example of the taxonomic classification of humans (*Homo sapiens*) can be seen in Figure 3.

Figure 3 Taxonomic Classification of Humans
Source: Nathan, 2009.

KINGDOM: Animalia
Multicellular organisms; cells with a nucleus, with cell membranes but lacking cell walls
PHYLUM: Chordata
Animals with a spinal chord
CLASS: Mammalia
Warm-blooded chordates that bear live young; females have mammary glands that secrete milk to nourish young
ORDER: Primates
Mammals with collar bone; eyes face forward; grasping hands with fingers; two types of teeth (incisors and molars)
FAMILY: Hominidae
Primates with upright posture, large brain, stereoscopic vision, flat face, different use of hands and feet
GENUS: *Homo*
Hominids with S-curved spine, recognisable as human
SPECIES: *Homo sapiens*
Humans with high forehead; well-developed chin; thin skull bones

3.1.2 Earth System spheres

The spheres of the Earth System (lithosphere: rock; atmosphere: air; hydrosphere: water, and biosphere: living systems) are the major physical and biological components of our living planet that function as an interdependent whole. The interactions between these spheres are studied in eco- and geo-physiology with the aim of increasing knowledge about how each sphere relates to the other spheres. For example, the study of nutrient cycling provides an opportunity to track the movement and transformation of chemical elements (e.g. nitrogen) between sources, sinks and reservoirs (e.g. nitrogen cycling through the atmosphere, soil, vegetation, animals and waterways). These spheres of the Earth System are thus subject to dynamic interactions and interrelations, including the exchange of matter and energy between the four components described in Figure 4.

Figure 4 The Four Spheres of the Earth System
Source: Adapted from Pidwirny, 2006.

(i) Lithosphere: describes the solid inorganic portion of the Earth (composed of rocks, minerals and elements). It can be regarded as the outer surface and interior of the solid Earth.

(ii) Atmosphere: is the vast gaseous envelope of air that surrounds the Earth. Its boundaries are not easily defined. The atmosphere contains a complex system of gases and suspended particles that behave in many ways like fluids.

(iii) Hydrosphere: describes the waters of the Earth … Water exists on the Earth in various stores, including the atmosphere, oceans, lakes, rivers, soils, glaciers, and groundwater.

(iv) Biosphere: consists of all living things, plant and animal. This zone is characterised by life in profusion, diversity, and ingenious complexity.

3.2 The Ecosystem Services Approach

The concept of ecosystem services was adopted as part of the United Nations MA project in which 1360 experts were involved worldwide between 2001 and 2005 (MA, 2005a). The purpose of the MA project was to assess the implications of ecosystem changes for human well-being (MA, 2005b: v). The findings are contained in five technical volumes and six synthesis reports, providing a high-quality scientific explanation of the state and evolution of the world's ecosystems, the services these ecosystems provide, and suggestions to restore, conserve and enhance the sustainable use of ecosystems. Ecosystem services represent the benefit humans obtain from ecosystems; they are grouped into four categories, as shown in Figure 5.

Figure 5 Ecosystems and Services
Source: Adapted from UK Parliamentary Office of Science and Technology, 2007: 1, Box 1.

An ecosystem may be considered as a unit within which an assemblage of living organisms interact with one another and with the chemical and physical environment. The resulting natural processes establish a series of complex ecological balances.

The Millennium Ecosystem Assessment grouped ecosystem services into four broad categories:

Supporting services, such as nutrient cycling, oxygen production and soil formation. These underpin the provision of the other 'service' categories.

Provisioning services, such as food, fibre, fuel and water.

Regulating services, such as climate regulation, water purification and flood protection.

Cultural services, such as education, recreation, and aesthetic value.

3.3 The Accounting Systems Approach – SNA and SEEA

Two prominent models of accounting systems are discussed briefly below.

3.3.1 The System of National Accounts (SNA)

The SNA, established in 1993, is a conceptual framework that sets the international statistical standard for the measurement of the market economy. It was published jointly by the United Nations, the Commission of the European Communities, the International Monetary Fund, the OECD, and the World Bank (UN STATS, 2009a).

The SNA framework includes a classification for environmental assets, which can be seen in Figure 6.

Figure 6 Environmental Assets within the 1993 SNA
Source: UNEP, 2003: 250, Table 7.1.

AN.1 Produced assets
- AN.11 Fixed assets
  - AN.111 Tangible fixed assets
    - AN.1114 Cultivated assets
      - AN.11141 Livestock for breeding, dairy, draught, etc.
      - AN.11142 Vineyards, orchards and other plantations
  - AN.112 Intangible fixed assets
    - *AN.1121 Mineral exploration*
- AN.12 Inventories
  - AN.122 Work in progress
    - AN.1221 Work in progress on cultivated assets

AN.2 Non-produced assets
- AN.21 Tangible non-produced assets
  - AN.211 Land
    - AN.2111 Land underlying buildings and structures
    - AN.2112 Land under cultivation
    - AN.2113 Recreational land and associated surface water
    - AN.2119 Other land and associated surface water
  - AN.212 Subsoil assets
    - AN.2121 Coal, oil and natural gas reserves
    - AN.2122 Metallic mineral reserves
    - AN.2123 Non-metallic mineral reserves
  - AN.213 Non-cultivated biological resources
  - AN.214 Water resources
- AN.22 Intangible non-produced assets
  - *AN.222 Leases and other transferable contracts*

3.3.2 System of integrated Environmental and Economic Accounts (SEEA)

The SEEA was developed in 2003 as a satellite system of the SNA.

> It brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy and the impact of the economy on the environment. It provides policy-makers with indicators and descriptive statistics to monitor these interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development.
>
> (UN STATS, 2009b)

The SEEA 2003 comprises four categories of accounts: (i) flow accounts for pollution, energy and materials; (ii) environmental protection and resource management expenditure accounts; (iii) natural resource asset accounts, and (iv) valuation of non-market flow and environmentally adjusted aggregates (UN STATS, 2009b). The SEEA also includes a classification for environmental assets, as shown in Figure 7 below.

Figure 7 Excerpt from SEEA Asset Classification
Source: UNEP, 2003: 252, Table 7.2.

EA.1 Natural Resources

- EA.11 Mineral and energy resources (cubic metres, tonnes, tonnes of oil equivalents, joules)
- EA.12 Soil resources (cubic metres, tonnes)
- EA.13 Water resources (cubic metres)
- EA.14 Biological resources
  - *EA.141 Timber resources (cubic metres)*
  - *EA.142 Crop and plant resources, other than timber (cubic metres, tonnes, number)*
  - *EA.143 Aquatic resources (tonnes, number)*
  - *EA.144 Animal resources, other than aquatic (number)*

EA.2 Land and surface water (hectares)

- EA.21 Land underlying building and structures
- EA.22 Agriculture land and associated surface water
- EA.23 Wooded land and associated surface water
- EA.24 Major water bodies
- EA.25 Other land

EA.3 Ecosystems

- EA.31 Terrestrial ecosystems
- EA.32 Aquatic ecosystems
- EA.33 Atmospheric systems

Memorandum items – Intangible assets related to environmental issues (extended SNA codes)

- AN.1121 Mineral exploration
- AN.2221 Transferable licences and concessions for the exploration of natural resources
- AN.2222 Tradable permits allowing the emission of residuals
- AN.2223 Other tangible non-produced environmental assets

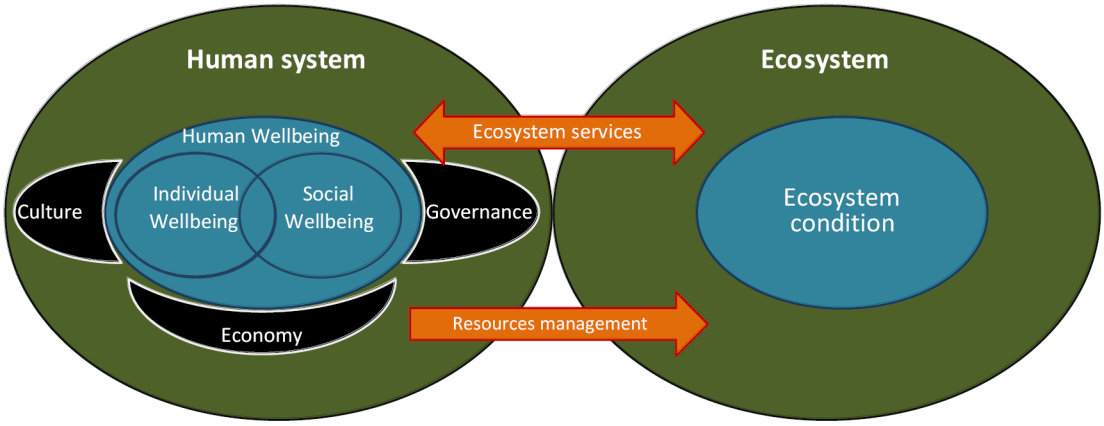
3.4 The Framework to Measure the Progress of Societies

Another interesting model explored was the framework developed by the OECD following the Declaration of Istanbul. This was signed in 2007 by OECD members along with many other international organisations during the second world forum on measuring the progress of societies. The (Taxonomy) Framework of The Global Project aims at:

> fostering the development of sets of key economic, social and environmental indicators to provide a comprehensive picture of how the well-being of a society is evolving.
>
> (OECD, 2007b)

The (Taxonomy) Framework builds on several leading frameworks to help draw the societal progress dimensions and their measurements. Illustrated in Figure 8 below, the framework considers that societies are based on two systems, the human system and the ecosystem, linked through two different channels, 'resources management' and 'ecosystem services'.

Figure 8 The Framework to Measure the Progress of Societies
Source: OECD, 2009: 11, Figure 1.



4. Developing an Appropriate Framework

In developing an appropriate framework for our research, we initially listed the resources that we believed should be included. In order to select the appropriate resources, we started from a global approach describing the Earth as the macro system comprising all resources and forms of life. From there we considered each in light of how they had been treated in terms of the models described above and listed them according to their inclusion in the first model reviewed, i.e. the biological kingdoms. From this, the shape of the framework emerged, integrating the rest of the models as follows:

Traditional science-based approach
Biological kingdoms were integrated in the framework by including resources like biodiversity, forestry and minerals, which link directly back to the animal, vegetable and mineral kingdoms.

The Earth System spheres were used in shaping the framework: lithosphere, atmosphere, hydrosphere and biosphere.

The ecosystem services approach
The ecosystem services approach was included throughout the framework as it covers the entire spectrum. To attribute the different services to each resource, we measured each resource against each ecosystem service and integrated them following the Millennium Ecosystem Assessment definition (see Appendix 2).

The accounting systems approach – SNA and SEEA
The accounting systems approaches helped direct the structure, terminology and meaning of the final framework. As the SNA did not include the depletion and degradation of natural capital (UNEP, 2003: 248–257), we looked more closely at the SEEA model, which better integrates the environmental constraints associated with the use of resources and adopts a classification system more in line with our requirements (see Figure 7).

The framework for measuring the progress of societies
This model incorporates several existing leading frameworks and was certainly the closest model to our requirements. The only major difference between this framework and ours is the approach used. In the OECD model, the focus is on the human condition, as it aims at reporting on well-being. In our case, we strongly believe that the ecosystem should enclose all other systems, such as those reviewed in the science-based approaches in Section 3.1 above.

4.1 Defining Resource Types

As discussed in Section 2.2, we have defined 'natural resources' broadly to include all resources naturally existing in the environment, without human intervention, i.e. water, air, forest, biodiversity. In contrast, 'human-generated resources' refer to resources that do not exist in their current form without human intervention, i.e. livestock, crops, planted forests. In other words, human-generated resources are derived from the management of natural resources to create an asset for economic, environmental, social or cultural purposes.[7] Therefore economic assets, such as livestock, crops and forestry, have their own datasets. In addition, 'human-generated resources' are based on those derived from the environment,[8] and as such need to be viewed as distinct from 'built assets', such as communication and transportation infrastructure, which are treated separately in Report 11, *The Future of Infrastructure* (in press [b]).

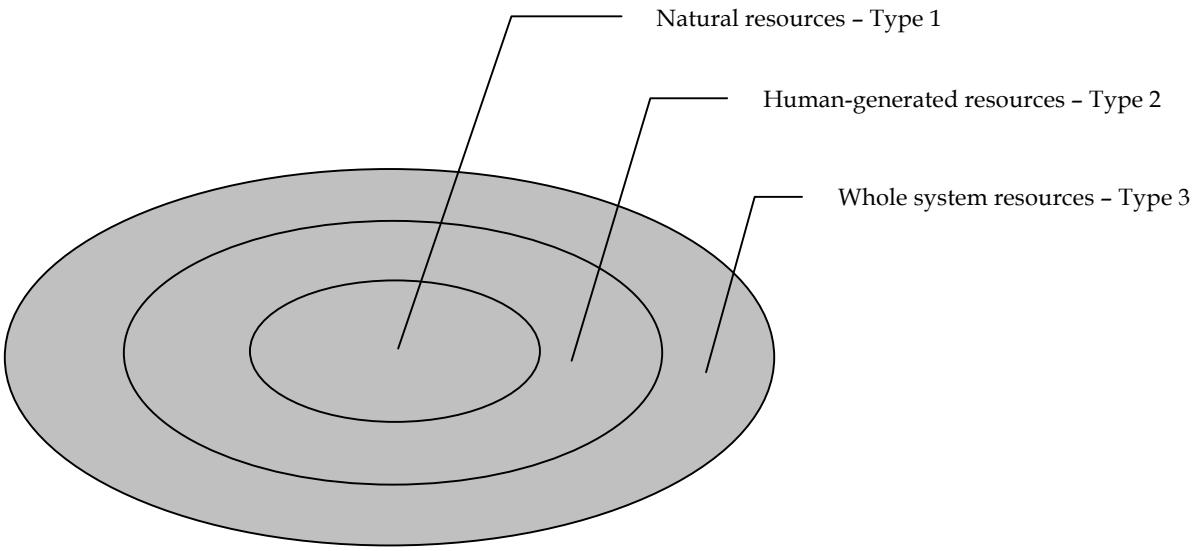
Lastly, 'whole system resources' recognises the linkages within and between natural resources and human-generated resources. In other words, the system as a whole is a type of resource that must be monitored and managed because of its influences on natural and human-generated resources. Whole system datasets include atmosphere, water quality and soil. The term 'whole system' also implies that these three datasets focus on measuring the quality of the environment (within which sit the previously mentioned resources) rather than measuring the quantity of outputs stored or harvested. Unlike the two types of resource described above, the indicators for whole system resources are often specific to a location – a city street corner, a stream or a section of land. Hence, as indicators, they tend to be very specific rather than national and significant fluctuations can exist.

The relationship between the three types of resource is perhaps best explained in terms of Figure 9 below, in that natural resources and human-generated resources remain dependent on the quality of the whole system, and human-generated resources remain dependent on the quantity and quality of natural resources. For example, if soil is contaminated, resources like biodiversity or crops will be directly impacted, affecting both natural and human-generated resources.

7 For example, flaxes or other native plants can be planted for cultural use.

8 For the purposes of this paper, 'derived' includes products extracted and/or obtained from natural resources.

Figure 9 How the Three Types of Resources Interrelate



It is important to note that resources can move between categories. For example, in the emerging industry of marine management, where fish and shellfish are farmed, the data is currently included in Dataset 5 (see Table 1), but as these figures become more significant, they are likely to need their own dataset. A further example is natural forests. These have traditionally been seen as a natural resource, but, due to conservation efforts to replant native forests, these are now seen as a human-generated resource.

4.2 Designing the Dataset Framework

From the work described above, a unique framework was developed. This is summarised in Table 1. Further detail on the resulting 11 datasets (with their indicators) is provided in Figure 10 (p. 21). A complete copy of the dataset framework is provided in Appendix 1. The following is an explanation of the summarised dataset framework shown in Table 1.

Column 1: Measurement Focus: Quality or Quantity

The measurement focus is the first category underpinning all resources. It states what is actually being measured in terms of quantity or quality. This distinction between quantity and quality in turn led to natural and human-generated resources (types 1 and 2) being separated from the whole system resources (type 3). As previously mentioned, resources included in type 3 are measured with a qualitative focus by location because these indicators cannot be meaningfully monitored using national averages. It would not be correct to set a single indicator for national air quality, as doing so would mask the differences between monitoring stations located in urban and rural locations. This type of resource is focused on regional data compared to other resources, in order to report information on resources in a meaningful and accurate manner.

Column 2: Type of Resource
This column shows which category the dataset falls into: Type I – Natural Resources; Type II – Human-generated Resources, or Type III – Whole System Resources.

Column 3: Nature of Resource
The next level describes the nature of the resource in terms of whether it is finite and/or fast-regenerating. Fast-regenerating resources are capable of regenerating within human management and planning time horizons, whereas finite resources only regenerate at time scales beyond human influence (e.g. thousands to millions of years). Further, the nature of the resources may also be described using other terms such as 'stock' and 'flow',[9] which are commonly used in the previously cited SNA. For this framework, we believe that 'fast-regenerating' and 'finite' better describe the nature of the resources, and that this approach is better suited to engage public dialogue.

Further, the terms 'non-renewable' and 'renewable' resources were not used in Column 3 for two reasons. Firstly, the classification 'non-renewable' and 'renewable' is used in the energy dataset (Column 6; see Appendix 1), and the use of the same term in different parts of the framework could be confusing. Secondly, we consider 'finite' or 'fast-regenerating' best describes the 'nature' of each resource.

Column 4: Type of Ecosystem Services
For each resource we have also included a level describing the relevant ecosystem services, so that these distinctions can be discussed further in Report 10. Ecosystem services are explained more fully in Figure 5 (p. 12).

Column 5: Datasets
This column lists the 11 datasets. These datasets and their indicators are summarised in Figure 10 (p. 20).

[9] Stock resources regenerate more slowly than is relevant to human management and planning time horizons (e.g. hundreds of years and above). Flow resources regenerate relatively quickly within the time horizons of human resource management (e.g. months, years, decades). These notions are defined with reference to the duration needed for each process to occur.

Table 1 Summary of the Dataset Framework

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services	Dataset
Column 1	Column 2	Column 3	Column 4	Column 5
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE	• Provisioning • Regulating • Cultural	1. Land
			• Provisioning • Cultural	2. Minerals
		FINITE & FAST-REGENERATING	• Provisioning	3. Energy
			• Provisioning • Supporting • Cultural	4. Water supply
		FAST-REGENERATING	• Provisioning • Cultural	5. Fisheries & Aquaculture
		FINITE & FAST-REGENERATING	• Provisioning • Supporting • Regulating • Cultural	6. Biodiversity
			• Provisioning • Regulating • Cultural	7. Forestry (natural forest)
	TYPE II – HUMAN-GENERATED RESOURCES	FINITE & FAST-REGENERATING	• Provisioning • Regulating	7. Forestry (planted forest)
			• Provisioning	8. Livestock & Crops
QUALITY	TYPE III – WHOLE SYSTEM RESOURCES	FAST-REGENERATING	• Regulating • Supporting • Cultural	9. Atmosphere
			• Regulating • Supporting • Cultural	10. Water quality
		FINITE	• Regulating • Supporting • Cultural	11. Soil

5. The Eleven Datasets

The datasets and their indicators are listed in more detail in Figure 10 below.

Figure 10 The Eleven Datasets and their Indicators

TYPE I – Natural Resources

1 Land
1.1 Land use – general
1.2 Land cover
1.3 Land use – specific (agriculture and forestry)

2 Minerals
2.1 Production of metals (including rocks, aggregate, limestone, etc.)
2.2 Production of non-metals

3 Energy
a Non-renewable energy
3a.1 Energy production
3a.2 Energy consumption

b Renewable energy
3b.1 Energy production
3b.2 Energy consumption

c Electricity
3c.1 Electricity generation non-renewables
3c.2 Electricity generation renewables
3c.3 Electricity consumption

4 Water Supply
4.1 Freshwater inflow volumes
4.2 Freshwater outflow volumes
4.3 Change in storage volumes
4.4 Abstraction volumes
4.5 Discharge volumes
4.6 Groundwater stock volumes

5 Fisheries and Aquaculture
5.1 Fish capture quantity
5.2 Aquaculture production quantity & trade value
5.3 Fish exports quantity & trade value
5.4 Fish imports quantity & trade value
5.5 Fish stock assessment

6 Biodiversity
6.1 Number of known native species
6.2 Number of threatened species
6.3 Land area under pest management
6.4 Protected natural areas – terrestrial
6.5 Protected natural areas – marine

7	**Forestry**[10]
	a Natural forest
7a.1	Removals & production[11]
	TYPE II – Human-generated Resources
7	**Forestry**
	b Planted forest
7b.1	Area & standing volume
7b.2	Exotic planting
7b.3	Exotic harvesting
7b.4	Area by species
7b.5	Production & consumption
7b.6	Exports of forestry products
7b.7	Imports of forestry products
8	**Livestock and Crops**
	a Livestock
8a.1	Livestock numbers
8a.2	Meat production
8a.3	Milk production
8a.4	Exports
	b Crops
8b.1	Production of cereals
8b.2	Production of vegetables (outdoor)
8b.3	Production of vegetables (indoor)
8b.4	Production of fruits
8b.5	Fertiliser use
8b.6	Exports
	TYPE III – Whole System Resources
9	**Atmosphere**
9.1	Air quality
9.2	Greenhouse gas emissions & removals
9.3	Stratospheric ozone level
10	**Water quality**
10.1	Freshwater quality
10.2	Seawater quality
11	**Soil**
11.1	Soil health
11.2	Proportion of soils not meeting target range by soil health indicator
11.3	Number of identified contaminated sites by management category
11.4	Erosion-prone soil area

[10] Forestry is the only dataset that is split between two types of resources, natural and human-generated; see also 7b.1 to 7b.7.

[11] Removals refer to the quantity of wood harvested per year.

5.1 The Sources of the Data

The following is a brief outline of where the data is sourced from for each of the datasets.

Dataset 1 – Land

Land statistics are collected from the Ministry for the Environment, combining data from the National Land Cover Database (LCDB2) and the Land Use and Carbon Analysis System (LUCAS) classifications (MfE, 2004; 2007: 21–23). The Ministry of Agriculture and Forestry Land Use database is also used for land use for agriculture and forestry figures (MAF, 2008a). As a result, three indicators were created reporting areas of: (i) land use – general; (ii) land cover, and (iii) land use – specific (agriculture and forestry).

Dataset 2 – Minerals

The national entity managing minerals is the Ministry for Economic Development (MED) – Crown Minerals. The categorisation used follows the one provided in MED's dataset (MED, 2009a), including units. Again, two indicators were created: (i) the quantities of metals, and (ii) the quantities of non-metals produced over time.

Dataset 3 – Energy (a)–(c)

Energy statistics are collected from the Ministry for Economic Development (MED, 2009b). Following a review of the International Energy Agency documents (IEA, 2005), it was decided to create three sub-categories of resource: (a) non-renewable energy (including oil, gas and coal); (b) renewable energy, and (c) electricity. With regard to indicators, it was decided to report on: (i) production and (ii) consumption, plus a third in the case of electricity, (iii) the quantity of electricity consumed over time.

Dataset 4 – Water Supply

With regard to water, the same indicators and units were used for both freshwater (with data sourced from MfE) and groundwater (sourced from the National Institute of Water and Atmospheric Research), both regrouped by Statistics New Zealand (Statistics NZ, 2007: 11). This dataset comprises six attributes, including: (i) freshwater inflows; (ii) freshwater outflows; (iii) change in storage; (iv) abstraction; (v) discharge, and (vi) groundwater stock.

Dataset 5 – Fisheries and Aquaculture

Figures reporting on fish and aquaculture use the same catalogue and units as the United Nations Food and Agriculture Organisation (FAO, 2009) and Statistics New Zealand (Statistics NZ, 2008; 2009: 25). This dataset comprises five indicators, reporting on: (i) fish capture; (ii) aquaculture; (iii) exports; (iv) imports, and (v) fish stock.

Dataset 6 – Biodiversity

Reporting on the state of New Zealand's biodiversity is a complex exercise. To be consistent with the data available, we decided to incorporate the International Union for Conservation of Nature (IUCN) approach into that used in the Department of Conservation's (DoC) threat classification, as reported in *Environment New Zealand 2007* (MfE, 2007: 346–403). Following this, five indicators were selected and reported on: (i) the number of known native species; (ii) the number of threatened species; (iii) the land area under pest management; (iv) terrestrial protected natural areas, and (v) marine protected natural areas.

Dataset 7 – Forestry (a)–(b)

This dataset has a similar design to the energy dataset, in that two sub-categories of resource are necessary: (a) natural forest, and (b) planted forest. While natural forest is a natural resource and is closely related to biodiversity, planted forest is clearly a 'human-generated' resource. To ensure clarity in the overall structure but ensure each dataset has integrity, these two resources were combined. Further, the dataset replicates MAF's indicators and unit structure (MAF, 2008b). Hence, (a) 'natural forest' comprises one indicator, i.e. wood volume harvested over time, while (b) 'planted forest' is classified into seven indicators: (i) area and standing volume; (ii) exotic planting; (iii) exotic harvesting; (iv) area by species; (v) production and consumption; (vi) exports of forestry products, and (vii) imports of forestry products. One could argue that over time, i.e. over a period of 50 to 100 years, planted forest, if untouched, could become natural forest. This concern brings us back to Section 4.2 when defining the nature of the resource, where again we are confronted by the notion of which timeframe we are reporting upon. See Section 2.4 for other limitations.

Dataset 8 – Livestock & Crops

The livestock statistics use the same classification and units as MAF (2008c). As a result, four indicators were created: (i) livestock quantity; (ii) meat production; (iii) milk production, and (iv) export trade quantities over time.

As with livestock, the data for crops follow the categories and units adopted by MAF (2008d). As a result six indicators were created, reporting on the quantities of production in terms of: (i) cereals; (ii) outdoor vegetables; (iii) indoor vegetables; (iv) fruit; (v) fertiliser use, and (vi) exports.

Dataset 9 – Atmosphere

Atmospheric quality is divided into three indicators using the same model as the MfE environmental indicators classification (MfE, 2007: 180–209). It comprises: (i) air quality; (ii) greenhouse gas emissions and removals, and (iii) the level of stratospheric ozone over time.

Dataset 10 – Water Quality

Similarly, water quality is broken down into two indicators: (i) freshwater quality, and (ii) seawater quality, based on the MfE models (MfE, 2007: 258–345).

Dataset 11 – Soil

The parameters used to define the state of soil use MfE's soil health classification (Hill et al., 2003: 6–7) and Landcare Research figures compiled by Statistics New Zealand (2009: 53–56). Soil reporting includes four indicators: (i) soil health; (ii) proportions of soil not meeting target range; (iii) number of identified contaminated sites by management category, and (iv) erosion-prone soil areas.

6. Next Steps

We expect both the process and ongoing feedback to shape the final report; hence this is version 1 of the methodology. The Institute welcomes all feedback so as not to duplicate work by other organisations and to ensure the resulting data is accurate and useful.

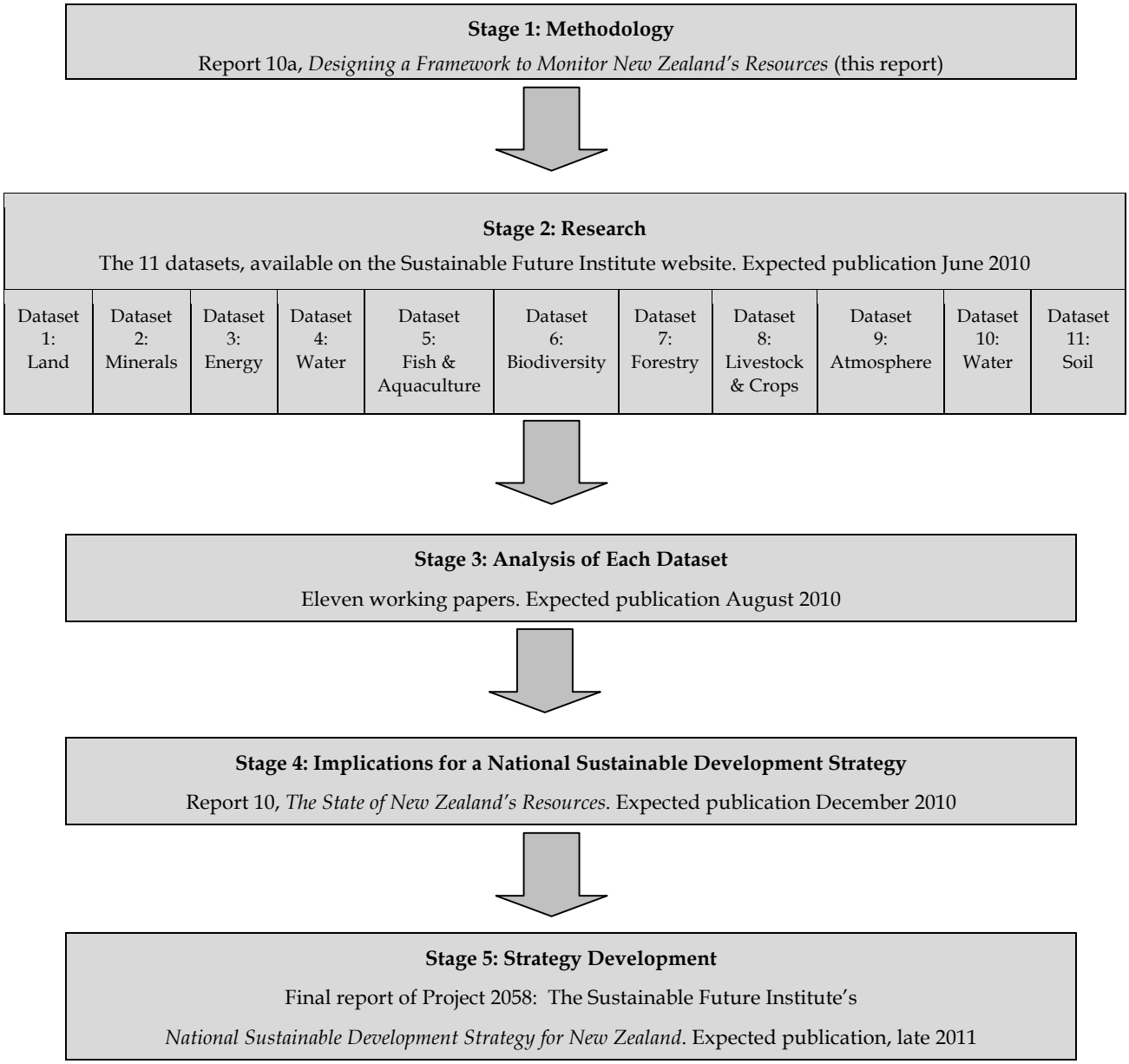
With this framework in place, the datasets will become the initial building blocks of Report 10, *The State of New Zealand's Resources*. Figure 11 outlines the five stages of the process.

Stage 2 of the process involves publishing the 11 datasets online. The reason for making this information available as we progress through the stages is to invite feedback, so that we can optimise our findings. Simply put, if better or missing information is available, we wish to know about it. Stage 1 is an ongoing project, and as such data will continue to be updated and regularly reported on the Sustainable Future website.

Once the 11 datasets are on the website, we will prepare a working paper for each, which will use this information to analyse and draw trends over time (Stage 3). The working papers will then be used to explore the implications in terms of the development of an NSDS for New Zealand in Report 10 (Stage 4).

Finally, all the reports that are part of *Project 2058* will be revisited, reviewed and reflected upon, in order to propose a strategy for New Zealand's long-term future (Stage 5).

Figure 11 The Five Stages



Abbreviations

[ ]	concentration
%EPT	percentage of three different taxa of macroinvertebrates in a river or stream (E = Ephemeroptera: mayflies, a common indicator to measure the water quality of streams and rivers; P = Plecoptera: stoneflies, and T = Trichoptera: caddisflies).
%v.v^{-1}	percentage of void space per volume of soil
□g.cm^{-3}	microgram per cubic centimetre
□g.m^{-3}	microgram per cubic metre
DoC	Department of Conservation
DU	Dobson units
FAO	(United Nations) Food and Agriculture Organisation
GWh	gigawatt per hour; 1GWh = 10^9 Wh
ha	hectare
IEA	International Energy Agency
IUCN	International Union for Conservation of Nature
k$NZ	thousand $NZ
k$US	thousand $US
kt	thousand tonnes
LCDB2	Land Cover Database 2
LUCAS	Land Use and Carbon Analysis System
m^3	cubic metre
MA	Millennium Ecosystem Assessment
MAF	Ministry of Agriculture and Forestry
MED	Ministry for Economic Development
MfE	Ministry for the Environment
mg.cm^{-3}	milligram per cubic centimetre
mg.L-1	milligram per litre
Mt CO2-e	megatonnes of carbon dioxide equivalent

N/A	not applicable
NIWA	National Institute of Water and Atmospheric research
NSDS	National Sustainable Development Strategy
OECD	Organisation for Economic Co-operation and Development
PCE	Parliamentary Commissioner for the Environment
PJ	petajoule; 1PJ = 10^{15} J
RE	roundwood equivalent, a common unit used in the forestry industry, here converted using conversion factors from Statistics New Zealand
SEEA	System of integrated Environmental and Economic Accounts
SFI	Sustainable Future Institute
SNA	System of National Accounts
UNEP	United Nations Environment Programme

Appendix 1 The Dataset Framework

This framework is designed to be read from left to right, breaking down into datasets and indicators from the initial measurement focus to the attributes, with their units.

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE	Provisioning, Regulating, Cultural	1. Land	1.1 Land use – general	cropping and horticulture		hectares
						high-producing grassland		
						lakes and rivers		
						low -producing grassland		
						natural forest		
						new forest land		
						forestry land planted before 1990		
						scrubland		
						settlements		
						w etland		
						other land		
					1.2 Land cover	artificial surfaces	built-in area	hectares
							urban parkland/open space	
							surface mine	
							dump	
							transport infrastructure	
						bare or lightly vegetated surfaces	coastal sand & gravel	
							river & lakeshore gravel & rock	
							landslide	
							alpine gravel & rock	
							permanent snow & ice	
							alpine grass/herbfield	
						w ater bodies	lake & pond	
							river	
							estuarine open w ater	
						cropland	short-rotation cropland	
							vineyard	
							orchard & other perennial crops	
						grassland	high-producing exotic grassland	
							low -producing grassland	
							tall tussock grassland	
							depleted tussock grassland	
							herbaceous freshw ater vegetation	
						sedgeland saltmarsh	herbaceous saline vegetation	
							flaxland	
						scrub & shrubland	fernland	
							gorse &/or broom	
							manuka &/or kanuka	
							matagouri	
							broadleaved indigenous hardw oods	
							sub-alpine shrubland	
							mixed exotic shrubland	
							grey scrub	
						forest	minor shelterbelts	
							major shelterbelts	
							afforestation (not imaged)	
							afforestation (imaged, post LCDB 1)	
							forest - harvested	
							pine forest - open canopy	
							pine forest - closed canopy	
							other exotic forest	
							deciduous hardw oods	
							indigenous forest	
							mangrove	
					1.3 Land use – specific (agriculture and forestry)	grassland		hectares
						tussock & danthonia used for grazing		
						grain, seed & fodder crop land		
						mature native bush		
						native scrub & regenerating native bush		
						other land		
						farm numbers		hectares
						grazing, arable, fodder & fallow land		
						land in horticulture		
						planted production forest		
						other land		

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**	Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE	Provisioning, Cultural	2. Minerals	2.1 Production of metals	gold	tonnes
						silver	
						magnetite (ironsand)	
					2.2 Production of non-metals	amorphous silica	tonnes
						bentonite	
						building and dimension stone	
						clay for brick, tiles	
						clay for pottery & ceramics	
						decorative pebbles including scoria	
						diatomite	
						dolomite for agriculture	
						dolomite for industry	
						limestone & marl for cement	
						limestone for agriculture	
						limestone for industry & roading	
						other	
						perlite	
						pounamu	
						pumice	
						recycled material	
						rock for reclamation & protection	
						rock, sand & gravel for building	
						rock, sand and gravel for roading	
						rock, sand, gravel & clay for fill	
						sand for industry	
						serpentine	
						silica sand	
						talc	
						zeolite	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset		Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5		Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE	Provisioning	3. Energy	3a. Non-renewable energy	3a.1 Energy production	crude oil, condensate & naphtha		PJ kt
							LPG		PJ kt
							gas		PJ kt
							coal		PJ kt
							petrol		PJ kt
							diesel		PJ kt
							fuel oil		PJ kt
							aviation fuels		PJ kt
							other petroleum products		PJ kt
						3a.2 Energy consumption	LPG	agriculture	PJ
								residential	
								commercial	
								industrial	
								national transport	
							gas	agriculture	PJ
								residential	PJ k$NZ
								commercial	PJ k$NZ
								industrial	PJ k$NZ
								national transport	PJ
							coal	agriculture	PJ kt
								residential	PJ kt
								commercial	PJ kt
								industrial	PJ kt
								national transport	PJ kt
							petrol		PJ kt
							diesel		PJ kt
							fuel oil		PJ kt
							aviation fuels		PJ kt
							other petroleum products		PJ kt

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset		Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5		Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FAST-REGENERATING	Provisioning	3. Energy	3b. Renewable energy	3b.1 Energy production	hydropower		PJ
							geothermal		
							solar		
							wind		
							biogas		
							wastes		
							woody biomass & animal products		
						3b.2 Energy consumption	geothermal	agriculture	PJ
								industrial	
								commercial	
								residential	
								national transport	
							solar	agriculture	PJ
								industrial	
								commercial	
								residential	
								national transport	
							wind	agriculture	PJ
								industrial	
								commercial	
								residential	
								national transport	
							biogas	agriculture	PJ
								industrial	
								commercial	
								residential	
								national transport	
							woody biomass & animal products	agriculture	PJ
								industrial	
								commercial	
								residential	
								national transport	
					3c. Electricity	3c.1 Electricity generation non-renewables	oil		PJ GWh[d]
							coal		PJ
							gas		PJ
							wastes		PJ GWh
						3c.2 Electricity generation renewables	hydropower		PJ GWh
							geothermal		PJ GWh
							biogas		PJ GWh
							wood		PJ GWh
							wind		PJ GWh
						3c.3 Electricity consumption	per sector	residential	PJ GWh k$NZ
								commercial	PJ GWh k$NZ
								industrial	PJ GWh k$NZ

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE & FAST-REGENERATING	Provisioning, Supporting, Cultural	4. Water Supply	4.1 Freshwater inflow volumes	precipitations		million m^3
					4.2 Freshwater outflow volumes	evapotranspiration		million m^3
						outflow to sea & net abstraction		
					4.3 Change in storage volumes	soil moisture		million m^3
						lakes & reservoirs		
						groundwater		
						snow		
						ice		
					4.4 Abstraction volumes	for irrigation	surface water groundwater	million m^3
						for hydroelectricity generation	surface water groundwater	million m^3
						for municipal supply & domestic use	surface water groundwater	million m^3
						for private industrial	surface water groundwater	million m^3
						for livestock use	surface water groundwater	million m^3
					4.5 Discharge volumes	from irrigation	surface water groundwater	million m^3
						from wastewater	surface water groundwater	million m^3
						from hydroelectricity generation	surface water groundwater	million m^3
						other	surface water groundwater	million m^3
					4.6 Groundwater stock volumes	unconfined aquifers	opening stock change in volume closing stock	million m^3
						confined aquifers	opening stock change in volume closing stock	million m^3
						total groundwater	opening stock change in volume closing stock	million m^3

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FAST-REGENERATING	Provisioning, Cultural	5. Fisheries & Aquaculture	5.1 Fish capture quantity	aquatic plants	brown seaweeds	tonnes
							red seaweeds	
						crustaceans	crabs, sea-spiders	
							lobsters, spiny-rock lobsters	
							shrimps, prawns	
						diadromous fish	river eels	
							salmon, trout, smelt	
						freshwater fish	carp, barbel and other cyprinids	
							miscellaneous freshwater fishes	
						marine fish	cod, hake, haddock	
							flounder, halibut, sole	
							herrings, sardines, anchovies	
							marine fishes not identified	
							miscellaneous coastal fishes	
							miscellaneous demersal fishes	
							miscellaneous pelagic fishes	
							sharks, rays, chimaeras	
							tuna, bonito, billfish	
						miscellaneous aquatic animal products	corals	
							sponges	
						miscellaneous aquatic animals	miscellaneous aquatic invertebrates	
							sea-urchins and other echinoderms	
						molluscs	abalones, winkles, conchs	
							clams, cockles, arkshells	
							miscellaneous marine molluscs	
							mussels	
							oysters	
							scallops, pectens	
							squids, cuttlefishes, octopuses	
						whales, seals and other aquatic mammals (number)	blue-whales, fin-whales	
							sperm-whales, pilot-whales	
					5.2 Aquaculture production quantity & trade value	freshwater diadromous fish	salmon, trout, smelt	tonnes k$US
						marine diadromous fish	salmon, trout, smelt	tonnes k$US
						marine molluscs	abalones, winkles, conchs	tonnes k$US
							mussels	tonnes k$US
							oysters	tonnes k$US

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FAST-REGENERATING	Provisioning, Cultural	5. Fisheries & Aquaculture	5.3 Fish exports quantity & trade value	crustaceans	crustaceans, frozen	tonnes k$US
							crustaceans, not frozen	tonnes k$US
							crustaceans, prepared or preserved	tonnes k$US
						fish	fish fillets, frozen	tonnes k$US
							fish meat, w hether or not minced, and fillets, fresh or chilled	tonnes $US000
							fish meat, w hether or not minced, frozen	tonnes k$US
							fish prepared or preserved	tonnes k$US
							fish, dried, salted or smoked	tonnes k$US
							fish, fresh or chilled, excluding fillets and meat	tonnes k$US
							fish, frozen, excluding fillets and meat	tonnes k$US
							fish, live	tonnes k$US
						other	other products	tonnes k$US
						molluscs & aquatic invertebrates	molluscs and other aquatic invertebrates, live, fresh or chilled	tonnes k$US
							molluscs and other aquatic invertebrates, other than live, fresh or chilled	tonnes k$US
							molluscs and other aquatic invertebrates, prepared or preserved	tonnes k$US
					5.4 Fish imports quantity & trade value	crustaceans	crustaceans, frozen	tonnes k$US
							crustaceans, not frozen	tonnes k$US
							crustaceans, prepared or preserved	tonnes k$US
						fish	fish fillets, frozen	tonnes k$US
							fish meat, w hether or not minced, and fillets, fresh or chilled	tonnes k$US
							fish meat, w hether or not minced, frozen	tonnes k$US
							fish prepared or preserved	tonnes k$US
							fish, dried, salted or smoked	tonnes k$US
							fish, fresh or chilled, excluding fillets and meat	tonnes k$US
							fish, frozen, excluding fillets and meat	tonnes k$US
							fish, live	tonnes k$US
						other	other products	tonnes k$US
						molluscs & aquatic invertebrates	molluscs and other aquatic invertebrates, live, fresh or chilled	tonnes k$US
							molluscs and other aquatic invertebrates, other than live, fresh or chilled	tonnes k$US
							molluscs and other aquatic invertebrates, prepared or preserved	tonnes k$US
					5.5 Fish stock assessment	proportions of assessed fish stocks by assessment category	near or above target levels	%
							probably near or above target levels	
							possibly near or above target levels	
							below target levels	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE & FAST-REGENERATING	Provisioning, Supporting, Regulating, Cultural	6. Biodiversity	6.1 Number of known native species	bacteria	marine	number
							land-based	
							freshwater	
						protozoa	marine	
							land-based	
							freshwater	
						chromista	marine	
							land-based	
							freshwater	
						plants	marine	
							land-based	
							freshwater	
						fungi	marine	
							land-based	
							freshwater	
						animals	marine	
							land-based	
							freshwater	
					6.2 Number of threatened species	bats	acutely threatened	number
							chronically threatened	
							at risk	
						birds	acutely threatened	
							chronically threatened	
							at risk	
						reptiles	acutely threatened	
							chronically threatened	
							at risk	
						frogs	acutely threatened	
							chronically threatened	
							at risk	
						freshwater fish	acutely threatened	
							chronically threatened	
							at risk	
						invertebrates	acutely threatened	
							chronically threatened	
							at risk	
						plants	acutely threatened	
							chronically threatened	
							at risk	
						fungi	acutely threatened	
							chronically threatened	
							at risk	
					6.3 Land area under pest management	area managed on conservation lands	rodents	hectares
							mustelids/cats	
							pest herbivores	
							weeds	
							possums	
						land area under management of pest species	possums	million hectares
							goats	
							weeds	
							deer	
							tahr	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE & FAST-REGENERATING	Provisioning, Supporting, Regulating, Cultural	6. Biodiversity	6.4 Protected natural areas – terrestrial	protected under National Parks Act	national parks	hectares
							specially protected areas	
							w ilderness areas	
						protected under Conservation Act	conservation parks	hectares
							ecological areas	
							sanctuary areas	
							w ilderness areas	
							stew ardship areas	
							amenity areas	
							w ildlife management areas	
							marginal strips	
						protected under Reserves Act	nature reserves	hectares
							scientific reserves	
							historic reserves	
							scenic reserves	
							local purpose reserves	
							recreation reserves	
						protected under Wildlife Act	w ildlife refuges	hectares
							total	
						private land protected under	Conservation Act	hectares
							Reserves Act	
							Wildlife Act	
							other legal protection	
					6.5 Protected natural areas – marine	protected under Marine Reserves Act and Mammals Protection Act	marine reserves	hectares
							marine mammal sanctuaries	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset		Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5		Col 6	Col 7		Col 8
QUANTITY	TYPE I – NATURAL RESOURCES	FINITE & FAST-REGENERATING	Provisioning, Regulating, Cultural	7. Forestry	7a. Natural Forest	7a.1 Removals and production	estimated roundwood removals	saw logs	000 m³
								peeler logs	
								small logs	
								pulp logs	
								export chips	
								export logs	
							sawn timber production		
	TYPE II – HUMAN-GENERATED RESOURCES	FINITE & FAST-REGENERATING	Provisioning, Regulating	7. Forestry	7b. Planted Forest	7b.1 Area & standing volume	total forest area		000 ha
							standing volume		000 m³
						7b.2 Exotic planting	new planting		000 ha
							restocking (replanting after harvesting)		
						7b.3 Exotic harvesting	harvesting (area clear felled)		
						7b.4 Area by species	radiata pine		000 ha
							Douglas fir		
							cypress species		
							other softwoods		
							eucalyptus species		
							other hardwoods		
						7b.5 Production & consumption	estimated roundwood removals		000 m³
							roundwood consumption		
						7b.6 Exports of forestry products	logs and woodchips		000 m³ RE
							sawn timber		000 m³ 000 m³ RE
							wood pulp		000 m³ RE tonnes
							paper and paperboard		000 m³ RE tonnes
							panel products		000 m³ 000 m³ RE
							other forestry products		
							all forestry products		000 m³ RE
						7b.7 Imports of forestry products	sawn timber		000 m³ 000 m³ RE
							wood pulp		000 m³ RE tonnes
							paper and paperboard		000 m³ RE tonnes
							panel products		000 m³ 000 m³ RE
							other forestry products		
							all forestry products		000 m³ RE

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset		Indicator	Attribute**	Units
Col 1	Col 2	Col 3	Col 4	Col 5		Col 6	Col 7	Col 8
QUANTITY	TYPE II – HUMAN-GENERATED RESOURCES	FINITE & FAST-REGENERATING	Provisioning	8. Livestock and crops	8a. Livestock	8a.1 Livestock number	beef calves	head
							beef cattle	
							dairy calves	
							dairy cattle	
							sheep	
							lambs	
							chickens	
							deer	
							pigs	
							goats	
						8a.2 Meat production (total w eight at slaughter)	sheep	tonnes
							lambs	
							bulls	tonnes
							calves	
							cow s	
							heifers	
							goats	tonnes
							pigs	
							steers	
							deer	tonnes
							poultry	
						8a.3 Milk production	milk processed	million litres
							milkfat processed	million kg
							protein processed	
							milksolids processed	
							average litre per cow	litres
							average milkfat per cow	kg
							average kg protein per cow	
							average kg milksolids per cow	
						8a.4 Exports	live animals	k$NZ
							beef and veal	
							lamb and mutton	
							venison	
							other meat	
							butter, AMF and cream products	
							cheese	
							w holemilk pow der	
							skimmilk, buttermilk pow der and infant foods	
							casein, protein products and albumins	
							other dairy products	
							w ool	
							carpets and other w ool products	
							hides, leather and dressed skins	
							other agricultural products	
							other food	
							miscellaneous agricultural and food products	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset		Indicator	Attribute**	Units
Col 1	Col 2	Col 3	Col 4	Col 5		Col 6	Col 7	Col 8
QUANTITY	TYPE II - HUMAN-GENERATED RESOURCES	FINITE & FAST-REGENERATING	Provisioning	8. Livestock and Crops	8b. Crops	8b.1 Production of cereals	barley	tonnes & hectares
							w heat	
							peas field	
							oat grain	
							maize grain	
							other cereals	
						8b.2 Production of vegetables (outdoor)	asparagus	hectares
							broccoli	
							cabbage	
							carrots	
							cauliflow er	
							green beans	
							kumara	
							lettuce	
							melon w ater/rock	
							onions	
							peas (fresh/processed)	
							potatoes	
							pumpkin	
							squash	
							sw eet corn	
							tomatoes	
							other	
						8b.3 Production of vegetables (indoor)	tomatoes	hectares
							capsicum/peppers	
							cucumbers	
							mushrooms	
						8b.4 Production of fruits	total kiw ifruit	hectares
							w ine grapes	
							apples	hectares
							pears	
							nashi (Asian) pears	
							peaches	hectares
							apricots	
							nectarines	
							cherries	
							plums	
							avocados	
							feijoas	
							tamarillos	
							passionfruit	
							persimmons	
							blackcurrants	
							blueberries	
							boysenberries	
							raspberries	
							straw berries	
							oranges	
							grapefruit/goldfruit	
							lemons	
							mandarins	
							tangelos	
							olives	
							nuts	
						8b.5 Fertiliser use	urea	tonnes
							diammonium phosphate (DAP)	
							ammonium sulphate	
							super-phosphate	
							lime	
							all other nitrogen-containing fertilisers	
							all other phosphatic fertilisers	
							all potassic fertilisers	
							effluent sprayed on fields	hectares
						8b.6 Exports	kiw ifruit	k$NZ
							pipfruit	
							w ine	
							other fresh and processed fruit	
							vegetables, grains and seeds	

Measurement Focus	Type of Resource	Nature of Resource	Type of Ecosystem Services*	Dataset	Indicator	Attribute**		Units
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7		Col 8
QUALITY	TYPE III – WHOLE SYSTEM RESOURCES	FAST-REGENERATING	Regulating, Supporting, Cultural	9. Atmosphere	9.1 Air quality by region	PM_{10}		µg.m^{-3}
						nitrogen dioxide		
						carbon monoxide		
						sulphur dioxide		
						tropospheric ozone		
					9.2 Greenhouse gas emissions & removals	emissions	carbon dioxide	Mt CO_2-e
							methane	
							nitrous oxide	
							sulphur hexafluorine	
							hydrofluorocarbons	
							perfluorocarbons	
						emissions by sector	energy	Mt CO_2-e
							industrial processes	
							waste	
							agriculture	
						removals	total net removals	
					9.3 Stratospheric ozone level	national average yearly ozone levels	ozone [ ]	DU
			Regulating, Supporting, Cultural	10. Water Quality	10.1 Freshwater quality	river water quality trends	nitrogen trends	mg.L-1
							dissolved reactive phosphorous trends	
							ammoniacal nitrogen	
							E. coli [ ]	[ ]/100mL
							visual clarity	metre
							water temperature	Celsius degree
							dissolved oxygen	mg.L-1
							MCI	MCI
							macroinvertebrate richness	%EPT
						lake water quality trends	total nitrogen	mg.L-1
							total phosphorous	
							visual clarity	metre
							algal biomass	mg.L-1
						groundwater quality trends	nitrate trends	mg.L-1
							E. coli [ ]	[ ]/100mL
						recreational water quality trends	proportion of complying samples (*E. Coli* [ ]) per sites	number of site
					10.2 Seawater quality	recreational water quality trends	proportion of complying samples (*enterococci* [ ]) per sites	number of site
		FINITE	Regulating, Supporting, Cultural	11. Soil	11.1 Soil health	total carbon content		mg.cm^{-3}
						total nitrogen content		
						pH in water		N/A
						Olsen phosphate		µg.cm^{-3}
						mineralisable nitrogen		
						macroporosity		%v.v^{-1}
					11.2 Proportions of soils not meeting target range by soil health indicator	acidity		%
						organic resources		
						fertility		
						physical composition		
					11.3 Number of identified contaminated sites by management category	cleaned sites		number of sites
						actively managed sites		
						not cleaned or actively managed		
					11.4 Erosion-prone soil area	North Island		ha
						South Island		
						total		

* MA Ecosystem Services: Provisioning, Regulating and Supporting
** Refer to the relevant worksheet for more details

Appendix 2 The Ecosystem Services Definition

Source: MA, 2005b: 40

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and the supporting services needed to maintain other services (CF2). Many of the services listed here are highly interlinked. (Primary production, photosynthesis, nutrient cycling, and water cycling, for example, all involve different aspects of the same biological processes.)

Provisioning Services

These are the products obtained from ecosystems, including:

Food. This includes the vast range of food products derived from plants, animals, and microbes.

Fibre. Materials included here are wood, jute, cotton, hemp, silk, and wool.

Fuel. Wood, dung, and other biological materials serve as sources of energy.

Genetic resources. This includes the genes and genetic information used for animal and plant breeding and biotechnology.

Biochemicals, natural medicines, and pharmaceuticals. Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems.

Ornamental resources. Animal and plant products, such as skins, shells, and flowers, are used as ornaments, and whole plants are used for landscaping and ornaments.

Fresh water. People obtain fresh water from ecosystems and thus the supply of fresh water can be considered a provisioning service. Fresh water in rivers is also a source of energy. Because water is required for other life to exist, however, it could also be considered a supporting service.

Regulating Services

These are the benefits obtained from the regulation of ecosystem processes, including: Air quality regulation. Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality.

Climate regulation. Ecosystems influence climate both locally and globally. At a local scale, for example, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.

Water regulation. The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.

Erosion regulation. Vegetative cover plays an important role in soil retention and the prevention of landslides.

Water purification and waste treatment. Ecosystems can be a source of impurities (for instance, in fresh water) but also can help filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems and can assimilate and detoxify compounds through soil and subsoil processes.

Disease regulation. Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.

Pest regulation. Ecosystem changes affect the prevalence of crop and livestock pests and diseases.

Pollination. Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators.

Natural hazard regulation. The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves.

Cultural Services

These are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including:

Cultural diversity. The diversity of ecosystems is one factor influencing the diversity of cultures.

Spiritual and religious values. Many religions attach spiritual and religious values to ecosystems or their components.

Knowledge systems (traditional and formal). Ecosystems influence the types of knowledge systems developed by different cultures.

Educational values. Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.

Inspiration. Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.

Aesthetic values. Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations.

Social relations. Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.

Sense of place. Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem.

Cultural heritage values. Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species.

Recreation and ecotourism. People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.

Supporting Services

Supporting services are those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. (Some services, like erosion regulation, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people.)

These services include:

Soil Formation. Because many provisioning services depend on soil fertility, the rate of soil formation influences human well-being in many ways.

Photosynthesis. Photosynthesis produces oxygen necessary for most living organisms.

Primary production. The assimilation or accumulation of energy and nutrients by organisms.

Nutrient cycling. Approximately 20 nutrients essential for life, including nitrogen and phosphorus, cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems.

Water cycling. Water cycles through ecosystems and is essential for living organisms.

References

Cofinas, M., & Creighton, C. (2001). *Australian native vegetation assessment: Glossary*. Canberra: Department of Water, Heritage and the Arts. Retrieved December 3, 2009 from: http://www.anra.gov.au/topics/vegetation/pubs/native_vegetation/nat_veg_glossary.html

Food and Agriculture Organisation (FAO) (2009). *Fishery and aquaculture country profiles: New Zealand*. Rome: Food and Agriculture Organisation of the United Nations. Retrieved February 2, 2010 from http://www.fao.org/fishery/countrysector/FI-CP_NZ/3/en

Hill, R. B., Sparling, G., Frampton, C., & Cuff, J. (2003). *National soil quality review and program design*. Wellington: Ministry for the Environment.

International Energy Agency (IEA) (2005). *Energy statistics manual*. Paris: International Energy Agency and the Organisation for Economic Cooperation and Development.

Millennium Ecosystem Assessment (MA) (2005a). *Overview of the Millennium Ecosystem Assessment*. Retrieved November 21, 2009 from http://www.millenniumassessment.org/en/About.aspx#

Millennium Ecosystem Assessment (MA) (2005b). *Ecosystems and human well-being: Synthesis*. Washington DC: Island Press.

Ministry of Agriculture and Forestry (MAF) (2008a). *Land use statistics*. Wellington: Ministry of Agriculture and Forestry. Retrieved August 4, 2009 from http://www.maf.govt.nz/statistics/land-use/

Ministry of Agriculture and Forestry (MAF) (2008b). *Forestry production and trade statistics*. Wellington: Ministry of Agriculture and Forestry. Retrieved August 4, 2009 from http://www.maf.govt.nz/statistics/forestry/

Ministry of Agriculture and Forestry (MAF) (2008c). *Pastoral statistics*. Wellington: Ministry of Agriculture and Forestry. Retrieved August 4, 2009 from http://www.maf.govt.nz/statistics/pastoral/

Ministry of Agriculture and Forestry (MAF) (2008d). *Horticulture and arable statistics*. Wellington: Ministry of Agriculture and Forestry. Retrieved August 4, 2009 from http://www.maf.govt.nz/statistics/horticulture/

Ministry for Economic Development (MED) (2009a). *Minerals facts & figures*. Wellington: Ministry for Economic Development, Crown Minerals. Retrieved January 15, 2009 from http://www.crownminerals.govt.nz/cms/minerals/facts-and-figures

Ministry for Economic Development (MED) (2009b). *New Zealand energy data file*. Wellington: Ministry for Economic Development. Retrieved January 15, 2009 from http://www.med.govt.nz/templates/StandardSummary____15169.aspx

Ministry for the Environment (MfE) (2004). *The New Zealand land cover database*. Retrieved February 1, 2010 from http://www.mfe.govt.nz/issues/land/land-cover-dbase/lcdb2-class-table.pdf

Ministry for the Environment (MfE) (2007). *Environment New Zealand 2007*. Wellington: Ministry for the Environment.

Nathan, S. (2009). Classification of humans. *Te Ara: The encyclopedia of New Zealand*. Retrieved November 24, 2009 from http://www.TeAra.govt.nz/en/collections-of-plants-and-animals/1/1

Organisation for Economic Co-operation and Development (OECD) (2007a). *Environmental Performance Review of New Zealand*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development (OECD) (2007b). *Measuring the progress of societies: Frequently asked questions*. Retrieved February 25, 2010 from http://www.oecd.org/document/57/0,3343,en_40033426_40037349_40305593_1_1_1_1,00.html

Organisation for Economic Co-operation and Development (OECD) (2009). *A framework to measure the progress of societies: Draft OECD working paper*. Paris: OECD Publishing.

Parliamentary Commissioner for the Environment (PCE) (2010). *How clean is New Zealand? Measuring and reporting on the health of our environment.* Wellington: Parliamentary Commissioner for the Environment. Retrieved April 30, 2010 from http://www.pce.parliament.nz/reports_by_subject/all_reports/legislation__and__policy/how_clean_is_new_zealand

Pidwirny, M. (2006). The natural spheres. In M. Pidwirny (Ed.), *Fundamentals of physical geography* (2nd ed.). Kelowna: University of British Columbia Okanagan. Retrieved November 23, 2009 from: http://www.physicalgeography.net/fundamentals/5c.html

Statistics NZ (2007). *Water physical stock account 1995–2005*. Wellington: Statistics New Zealand.

Statistics NZ (2008). *Environmental accounts: Fish*. Wellington: Statistics New Zealand. Retrieved February 2, 2009 from http://www.stats.govt.nz/publications/nationalaccounts/environmental-accounts/fish.aspx

Statistics NZ (2009). *Measuring New Zealand's progress using a sustainable development approach: 2008*. Wellington: Statistics New Zealand.

Sustainable Future Institute (SFI) (2007). *A National Sustainable Development Strategy: How New Zealand measures up against international commitments*. Wellington: Sustainable Future Institute. Retrieved November 15, 2009 from http://sustainablefuture.info

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

Sustainable Future Institute (SFI) (in press [a]). *The state of New Zealand's resources*. Report 10. Wellington: Sustainable Future Institute.

Sustainable Future Institute (SFI) (in press [b]). *The future of infrastructure*. Report 11. Wellington: Sustainable Future Institute.

UK Parliamentary Office of Science and Technology (2007). *Ecosystems services*. Retrieved November 17, 2009 from www.parliament.uk/documents/upload/postpn281.pdf

UNEP (2003). *Handbook of national accounting: Integrated environmental and economic accounting*. New York: United Nations.

UN STATS (2009a). *About the System of National Accounts 1993*. Retrieved November 17, 2009 from http://unstats.un.org/unsd/sna1993/introduction.asp

UN STATS (2009b). *Integrated environmental and economic accounting 2003 (SEEA 2003)*. Retrieved November 17, 2009 from http://unstats.un.org/unsd/envaccounting/seea.asp

MCGUINNESS INSTITUTE