



Royal Society of New Zealand response to the Conservation and Environment Science Roadmap

The Royal Society of New Zealand operates under an Act of Parliament to advance and promote science, technology, and the Humanities in New Zealand with a function to provide expert advice on important public issues to the Government and the community.

In this context, the Society welcomes the opportunity to comment on the Ministry for the Environment and Department of Conservation's discussion paper on a Conservation and Environment Science Roadmap¹. This response has been drawn together by the Society with input from a number of conservation and environmental science experts who are listed at the end of the submission.

Major drivers, trends and issues for the next 20 years

The challenges and opportunities identified by the Roadmap² are important, and in particular:

- Climate change mitigation and adaptation opportunities
- Freshwater, terrestrial, coastal and marine ecosystem management Protecting New Zealand's unique flora and fauna
- mātauranga Māori and Treaty-related opportunities
- Underpinning science, including essential long-term monitoring and research infrastructure.
- The need for science capability and coordination.
- Science literacy and social license.

The benefits we gain in terms of economy and wellbeing (ecosystem services³) from our natural capital provide both a research need and an opportunity to develop more integrated resource management and policy, and could be highlighted more in the resulting Roadmap themes.

New Zealand has a large body of research in a number of these areas, but building capability in the New Zealand science community, and in the public, is a core need identified in themes throughout the Roadmap. The individual themes capability sections should link to existing Ministry of Education and Tertiary Education Commission mechanisms, such as Centres of Research Excellence, to facilitate this

¹ <http://www.mfe.govt.nz/more/about-us/conservation-and-environment-science-roadmap>

² The challenges and opportunities identified by the Roadmap include: climate change – mitigation and adaptation opportunities; enhancing ecosystem services; freshwater; our land, coastlines and seas; the urban ecosystem; environmental contaminants; protecting New Zealand's unique flora and fauna; globalisation and biosecurity; mātauranga Māori and Treaty-related opportunities; social dimensions of conservation; underpinning science; and providing solutions through technology.

³ Ecosystem services are the processes by which people obtain benefits from ecosystems, such as clean air, fresh water, and the pollination of crops. These benefits are currently classified in the Roadmap as being one of four types: provisioning (e.g., food, fibre, water, fuel, genetic resources); regulating (e.g., air quality, climate, water flow, pollination, erosion control, pest and disease control); cultural (e.g., spiritual, aesthetic, recreational, educational); or supporting (e.g., photosynthesis, soil formation, nutrient cycling).

capability building. CRIs, universities and independent research organisations play a crucial complementary role in this, and a 20-year road map requires commitment to some stability in resourcing for key human resources and critical infrastructure.

To reach the goals of the Roadmap, in terms of producing the scientific knowledge needed for conservation and environment policy and management, it would be useful to identify a timeframe for addressing the research questions within the 20-year period, as some areas need to be addressed particularly urgently. It would also be useful to identify, more strongly the relevant policy objectives for the Roadmap, and have a strategy for monitoring and identifying whether these objectives are being met. Consideration could also be given to the underpinning importance of basic research in these areas and in improving the communication of the resulting science and mātauranga Māori to policy makers. For example, through the use of common language and te reo Māori, to maximise its uptake into planning and policy, and have a greater chance of informing and implementing change.

Proposed criteria for research priorities

The proposed criteria for research priorities of being answerable by New Zealand research teams (along with appropriate international collaboration); being answerable on the basis of measurable values rather than value judgements; not being simple yes/no/it depends answers; and containing a subject, action and outcome, are useful criteria. The criteria could also include a consideration of questions which only New Zealand is interested in or capable of answering (for example around endemic species), and science that addresses New Zealand's regional and international obligations (for example around the Pacific and Antarctica).

What benefits do you see being provided by the Roadmap

If monitored and supported, the Roadmap could:

- Identify important science areas that need addressing for conservation and environment policy and management.
- Connect and inform science investment strategies, such as National Statement of Science Investment (NSSI), National Science Challenges, Strategic Science Investment Fund (SSIF), and the Endeavour Fund
- Support investment in critical infrastructure and monitoring for the next 20 years.
- Identify capability needs, to inform the development of expertise required to deliver the Roadmap's goals.
- Help prioritise investment in all sectors engaged in conservation and environment science, and its application, around the major themes identified, in terms of funding and priority order.

Most important key themes

In addressing the major drivers, there could be some refinement of the key themes, which we outline below. There would be benefit from greater clarity on how the main themes and the cross-cutting elements will be integrated, and how this Roadmap links to other changes/strategies that are underway – e.g. development of investment strategy for the Strategic Science Investment Fund, Biosecurity 2025, and the Primary Sector Roadmap.

Some cross cutting elements, including climate change, biodiversity and mātauranga Māori are rightly identified with their own theme as they are critical to all aspects of conservation and environment, and there are potential conservation and environment research questions relating to these themes outside the other thematic areas. Other cross-cutting elements need attention:

- Biosecurity and introduced organisms could be linked together.
- Anthropogenic substances, in terms of environmental contamination, do not stand out clearly within the latter themes.
- New and emerging technologies don't stand on their own outside the other thematic areas, as all cutting edge science is looking to new approaches, tools and techniques to assist their fields.

In addition, when describing the individual themes within the Science directions section, it would be helpful if the identified themes could identify the issues relating to the cross cutting elements within them.

Consideration of individual themes

A number of statements found in some of the themes could be appropriate across other themes as well, for example:

- The research question 5.3 for mātauranga Māori could similarly be framed in Themes 3 & 4.
- A version of the capability needs statement in the theme of Populations and Species *“Increased skills in techniques and technologies along with increased science literacy and understanding of mātauranga Māori to inform decision making”* could also be included in the other themes.

The underpinning crosscutting elements of biodiversity and long term monitoring needs to be strengthened in Themes 2-5, so that we have a proper understanding of the environments, habitats and species New Zealand is trying to preserve. This will assist with the development and implementation of National Environmental Standards for land and water for the New Zealand environment.

Ecological interconnections across freshwater, terrestrial, coastal and marine ecosystems should be reflected across the ecosystem themes, and the ecosystem services provided by each of these ecosystems could also be better articulated. In reflecting the different demands on these ecosystems, the enduring questions should also address the limits appropriate to ensure ecosystem integrity, sustainability and resilience.

In considering the individual themes, there was general agreement with the enduring questions, vision and research questions identified in each of the themes, subject to the following clarifications:

Theme 1: Climate change

If New Zealand is to meet its commitments under the 2015 Paris Climate Agreement, answers to many of the research questions relating to climate change will be needed early within the Roadmap's 20-year horizon. A major goal of the theme should be for research that contributes to making significant progress towards achieving a low carbon economy within 5 years, and becoming net carbon zero in 20 years, rather than simply improving understanding of the pathways to such an economy.

Important social and economic questions could be included in terms of mātauranga Māori, and how New Zealand society, and Māori communities in particular, adapt to climate change. There also needs to be consideration of the impacts of the Southern Ocean and Antarctic ice sheets, both for New Zealand and globally. Research questions around the New Zealand Emissions Trading Scheme should also be included within the scope of this theme.

Theme 2: Integrated ecosystems and processes

This theme could include the cross-domain environmental impacts of New Zealand's natural hazards such as earthquakes and volcanoes, relationships between land management, freshwater and marine ecosystems, and social science questions around legal and planning frameworks to facilitate cross-domain management. An important crosscutting element will be comprehensive monitoring programmes

to support work in these areas, including increased knowledge about the distribution of our native species, and increased capability needs around biodiversity informatics. The research question 2.3 on ecosystem services is an important one, and could be asked in other themes of the Roadmap. There is a need to better identify an agreed set of ecosystem service concepts; a robust set of data on levels of ecosystem services; a sound understanding of the trade-offs between ecosystem services within localities and regions; the identification of off-site effects of ecosystem services; and a better understanding of public preferences for ecosystem services in New Zealand.

Theme 3: Freshwater ecosystems and processes

The enduring question for freshwater should focus more strongly on how a sustainable environment underpins a healthy society and economy, including the benefits from having continuous access to clean water. This is a more important starting point than the current focus on minimising the health impacts from polluted water.

Additional emphasis in the research questions should also be given to the major drivers of freshwater degradation and loss of ecosystem services including: sedimentation (a long-term issue with legacies in stream and lake beds), the supply of nutrients (eutrophication), the presence of pest exotic species (particularly fish and weeds), the loss of connectivity within ecosystems (reflected, for example, in our inability to maintain existing wetland ecosystems and native fish migration), hydrology and biodiversity.

Within the section on emerging ideas, the discussion on tipping points needs to be linked into considerations of concepts of ‘headroom’ for nutrient loads under future scenarios (e.g., climate change) and concepts such as climatic eutrophication⁴.

The section on ‘new or expanding capability needs’ should list the discovery and documentation of biota first, and include reference to connected and interoperable models to understand impacts of climate and land use on aquatic systems. The investment in basic hydrological science and monitoring programmes should also include the need for long-term time series to provide data on environmental trends, biota and river states.

Theme 4: Land ecosystems and processes

The enduring question needs to highlight how environmental quality can underpin and contribute to economic prosperity, rather than put them in tension. The vision for the theme might be expressed more directly as “the better management of land and resource use”, rather than the “better understanding of the consequences of management actions”. There could also be a goal of land use taking into account impacts on aquatic ecosystems, such as the impact of terrestrially derived sediment and nutrient run off on rivers, lakes and coastal seas.

In terms of emerging ideas, more research would be valuable on ecosystem-level management and resilience, including the discovery and documentation of New Zealand’s native biota, and the effect of anthropogenic substances such as fluorine, zinc and cadmium on soil microbiological processes and soil properties.

Theme 5: Coastal and marine ecosystems and processes

It is encouraging to see the recognition of the need to rejuvenate, or restore, marine ecosystems, and to optimise their resilience. This will need underpinning research on both how marine ecosystems function

⁴ The change in biological processes as a result of rising temperatures, including: (i) changing growth and respiration of organisms, potentially leading to lower net primary production; (ii) enhanced oxygen consumption (and, as warm water holds less oxygen, the risk of oxygen depletion) and increased nutrient release from sediments; and (iii) changing seasonal and trophic dynamics.

and how they can change, often in an abrupt fashion. These tipping points are the product of change in ecosystem function, and therefore will need a holistic assessment of physical, chemical and biological drivers to understand their dynamics and consequences. In this context, it would be good to highlight on how a high quality marine environment underpins the social and economic environment, as in the land and freshwater themes.

The context for this section should identify a number of other potential marine hazards for the environment, including: the impacts of sea level rise; the impact of changing wave climate, currents, and storm intensity on coastal ecosystems and human structures; and the impacts of submarine faults, and tsunamis on coastal New Zealand.

The emerging ideas within this theme could include how to improve on our understanding of marine ecological biomes and provinces in the seas around New Zealand⁵. The primary input of new organic matter in conjunction with physical and nutrient aspects of the environment, combined with their seasonal cycles, should allow better predictions about the distribution and vulnerability of species and populations. An ecological footprint analysis of the spatial extent and legacy effects of current and emerging contaminants, could also be valuable as part of the emerging idea on this topic.

In the next 20 years there will be increased pressure and additional uses of marine space – both on the coasts/harbours and in open water. There should be reference to marine farming in the research questions, and wider fisheries, even if these are being addressed through the Primary Industries roadmap, in relation to the ecosystem approach to their management, and the management of multiple activities in the same marine space. In addition, although there is a good statement about impacts of land-use intensification in the context section, this is not well reflected in the research questions. It would be good to have question 5.2 broadened (or a new question added) to cover interactions between land, freshwater and sea – and not just in the light of hazard science and climate change modelling. Impacts of sediment and land use practices are hugely significant along our coasts (e.g. Firth of Thames), and increasingly include the impacts of other types of resource extraction in addition to fishing.

Theme 6: Urban ecosystems and processes

The enduring questions, vision and research questions identified for this theme were unclear. The consideration of resilient cities in the theme seems to go into different territory than the consideration of our environment and natural heritage that dominates the other themes.

Just as the primary sector has been separated from the Conservation and Environment Roadmap, perhaps there is a place for separate consideration of built environments. Many of the listed research questions could be encompassed within the themes addressing integrated ecosystems, and consideration of wider social and economic issues.

If it is to be retained in the Roadmap, the focus of urban ecosystems should be modified to reflect the need for evidence-based research to help create biodiversity-rich and sustainable cities and towns. Urban conservation is an emerging interdisciplinary field that explores the interactions between people and biodiversity in urban contexts.

Urban areas may play a role in conserving populations of endemic biodiversity and provide connectivity to allow flora and fauna to move through the built environment to habitats on either side. Major points and airports can play an important role in the arrival, establishment and eventual spread of weeds and pests. Additionally, urban biodiversity can benefit people and the environment (through the provision of ecosystem services), providing important refugia for some native species.

⁵ Longhurst (1998) Ecological Geography of the Sea. Academic Press, 398 pp.

As our urban areas grow and face the challenge of environmental change (particularly climate change and pollution), the challenges for their land, freshwater and marine biodiversity, and the people within them, will need to be addressed, beyond the development of models.

The enduring question would also need to include freshwater environments as an area of urban impact, as urban streams are often highly degraded as a result of discharges of stormwater, wastewater and direct physical modification.

Theme 7: Populations and species

This is an important theme for New Zealand. The Roadmap talks about the importance of avoiding irreversible changes, and biological extinction is probably the most completely irreversible process covered by the document.

Preventing extinction should be spelt out much more clearly within the theme's enduring question, vision and goals, along with reducing population vulnerability. Avoiding extinction is also a good goal because progress towards or away from the goal, are objectively measurable. However, New Zealand cannot protect what it doesn't know, and many components of our flora and fauna are still unknown.

Within the "Context" for the Theme, the focus could be more positive and move from the challenges of intensive management becoming less and less affordable, to one of better technology and co-location of programs (efficiencies of scale) allowing more and more species to be effectively managed per unit funding.

For example, the last vertebrate extinctions in New Zealand (short-tail bat and bush wren) followed the Big South Cape rat invasion in about 1962. Advances in bait technology and GPS bait delivery mean that such a pest invasion would now be much simpler to manage. Pest management and eradication are now achieved over increasingly larger areas at lower and lower cost. That, and the potential for multiple species to benefit from management in single places, means it is increasingly possible for species management to keep pace with new and increasing cumulative threats.

An alternative context could include a short overview of the history of advances in management of pests and conservation generally. Most of the threats in New Zealand come from land use conversion (now largely, though not entirely, controlled under the Resource Management Act) and biological invasions (now managed through pest control technologies, large scale eradication, and better border biosecurity). Within the "Emerging ideas", the following are suggested:

- Include a point that more efficient pest control technologies are allowing larger and larger areas to be treated more cost-effectively, and that eradication is increasingly realistic over larger areas.
- Remove the point about genomics being used to guide which species to abandon. It could be contested whether any threatened species, where humans are the direct or indirect driver, is a hopeless case and should be abandoned. Black robins recovering from a population of five individuals is the textbook example of this. An aspirational long term document should not have as its lead idea that we have to figure out what to give up on.
- Remove the point about "some species are beginning to adapt rapidly in the face of mounting pressures", as all species are undergoing changes in gene pools, and it could imply that action, research and expenditure are not required because it's "natural" that species will either change to be able to survive or will "naturally" go extinct.
- The bullet point about "advances in species recovery through gene technology" should be more cautious. Research is still in its infancy, and the example of the auroch cattle in Europe would not apply to threatened New Zealand species which have no domesticated forms. Such

approaches may be unachievable within the Roadmap's timeframe and more expensive than traditional conservation efforts to stop the species going extinct in the first place. The best-case outcome of a de-extinction program may be the creation of an extremely small inbred population of the target species.

- Include the use of gene technologies for invasive species management.

The research questions within the theme could also be further developed. The first and most important research question should be about advances in pest management and small population management (including gene technologies) to allow preservation of all New Zealand native species.

The questions could also include better understanding of New Zealand's marine and terrestrial biomes, species interdependencies, functional extinction through declines in abundance (rather than outright loss of species *per se*), habitat loss and on-going change and distributions, and better protecting species vulnerability. Important crosscutting areas, in addition to climate change, mātauranga Māori, and biosecurity, include taxonomic infrastructure and data systems.

The theme's related roadmaps and strategies should also include Predator Free New Zealand 2050.

Theme 8: Biosecurity

Biotechnology will be an important element for this theme, along with developments in analysing big data quickly to allow for real time responses. For example, tools to identify 'kauri dieback' that can work in field conditions are becoming available. Another important element is the crosscutting area of databases and taxonomic infrastructure, which should be highlighted more within the theme, and an additional research question could be included on "how can we better use our taxonomic knowledge to rapidly determine invasive species?". Biosecurity 2025⁶ should also be included within the list of related strategies.

Theme 9: Mātauranga Māori

This crosscutting area needs to be better integrated into all the other thematic areas, and should recognise the pivotal role and nature of indigenous knowledge in the environment and conservation by strongly reflecting and implementing Vision Mātauranga⁷ policy. This should include approaches to better bridge and align mātauranga Māori with science; respond to national issues and Māori aspirations; and reflect international drivers and strategy (e.g. Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES)). The vision for the theme should include innovative science that includes mātauranga Māori, and builds Māori and science capability and capacity to achieve Māori aspirations and inclusive decision-making for the benefit of New Zealand society. Vision Mātauranga should also be mentioned in the related roadmaps and strategies.

Theme 10: Social and economic dimensions

The enduring question of how can people be enabled and encouraged to make and implement long-term, sustainable decisions that are mutually beneficial for society and the environment is an important one.

The vision for the theme should include people benefiting from a healthy and diverse environment, while the research questions could include:

- How can the environmental impact of more rapid increases in population and tourism numbers be managed?

⁶ <http://www.mpi.govt.nz/protection-and-response/biosecurity/biosecurity-2025/>

⁷ <http://www.mbie.govt.nz/info-services/science-innovation/pdf-library/vm-booklet.pdf>

- What long term benefits does a healthy environment have for human health and wellbeing in New Zealand?

*A Nation of Curious Minds*⁸ and Predator Free New Zealand 2050 should also be mentioned in the related roadmaps and strategies section.

Theme 11: Informatics, modelling and monitoring

This theme should be split into two themes: “Informatics and modelling”, and “Long term environmental monitoring and underpinning infrastructure”.

In New Zealand most long term ecological monitoring does not have long-term funding, and is maintained either by a series of short term research grants, or is unfunded and carried out voluntarily. Excellent examples of this include the Orongorongo and Craigieburn long term seedfall datasets, which have been vital for conservation in the Department of Conservation’s Battle for our Birds, and measuring plant responses to climate change. This need to secure funding to maintain long term monitoring should be given higher priority.

Similarly, references to the use, support and development of underpinning databases⁹ and collections should be expanded. For example, a whole-of-systems approach should be taken for taxonomic collections and scientific taxonomic capacity, to strategically connect funders, policy makers and priority setters. That is to interconnect providers, custodians, practitioners, stakeholders, and end-users, to address coordination, investment, stewardship, protection, and training. These databases and collections should also be integrated into international databases and monitoring systems, particularly from a biosecurity awareness perspective. An emerging idea in this context could be “unlocking the data in New Zealand’s taxonomic collections”. Open access for environmental data will be an important issue, and is rightly identified under capability needs.

Reference to the Royal Society of New Zealand’s report on National Taxonomic Collections in New Zealand¹⁰ could be included in the context section for the theme. The Society’s report noted a lack of alignment between the funding of taxonomy/collections infrastructure and the delivery of services. There is weak strategic alignment between the setting of output priorities by departments and agencies that are providing services and benefits, and the input priorities of those providing the main funding to the infrastructure of collections. There is also no obvious alignment between the input science funding to research organisations and taxonomic/collection infrastructure, despite that fact that New Zealand depends significantly on all of these biological collections and accurate species information. It would be useful if the Roadmap recognises the need to address some of these critical structural issues in the science system.

Theme 12: New and emerging technologies

This theme should be absorbed within the other themes. Many of the research questions looked like having yes/no answers, and it wasn’t clear how the open nature of ‘new technologies’ provided a roadmap, given the likely emergence of unknown new technologies over the next 20 years. Environment and conservation focussed research over the next 20 years will by necessity incorporate new technology, and this will be an important area of capability building within the individual themes.

⁸ <http://www.curiousminds.nz/about/article/9/curious-minds/>

⁹ Including climate and hydrological databases that are vital for conservation and environmental science

¹⁰ <http://www.royalsociety.org.nz/expert-advice/papers/yr2015/national-taxonomic-collections-in-new-zealand/>

Other comments

There would be benefit in including a glossary of terms, including the definition of words such as environment, managed ecosystems, and pests. The provision of more complete investment figures for the approximate 2015/16 investment from government departments and MBIE Endeavour Fund for themes would be useful, so that they include relevant CRI Core funding and relevant National Science Challenge funding.

For further information

The following experts provided valuable contributions to, and comments on the paper: Associate Professor Chris Anderson, Associate Professor Jacqueline Beggs, Dr Ilse Breitwieser, Emeritus Professor Ross Cullen, Dr Janet Grieve FRSNZ, Alistair Jan Gunn FRSNZ, Professor David Hamilton, Garth Harmsworth, Dr Simon Hills, Professor Dave Kelly FRSNZ, Alan Mark FRSNZ, Dr Matt McGlone FRSNZ, Dr Wendy Nelson FRSNZ, Dr Duane Peltzer, Professor David Penny FRSNZ, Dr John Quinn, Professor James Renwick, Professor Jacinta Ruru, Professor Dame Anne Salmond FRSNZ, Dr David Teulon and Professor Simon Thrush FRSNZ.

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