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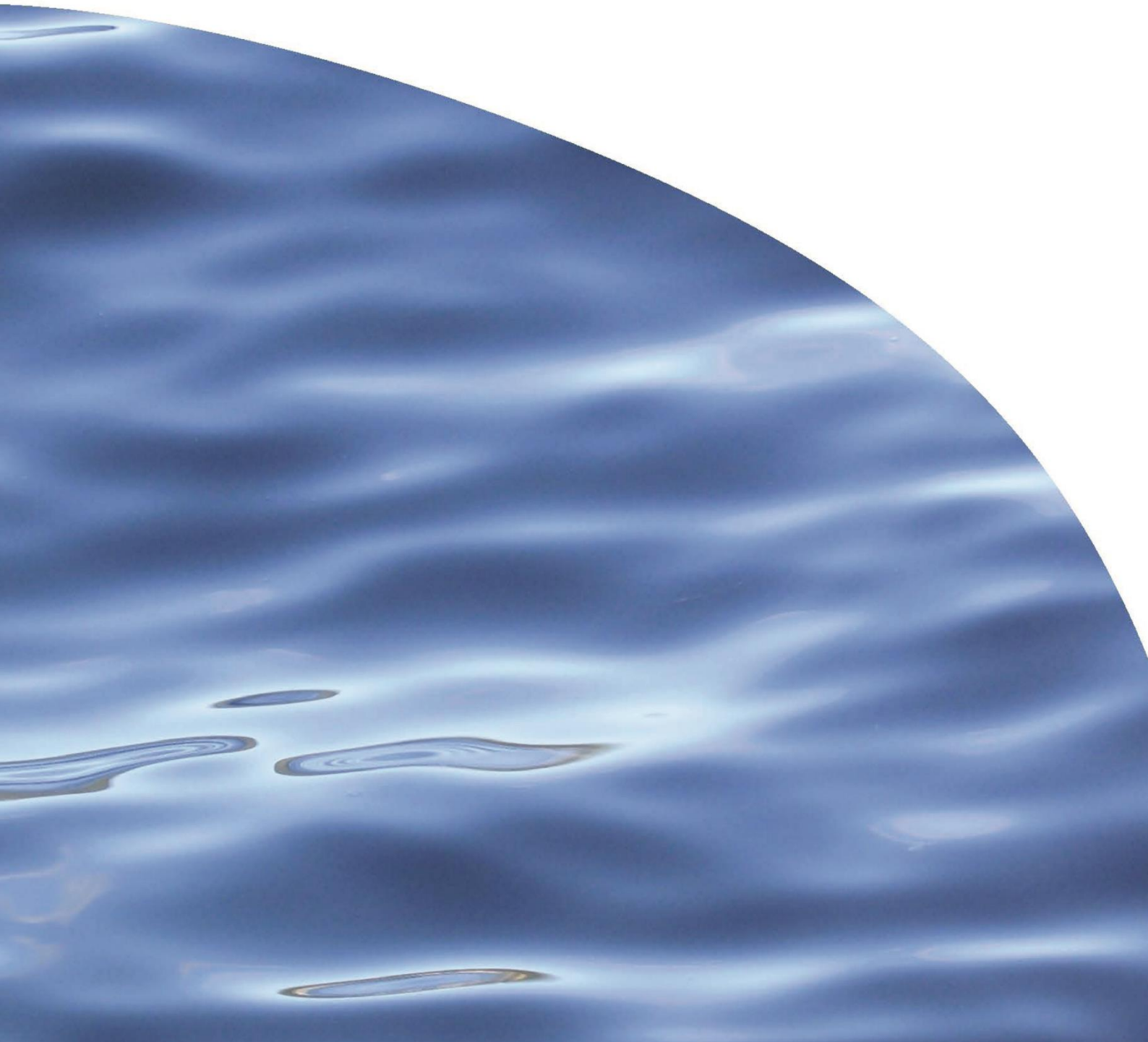
ENVIRONMENTAL LIMITS - A PROPOSED FRAMEWORK FOR AOTEAROA NEW ZEALAND



ENVIRONMENTAL LIMITS - A PROPOSED FRAMEWORK FOR AOTEAROA NEW ZEALAND

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Prepared for the Ministry for the Environment

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EXECUTIVE SUMMARY

Ensuring that New Zealand is operating within the limits of the natural and built environment will play an important role in the transition to a sustainable and resilient way of life. The Ministry for the Environment (MfE) is exploring how to improve New Zealand's resource management system, and how the improvement of environmental outcomes could be achieved. To inform this work, the MfE commissioned the Cawthron Institute to assess national and international frameworks for environmental limits and make recommendations for a new framework for New Zealand.

Conceptualising environmental limits and targets

Exemplified by the book *Limits to Growth* (Meadows et al. 1972), the concept of limits is central to modern environmental thought and management, although jurisdictions vary widely in whether and how they set, implement, and enforce environmental limits. The theory and practice of limit setting have been further developed through concepts of 'carrying capacity', 'critical loads', 'tolerable windows', 'safe minimum standards', and most recently, 'planetary boundaries'. Efforts to establish limits have often invoked the terminology of thresholds, tipping points, and critical loads. However, some earth systems exhibit gradual, variable, or complex responses to increasing human pressures, rather than clear threshold effects. Consequently, environmental limits cannot be defined solely on natural system dynamics and scientific analysis, but also require a normative assessment of acceptable levels of system change.

We therefore adopt the following definition of a limit:

> The level of some environmental pressure, indicator of environmental state or benefit derived from the natural resource system, beyond which conditions which are deemed to be unacceptable in some way, either because the system is judged to be damaged or because its integrity is at risk. (Haines-Young et al. 2006 p. 8)

Aligned with the concept of environmental limits is the concept of environmental targets which are aspirational statements about the desired state of an environmental system and its outcomes for people. Environmental targets have been used to specify broader environmental goals or objectives, set short-term markers of progress towards longer-term goals, or identify the improvements required to stay within or return to the 'safe and just operating space' defined by environmental limits.

The concept of planetary boundaries (PB) has become the dominant expression of environmental limits thinking over the last decade, and several countries have discussed applying the framework in national policy (including Germany, Switzerland and Sweden). Planetary boundary proponents identified nine key processes that are fundamental to Earth system functioning. For each process, they proposed a global

boundary that should not be transgressed if we are to avoid unacceptable environmental change.

Others have observed that the global economic system that has caused exceedance of environmental limits has also contributed to significant inequality, resulting in huge sections of the world's population living without the necessities of life. Proponents of the 'Oxfam Doughnut' advanced the PB framework by adding an inner boundary representing the minimum standards for human wellbeing as defined by the United Nations Sustainable Development Goals. Together with the outer boundary of ecological limits, this defines the 'safe and just operating space for humanity'.

Attempts to apply the Planetary Boundaries framework

While the PB framework was not designed to be disaggregated or down-scaled to the level of nations or communities, many researchers and policy analysts have attempted to do so, as a guide to environmental policymaking at relevant scales. While most studies default to allocating global boundaries on an equal *per capita* basis, the choice of allocation method results in very different levels of exceedance across countries. Further, a measured size of a country's environmental impact depends on whether impacts are defined as resulting from the production or consumption of goods and services. Consumption provides a better representation of a country's contribution to global changes, whereas production-based analyses better reflect the pressures and impacts on sub-global environmental systems.

All of the PB analyses we reviewed—whether global, national, or regional in scale—reported the transgression of one or more environmental boundaries. Existing efforts to manage environmental impacts are not sufficient to prevent the disruption of key Earth system processes that are essential to maintaining the safe operating space for human life. Further, basic human needs are not being met under current political and economic systems, and significant disparity exists both within and across jurisdictions.

The consequences of exceeding a limit are often better understood than the processes leading to that exceedance. In many cases, it is only possible to identify levels of vulnerability for certain species or habitats, because significant information gaps prevent full quantification of cumulative impacts. In cases of reversible ecosystem change, environmental managers have commonly incorporated limits and targets into regulatory decisions retrospectively.

Increasingly, indigenous knowledge is being recognised worldwide as a means to enhance understanding of our environment, to identify solutions to complex problems, and to provide a basis for strengthening cultural identity. Alongside this is the national need to recognise Treaty of Waitangi obligations and ensure Māori values, principles and practices are considered when setting limits and targets. At the heart of Māori principles and practices is te ao Māori, a holistic view of the world, acknowledging the interconnectedness and interrelationship of all living and non-living things, and the

Māori place in it. The implementation of Māori environmental limits and targets is a place-based exercise. It reflects an inherent knowledge of the natural environmental gained by living in and being part of that environment for hundreds of years (whakapapa). It further reflects a right and responsiblity to care for the environment (rangatiratanga, kaitiakitaga) to ensure sustainability for future generations. Specific cultural practices 'operationalise' these principles.

Environmental limits and targets in New Zealand

In New Zealand, the use of limits and targets is more common in some fields of environmental management than others. For freshwater environments, New Zealand has a set of objectives, limits, and targets to guide freshwater management nationwide, with regional councils responsible for local implementation. Marine fisheries have been managed using a limits-based approach since the mid-1980s, and air quality since 2004. More recently, the government has legislated greenhouse gas emissions targets for New Zealand.

By contrast, marine and coastal ecosystems, land, biodiversity, and the built environment are subject to few binding environmental limits or targets. Existing limits and targets are not necessarily well coordinated and do not address the wider scope of environmental management for these subject areas. Furthermore, setting limits on, for example, nitrogen discharges to water does not ensure that aquatic environments will be healthy. Both freshwater and marine environments are ecologically complex systems; their status is the result of multiple factors interacting in complex ways. Especially where an environmental limit cannot be clearly specified and directly managed, complementary measures will be needed to protect environmental integrity and to avoid transgressing ecological, social and cultural boundaries.

Tikanga Māori supports the use of limits for environmental management, yet there has been limited involvement of Māori in limit setting and implementation in New Zealand. Many of the policies we reviewed make no mention of te ao Māori, requirements for engagement, or partnership with tangata whenua in environmental management, thus falling short of Treaty principles of active protection, participation and partnership. Two exceptions are biodiversity policies and the fisheries management system. More recently, in freshwater policy, the government has moved to strengthen the role of Māori values and communities in decision making, through its centring of 'Te Mana o Te Wai'. While there remain areas to be addressed, especially concerning allocation, these freshwater policies provide examples of how environmental limits and targets can be set in ways that recognise the rights and responsibilities of tangata whenua. Further, tikanga such as rahui and mātaitai reserves, and objectives in iwi management plans, provide strong examples of Māori-led approaches to environmental limit and target setting. Collectively, these examples highlight opportunities to strengthen limit and target setting in line with tangata whenua interests and aspirations.

Voluntary industry accords can be an effective method for establishing and implementing environmental limits and targets if most members of the industry comply with the accord. Such accords can also facilitate eventual regulatory limits that address any remaining non-compliance and provide long-term protection. Actions by individual businesses, such as achieving carbon-neutral or ISO certification, can provide industry leadership and thereby facilitate the adoption of regulatory limits or industry-wide accords.

A recommended framework for New Zealand

Both international and New Zealand case studies demonstrate the value of legally binding limits and targets to provide a minimum level of protection for environmental systems and drive long-term action for environmental improvement, in a way that is resilient to political changes. We therefore recommend the enactment of clear requirements for environmental limits and target setting in new or amended overarching legislation that would govern all other statutory environmental instruments.

This overarching legislation would include:

- the subject areas and topics for which limits and targets *must be set* by statutory instruments;
- goals and principles for limits and target setting;
- procedural requirements for reporting and review; and
- governance requirements for oversight and enforcement of limits.

The required limits and targets would be binding, stated in statutory instruments with clear duties for policy and decision makers to actively secure them and not undertake actions that are likely to result in the transgression of limits. The legislation would allow for limits and targets to be set at national or sub-national scales (e.g. regional, local, city, catchment), to enable integrated management of issues across natural systems. National-scale limits and targets would also be expected to deliver on New Zealand's international environmental commitments.

Based on our reviews and expert input, we conclude that priority should be given to setting environmental limits that protect a minimum level of environmental quality necessary to sustain human wellbeing and ecosystem functioning. In particular, defining a minimum environmental state is likely to be important to prevent the ongoing deterioration of environmental systems, to identify the minimum requirements for rehabilitating already degraded systems, to uphold environmental justice by securing minimum environmental standards for all, and to uphold the Treaty of Waitangi by ensuring protection of taonga and culturally significant environments.

We also recommend that specific, measurable, and timebound targets should be set where current environmental outcomes are less than those articulated in policy, plans or strategic objectives. Targets provide a focus for action planning, a metric to measure progress and a basis for holding government to account.

The overarching legislation would include clear goals, narrative objectives and principles to guide environmental limit and target setting. The goals would identify the high-level rationale for setting environmental limits and targets, and the narrative objectives would specify the environmental bottom lines that must be secured through the development of limits and targets for each subject area. The principles would provide guidance on when, at what scale and how limits and targets should be set for each subject area.

In addition, the overarching legislation would set out requirements for reporting and review, overseen by an independent authority that can call to account government agencies that do not meet limit setting requirements or demonstrate sufficient progress towards targets. This recommended approach bears strong similarity to the overarching environmental legislation operating in Sweden and proposed for the United Kingdom, both of which require environmental limits and/or targets to be set for key environmental issues.

Given that the proposed overarching legislation would be quasi-constitutional in nature, its development should be governed by Treaty principles, with ample avenues for public participation. Specifically, iwi/hapū representatives should be involved in identifying the goals, topics, narrative objectives and principles for limit and target setting, followed by wider consultation on the proposed statute. Indicative goals, subject areas and principles are included in this report.

Complementary measures

Legislation alone is not sufficient to achieve the level of environmental protection and improvement required in New Zealand. Non-statutory instruments and non-governmental organisations play an important role in New Zealand's environmental management. Māori authorities, industry groups, international organisations and NGOs use limits and targets to guide their management activities and set expectations for other entities. The legislation we are recommending would support and build upon rather than supersede these initiatives. By giving greater prominence to the role of environmental limits in New Zealand more generally, the legislation can guide and support communities in articulating their own minimum environmental standards, which can in turn inform limits set through statutory instruments.

Furthermore, overarching legislation to establish minimum environmental outcomes (i.e. limits and targets) must be accompanied by reforms to funding, compliance, and enforcement frameworks. Compliance monitoring and reporting in particular are

crucial to ensure that resource users and governments are accountable for their environmental effects.

The report provides further analysis of the need for limits and targets in four subject areas—land use change, biodiversity, coastal environments, and the built environment—and commentary on processes for setting limits and targets at national and sub-national scales.

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LIST OF ABBREVIATIONS

APZ	Agricultural Protection Zoning
BMPP	Best Management Practice Program
CFC	Chlorofluorocarbon
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CRP	Conservation Reserve Program
CWA	Clean Water Act
Defra	Department for Environment, Food and Rural Affairs
EC	European Commission
EAP	Environment Action Programme
EIA	Environmental impact assessment
EQS	Environmental Quality Standards
EU	European Union
Freshwater NPS	National Policy Statement for Freshwater Management
GBR	Great Barrier Reef
GCAP	Greenest City Action Plan
GHG	Greenhouse gas
IMP	Iwi management plan
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LEZ	Low emission zone
MBO	Management by objectives
MfE	Ministry for the Environment
OEP	Office for Environmental Protection
PB	Planetary boundary
PDR	Purchase of development rights
$PM_{2.5}$	Atmospheric particulate matter with a diameter of < 2.5µm
POP	Persistent organic pollutant
RMA	Resource Management Act
RMS	Resource management system
SMART	Specific, measurable, achievable, realistic, timely
TMDL	Total maximum daily load
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
WIP	Watershed implementation plan
WQIP	Water Quality Implementation Plan
WQS	Water quality standards

1. INTRODUCTION

1.1. Report purpose and scope

The natural environment of Aotearoa New Zealand is part of the country's cultural identity and a pillar of its economic growth (OECD 2017; MfE 2019a). It enhances the quality of life for New Zealanders and brings pleasure to millions of tourists that visit the country each year. By international standards, New Zealand is regarded as a green and clean country, with environmental policies informed by an advanced and comprehensive natural resource management system anchored on a multi-level governance model with a set of integrated environmental regulations and collaborative approaches to environmental management (OECD 2017).

Ensuring that New Zealand is operating within the limits of the natural and built environment will play an important role in the transition to a sustainable and resilient way of life. A clear framework for limits and targets would form an important component of a future resource management system and the Ministry for the Environment (MfE) is exploring what transformation of the system could involve, and how the improvement of environmental outcomes could be achieved. To help inform this work, MfE commissioned the Cawthron Institute to assess existing national and international frameworks for environmental limits and examine the feasibility of a new framework for these in New Zealand.

This technical report summarises the state of the art with respect to operating models for setting and implementing limits and targets, including legislative frameworks and requirements, and provides recommendations on a model that describes when, and under which conditions, limits and targets would be set, as well as the capabilities needed to support implementation across New Zealand.

1.2. The centrality of environmental limits in resource management reforms

Within New Zealand's resource management system, the Resource Management Act (RMA) 1991 is the principal statute for managing the built and natural environments. The RMA sets the framework for central and local government to achieve a coordinated, streamlined and comprehensive approach to environmental management (MfE 2019a). To achieve these purposes, the RMA assigns different roles and responsibilities to central and local government. Central government has responsibility for administering the RMA, providing national direction and responding to national priorities relating to the management of the environment and environmental issues. Most of the everyday decision-making under the RMA is devolved to city, district, regional and unitary councils.

Since its inception, the RMA has been subject to numerous reviews and reforms. Recent changes include the Resource Legislation Amendment Act 2017, the Resource Management Amendment Act 2013, and the Resource Management (Simplifying and Streamlining) Amendment Act 2009. The RMA also works in conjunction with other important planning and environmental management statutes, including the Local Government Act 2002, the Land Transport Management Act 2003 and the Climate Change Response Act 2002. The decision-making frameworks in these statutes are intertwined, and changes in one area can impact other aspects of the system.

The numerous reviews and reforms have added complexity to the RMA, rendering it unwieldy, and there have been significant problems with the Act's implementation. The Ministry for the Environment considers that while much of the RMA remains sound, it is underperforming in the management of key environmental issues and in delivering affordable housing and well-designed urban communities (MfE 2019a). Questions have been raised by many stakeholders as to whether the resource management system can respond effectively to future challenges associated with ecosystem degradation, biodiversity loss and climate change (MfE 2019a).

Consideration of these issues prompted the Government to commission a comprehensive review of the resource management system with a focus on the RMA. The priority for the review is to set a high-level framework for an improved system and not to resolve specific issues with the current legislation (Terms of Reference: Resource Management Review Panel 2019).[1] The concept of environmental limits is central to this review, which aims 'to improve environmental outcomes and better enable urban and other development within environmental limits' (ibid p.1). Further, the terms of reference specify 'improving environmental outcomes, including through strengthening environmental bottom lines' (ibid p.7) as a key issue to be addressed.

While Severinsen (2019) and others contend that the RMA was always intended to protect environmental bottom lines, the Resource Management Review Panel (2019 p.13) found that

> it suffered from a lack of clarity about how it should be applied—taking over two decades for the courts to settle through the King Salmon case. As a consequence of this lack of clarity, as well as insufficient provision of national direction and implementation challenges in local government, clear environmental limits were not set in plans. Lack of clear environmental protections has made management of cumulative environmental effects particularly challenging.

[1] Terms of Reference: Resource Management Review Panel. Approved by Cabinet on 11 November 2019 https://www.mfe.govt.nz/sites/default/files/media/RMA/rm-review-final-terms-of-reference_0.pdf

This report is intended to contribute to the resource management reform discussion by providing information on existing use of environmental limits in New Zealand and worldwide and setting out a potential model for strengthening the implementation of environmental limits and targets in New Zealand.

The Resource Management Review Panel's issues and options paper (2019) also identifies a range of issues with the current resource management system that are likely to influence how environmental limits and targets are set, implemented, and resourced. These include:

- lack of clarity in the RMA about how to address cumulative environmental effects
- a focus on managing the effects of resource use rather than achieving outcomes
- insufficient recognition of the importance of proactive and strategic planning
- lack of effective integration across the resource management system
- excessive complexity, uncertainty and cost across the system
- lack of adequate national strategic direction
- insufficient recognition of the Treaty of Waitangi and lack of support for Māori participation
- weak and slow policy and planning
- weak compliance monitoring and enforcement
- capability and capacity challenges in central and local government, causing delays, uncertainty and adding costs
- weak accountability for outcomes and lack of effective monitoring and oversight.

While addressing these issues is outside the scope of this report, it is important to note the breadth and scale of these issues and the challenge they pose for limit setting. It will take significant, system-wide reforms to enable the nation-wide, effective implementation of limits and targets in environmental policy and decision making.

1.3. Structure of report

This report has four main sections. Following this introduction, we summarise our review of the peer-reviewed literature and policy reports on environmental limits and targets in Section 2. We describe the development of limits and targets concepts and definitions in the environmental management literature, recent work on global environmental limits, and the operationalisation of environmental limits and targets across a range of jurisdictions. Methods used to identify the relevant literature are summarised in Section 1.4.1. We discuss the operationalisation of limits and targets frameworks through a series of case studies in Section 3. Our discussion includes analyses of comprehensive policy frameworks and more narrowly defined limit and

target-based approaches to specific environmental management issues. The criteria used to select the case studies are presented in Section 1.4.2.

The focus of the report then moves to existing requirements for—and applications of—limit and target setting in New Zealand. In Section 4, we provide an analysis of the range of statutory requirements for environmental limits and targets in New Zealand, and the use of limits and targets in international agreements, Māori environmental management, and by industry organisations. The range of environmental subject areas and statutory and non-statutory instruments reviewed for this section are set out in Section 1.4.3. Our summary of environmental limit and target setting in New Zealand highlights the uneven use of limits and targets across environmental subject areas, and limited involvement of Māori in limit setting and implementation. These insights were central to our development of recommendations on requirements for environmental limits and targets in New Zealand.

In Section 5, we present our recommended framework for environmental limits and targets in New Zealand, which includes the development of overarching legislation, criteria for determining situations or contexts in which limits and targets are appropriate management instruments, and key considerations for implementing limits and targets. To inform our proposed model, we solicited input from a group of resource management experts through an online workshop. The range of topics and questions considered in the workshop are presented in Section 1.5 and the rationale for developing the limits and targets framework is summarised in Section 1.6. Conclusions are provided at the end of the report in Section 6.

In the remainder of this section, we outline the methods used to analyse current environmental limits theory and practice and develop recommendations for the future.

1.4. Review methods

1.4.1. Literature review

To understand how environmental limits and targets have been developed and implemented throughout the world, we identified relevant academic and grey literature using a combination of approaches. First, we identified publications on environmental limits that we were already aware of, including reports by international organisations (e.g. Sustainable Development Commission) and core academic references. We then reviewed the reference lists of these publications to identify further potentially relevant publications. We also searched for relevant publications that cited the core academic references in Google Scholar. All potentially relevant publications were entered into an Endnote library for further review.

To complement our searches in Google Scholar, we carried out keyword searches in academic databases (JSTOR, Web of Science, Science Direct, Sage Journals, Annual Reviews). These databases were selected to ensure coverage of the core academic publishers in environmental and social sciences. We then searched for the following keywords in the title/abstract/key words of articles and book chapters:

- environmental/ecological/natural limits
- environmental/ecological bottom lines
- environmental/ecological objectives
- environmental/ecological targets
- environmental/ecological standards
- planetary boundaries
- safe operating space.

Many of these searches generated thousands of results. To refine our searches, we combined the keywords with 'policy/law/legislation/regulation' or 'environmental management'. In some cases, we searched for literature published since 2000, as most articles that comment on the implementation and outcomes of limit-type policies have been published during this period. Nevertheless, our searches using the terms 'limits', 'bottom lines', 'objectives', 'targets' and 'standards' still generated a large number of irrelevant or only tangentially relevant publications (e.g. work on corporate environmental standards), due to variation in the use of this terminology. However, when relevant publications were identified, this often led to other potentially relevant papers through database recommendation functions. As before, all potentially relevant publications were entered into the Endnote library for further review.

References were then sorted into four categories, according to topic and publication type:

- policy reports on environmental management tools (i.e. limits, objectives, standards, targets)
- academic publications on environmental management tools
- policy reports on planetary boundaries
- academic publications on planetary boundaries, safe operating space, doughnut economics, etc.

We identified a subset of core references that we considered most relevant, comprehensive, and/or well-cited publications on the theory and implementation of environmental limits (and related approaches). These publications provided a baseline overview of key concepts and developments in the field and helped identify further references for detailed review.

1.4.2. Identification and review of international case studies

To complement our analysis, we reviewed a selection of international examples of limit and target setting approaches. These examples were selected to reflect a range of environmental subject areas and approaches, focusing on case studies that illustrated approaches different from those used in New Zealand. We conducted a preliminary search for information, reports, and academic publications on case studies of potential interest. Some of the case studies were suggested by MfE, while others were identified through our literature searches or based on our knowledge and experience of environmental management. We identified two types of case studies:

1. comprehensive policy frameworks that have been developed to institute a limit or objective-based approach to environmental management across multiple policy realms
2. more narrowly defined limit, objective, or standard-based approaches to a specific realm of environmental management (e.g. biodiversity).

The case studies under (1) provided insight into how environmental limits and related concepts have been operationalised under a guiding framework for national environmental policy. Those in (2) provided more detailed examinations of how effective limits-based policy tools have been at delivering improvements in specific areas of environmental management.

1.4.3. Review of environmental limits and targets in New Zealand

In consultation with MfE, we identified a list of requirements for limit and target setting under the RMA and related legislation and reviewed these for the following selection of subject areas and environmental issues:

- freshwater (water quantity; water quality; nitrogen and phosphorus; emerging contaminants)
- air (air quality; ozone-depleting emissions)
- land (soils; land use; forests)
- biodiversity (indigenous species; ecosystems and habitats; invasive species)
- climate change (greenhouse gas emissions; energy)
- marine/coastal environments (marine acidification; eutrophication; sedimentation; plastics; fisheries (including bycatch and seabirds); marine mammals; marine biodiversity)
- built environment (waste; housing; noise; exposure; wastewater; green space; light pollution; impermeable surface area)
- minerals.

For each of the above subject areas, we reviewed the relevant statutory drivers, described limits and targets, identified implementation processes, characterised

spatial and temporal scales, identified agencies responsible for implementation and enforcement, and identified whether te ao Māori, principles of kaitiakitanga, and Treaty partnership had been recognised in the statutory documents. We synthesised the information in a table to enable comparison of approaches to limit and target setting.

We also reviewed non-statutory requirements and approaches to limit and target setting and briefly described some key international agreements to which New Zealand is a party. Specifically, we reviewed:

- Minamata Convention on Mercury
- Convention on Biological Diversity
- United Nations Framework Convention on Climate Change, Kyoto Protocol and the Paris Agreement
- Vienna Convention for the Protection of the Ozone Layer and Montreal Protocol on Substances that Deplete the Ozone Layer
- Stockholm Convention on Persistent Organic Pollutants
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London Protocol
- International Convention for the Prevention of Pollution from Ships (MARPOL)
- Ramsar Convention on Wetlands of International Importance
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

As a third component of our review, we identified and analysed approaches to limits and targets expressed in agreements between the civil society and New Zealand government, including those expressed in Māori environmental management and agreements with industrial sectors in New Zealand.

1.5. Experts workshop

To help inform our proposed framework and feasibility analysis on limits and targets in New Zealand, we convened a workshop with resource management and subject matter experts. Workshop participants included Māori resource management professionals, regional council staff, scientists, policy managers/analysts, hearing commissioners and representatives of industry and environmental organisations. The workshop was held online over three hours on 20 May 2020. A list of participants is given in Appendix 1.

The workshop was designed to provide participants with an opportunity to share and listen to ideas, not to reach consensus on any particular topic. The specific objectives of the workshop were:

- to present a summary of national and international approaches to limit and target setting
- to seek feedback from participants on the proposed environmental limits framework
- to assess the capability of New Zealand to implement a limits-based approach.

Input from participants was solicited through shared online documents and dialogue in collective and break-out group discussions. The workshop was structured into four sessions:

- session 1: Introduction to environmental limits (presentation and collective discussion)
- session 2: Conceptual framework for environmental limits (break-out group discussion)
- session 3: Applying the conceptual framework to subject areas (break-out group discussion)
- session 4: Operationalising a limits framework in New Zealand (collective discussion).

In break-out sessions, each participant was allocated to one of four thematic groups and tasked with answering six questions for one domain of environmental management (biodiversity, land, marine/coastal, built environment). The questions considered by participants were:

- why do we need environmental limits and targets?
- when (under what circumstances) are environmental limits useful and appropriate?
- at what scale(s) is it appropriate to set limits and targets? How does one determine the appropriate scale?
- how should environmental limits and targets be set (e.g. based on what knowledge and governance processes)?
- what challenges arise in setting and using limits?
- how should compliance with environmental limits and targets be governed?

1.6. Developing a limits and targets framework for New Zealand

Based on the insights generated through our reviews of the international literature and case studies, a stocktake of domestic requirements and the workshop with

environmental experts, we developed a proposal for a comprehensive environmental limits and targets framework for New Zealand. In developing our proposed framework, we sought to provide answers to the conceptual framework of six questions used in the workshop. We developed criteria for determining situations or contexts in which limits and targets are appropriate management instruments; identified the types of instruments through which limits and targets should be set and associated governance requirements; developed guidance on questions of scale and how to deal with uncertainty; and considered the capability and capacity required to implement the framework. Our resulting recommendations focus on describing the *types* of environmental limits and targets, legislation, and governance arrangements needed to improve environmental outcomes, but stop short of identifying specific laws or governance entities.

2. REVIEW OF LITERATURE ON ENVIRONMENTAL LIMITS AND TARGETS

2.1. Introduction

This section discusses key arguments for use of environmental limits as a basis for environmental management and governance, and how limits have been incorporated in environmental management generally. It summarises how the concept of limits has been taken up in the planetary boundaries (PB) framework and related concept of a safe and just operating space for humanity as a guiding framework for environmental management. Finally, it provides insights from the academic literature regarding the operationalisation of limits and targets in environmental policy and management.

2.2. Limits and targets in environmental management

2.2.1. History of environmental limits

The concept of limits is central to modern environmental thought and management, although jurisdictions vary widely in whether and how they set, implement, and enforce environmental limits. As Meadowcroft (2013, p. 991) explains, 'there are limits to the stress humans can impose on the natural systems that sustain us before serious consequences ensue.' This understanding is embedded in our approaches to nature conservation, climate change, protection of human health and resource use. The concept of limits is invoked when we create regulations to prohibit certain activities, set standards for discharges, allocate resources, or designate protected areas. Limits are often implicit in environmental management—except for water and air, where quality limits are specified (typically in the form of standards) and integral to decision making on discharges to the environment.

The first attempt to identify resource limitations and their linkages to Earth system dynamics (see Section 2.2.3) was the book *Limits to Growth* (Meadows et al. 1972), commissioned by the Club of Rome, an international group of businessmen, statesmen and scientists. Focusing on five trends of global concern, Meadows et al. used a systems-modelling approach to better understand the trends' causes, inter-relationships, and future implications. Their main message was that exponential expansion of human civilisation could not continue indefinitely. While *Limits to Growth* was controversial, the concept of environmental limits has played an increasing role in the environmental management discourse ever since.

Indeed, limits are central to the sustainable development paradigm that has dominated environmental management since the 1980s. The United Nations (UN) defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own

needs' (1987 p. 41). The UN explains that 'this implies limits, not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities' (ibid p. 16), and further that 'sustainability requires that long before these [limits] are reached, the world must ensure equitable access to the constrained resource and reorient technological efforts to relieve the pressure' (ibid p. 42). In doing so, the UN reframed the limits debate away from absolute limits that presage ecological disaster, towards living within limits that enable a good quality of life for current and future generations.

The concept of environmental limits has been widely taken up within the scientific community as well as by policy and governance theorists and a range of global policy organisations (Häyhä et al. 2016). The idea and practice of limit setting was further developed through the concepts of 'carrying capacity', 'critical loads', 'tolerable windows', 'safe minimum standards', and most recently, 'planetary boundaries' (PB) (see Section 2.3.1).

2.2.2. Defining limits and targets

A range of terms and definitions have been used to describe environmental limits and targets in the sustainability literature, often relying on scientific concepts of thresholds, tipping points or critical loads. However, as the PB framework highlights, not all Earth systems demonstrate clear threshold responses to increasing human pressures; many systems respond through more gradual, variable, or complex changes in system properties (see Steffen et al. 2015b). Consequently, environmental limits cannot be defined based on natural system dynamics and scientific analysis alone, but also require a normative assessment of acceptable levels of system change. As Haines-Young et al. (2006 p. v) state, 'fundamentally the idea of a limit involves setting a maximum level of damage to a natural resource system that we are prepared to tolerate or accept.'

In this study, we adopted Haines-Young et al.'s widely referenced definition of environmental limits, which incorporates both the biophysical properties of natural systems and their value to people:

> The term limit is used to refer to the level of some environmental pressure, indicator of environmental state or benefit derived from the natural resource system, beyond which conditions which are deemed to be unacceptable in some way, either because the system is judged to be damaged or because its integrity is at risk. The term can be applied irrespective of the type of dynamic exhibited by the system (linear response, simple non-linear response, threshold response) (Haines-Young et al. 2006 p. 8)

Environmental limits may thus refer to an environmental **state** (e.g. average air temperature), **pressure** (e.g. atmospheric CO_2 concentration), or **driver** of change (e.g. anthropogenic CO_2 emissions), depending on the system or issue of concern and information available. Typically, environmental limits are not set at the level at which conditions are expected to become unacceptable, but rather at a safe distance from this level, following the precautionary principle. For this reason, theorists sometimes distinguish between an 'absolute' environmental limit or bottom line, and a precautionary limit or safe minimum standard (see buffer zone in planetary boundaries framework, Rockström et al. 2009b). In this study, we focus on approaches to setting precautionary environmental limits that 'account for uncertainty in the precise position of the threshold with respect to the control variable but also allows society time to react to early warning signs that it may be approaching a threshold and consequent abrupt or risky change' (Steffen et al. 2015b, p. 1–2).

In contrast to environmental limits, environmental targets are aspirational statements about the desired state of an environmental system and its outcomes for people (Dao et al. 2018). In the field of environmental management, targets have been used to specify broader environmental goals or objectives, set short-term markers of progress towards longer-term goals, or identify the improvements required to stay within or return to the 'safe operating space' defined by environmental limits. Consequently, targets may be set on a precautionary basis where the aim is to deliver environmental protection—i.e. to prevent or limit degradation of existing environmental quality—or they may be more ambitious in order to achieve environmental improvement.

Targets may be attached to particular indicators or ecosystem components, or may be framed as broad over-arching objectives (Defra 2007) and be applied to pressures (e.g. pollutant emissions, resource consumption, waste production, etc.), to elements of quality or state of the environment (e.g. biological quality of water) or to specific impacts (e.g. human health, ecosystem health). According to Bourne and Fenn (2011), environmental targets should be relevant, achievable, effective, socially acceptable, and specific.

2.2.3. Theory of environmental limits and targets

The Earth system is composed of physical, chemical and biological processes that occur between the atmosphere, cryosphere, land, ocean and lithosphere (Steffen et al. 2020).[2] These components interact with each other and can experience rapid change. It is widely acknowledged that collective human activity has exerted substantial impacts on the structure and functioning of Earth system processes and that these impacts, if sustained, could have serious consequences for sustainable development, human wellbeing and resilience of the processes themselves (Hoekstra & Wiedmann 2014).

[2] There are other definitions which include the interior of our planet, but we do not consider them here.

The impacts of human activity are well illustrated in the Great Acceleration graphs, which originated from the International Geosphere-Biosphere Programme synthesis project (Figure 1). These graphs demonstrate the exponential growth of human activity after the Second World War, both in terms of economic activity, and hence consumption, and in resource use (Steffen et al. 2015a). For many scientists, human impact is now so severe and enduring that the current geological time can be declared as the Anthropocene (Zalasiewicz et al. 2011).

Eventually, an Earth system process may reach a tipping point (or people may judge that such a point has been reached), beyond which the reduction in benefit is no longer acceptable or tolerable. Such a critical level can be described as an 'environmental limit' (SNIFFER 2010). There is clear evidence that some critical environmental limits (e.g. average air temperatures, emissions/loads of pollutants, resource use) are being approached, or even surpassed, in many parts of the planet (Steffen et al. 2018; UNEP 2019). Evidence of this includes:

- sea level rising, melting of glaciers (Vermeer & Rahmstorf 2009; Jevrejeva et al. 2014) and higher frequency of extreme weather events as a result of climate change (Seneviratne et al. 2012)
- substantial loss of biodiversity (Hooper et al. 2012)
- vast areas of the planet degraded or at risk from non-sustainable use, including decline in tropical rainforest cover (Achard et al. 2014) and collapse of tropical coral reefs
- overfishing, with many fish stocks already fished to the limits of their capacity or beyond (Pinsky et al. 2011)
- overexploitation of ground and surface water resources in some parts of the world (Besbes et al. 2018).

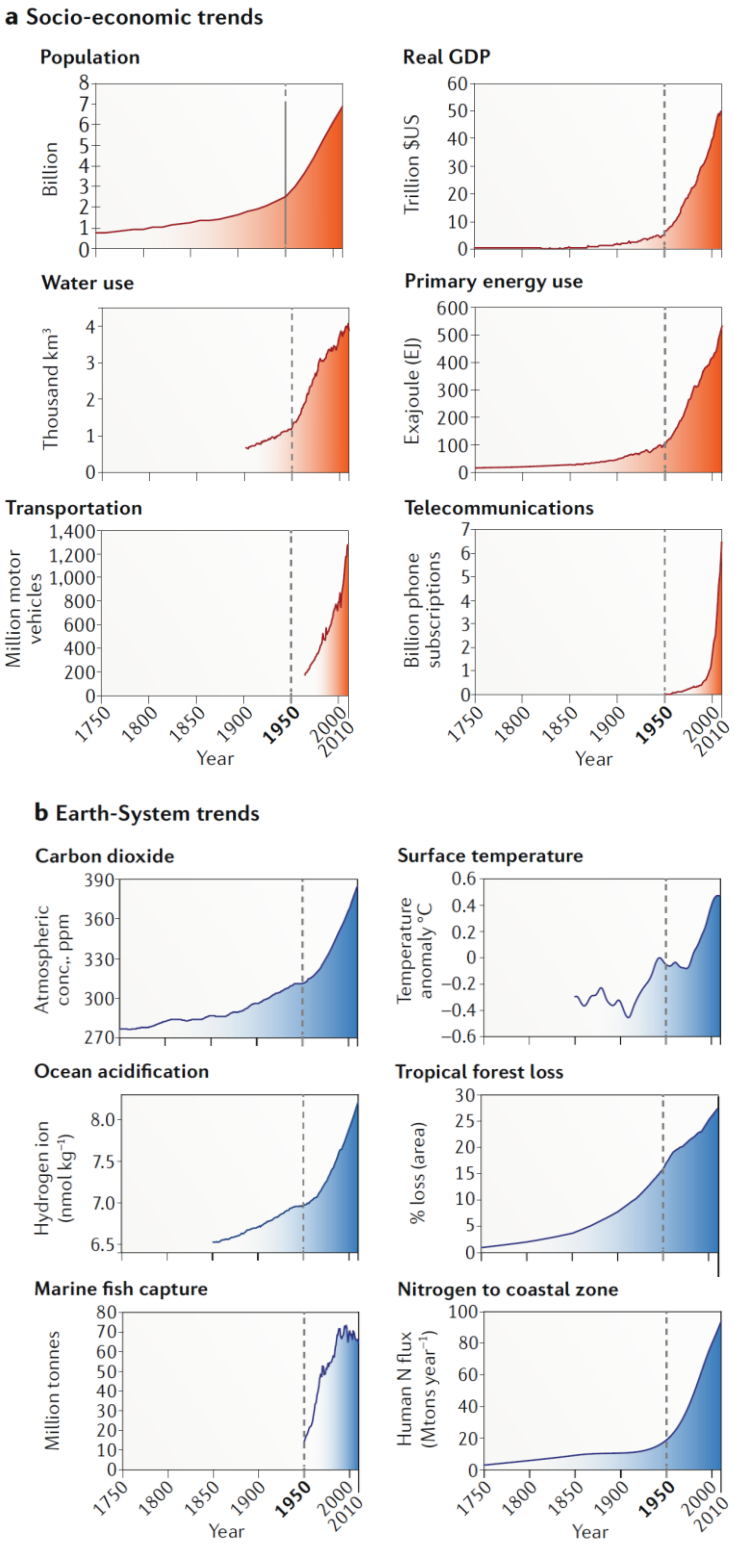

Figure 1. Trends for socio-economic and Earth system indicators, 1750–2010. Reproduced from Steffen et al. (2020).

In addition to limited natural resources, there is evidence that natural forces are controlling human population numbers through malnutrition and other severe diseases (Pimentel et al. 1999). There are also limits to our cognitive capacity and ability to anticipate the future and manage biological systems as if they were engineered systems (Meadowcroft 2012). This reality, it is argued, requires a new research framework that considers the full ensemble of processes and feedbacks for a range of biophysical and social systems. The new framework would allow a better understanding of the dynamic relationship between humans and the ecosystems on which they rely as well as more concerted policy instruments at local, national and supra-national levels (Carpenter et al. 2009). In many countries, efforts have been directed at conserving 'the last of the wild'—those few places, in all the biomes around the Earth, that are less influenced by human activity (Sanderson et al. 2002).

As briefly mentioned in Section 2.2.1, the first attempt to identify resource limitations and their linkages to Earth system dynamics was the book *Limits to Growth* (Meadows et al. 1972). Focusing on five major trends of global concern (accelerating industrialisation, rapid population growth, widespread malnutrition, depletion of non-renewable resources, and a deteriorating environment), Meadows et al. used a systems modelling approach to better understand the causes of these trends, their interrelationships, and their future implications. Their modelling work did not specify limits per se; rather, they analysed 12 scenarios and showed different environmental outcomes of world development from 1900 to 2100. The main conclusion was that exponential expansion of human civilisation could not continue indefinitely. On a finite planet, the scale of the human presence could not increase without end—one day, growth would have to stop (Meadowcroft 2012). Meadows et al. concluded:

> If the present growth trends…continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years [and] It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future

In *Limits to Growth: The 30-Year Update*, Meadows et al. use the same computer modelling approach to simulate 10 future scenarios through the year 2100. Each scenario tests updated parameter estimates and incorporates new predictions about the development of technology to understand what happens if the world choses different policies, ethics, or goals. Some general conclusions emerged from the modelling (Meadows et al. 2015):

- a global transition to a sustainable society is probably possible without reductions in either population or industrial output
- a transition to sustainability will require an active decision to reduce the human ecological footprint

- there are many choices that can be made about numbers of people, living standards, technological investment, and allocations among industrial goods, services, food, and other material needs
- there are many trade-offs between the number of people the earth can sustain and the material level at which each person can be supported
- the longer the world takes to reduce its ecological footprint and move toward sustainability, the lower the population and material standard that will be ultimately supportable
- the higher the targets for population and material standard of living are set, the greater the risk of exceeding and eroding its limits.

Meadows et al. (2015) also identified steps to ensure future sustainable development:

- extend the planning horizon. Base choice among current options much more on their long-term costs and benefits
- improve the signals. Learn more about the real welfare of human population and the real impact on the world ecosystem of human activity
- speed up response time. Look actively for signals that indicate when the environment or society is stressed. Decide in advance what to do if problems appear
- minimise the use of non-renewable resources
- prevent the erosion of renewable resources
- use all resources with maximum efficiency
- slow and eventually stop exponential growth of population and physical capital.

Since the work by Meadows et al. (1972), the concept of limits has played an increasing role in the environmental management discourse. Defining environmental limits is not straightforward, as there are not always biophysical ‘laws’ to define them. Setting environmental limits requires definition of (un)acceptable social and economic impacts arising from environmental degradation, a process for mitigating or reducing drivers/pressures of environmental change and a regulatory framework to address them (UK Parliamentary Office of Science and Technology 2011).

As a system approaches environmental limits, social inequalities become more evident. For example, when urban air quality deteriorates, the poor, in their more vulnerable areas, suffer more health damage than the rich, who usually live in neighbourhoods with better air quality. When mineral resources become depleted, late-comers to the industrialisation process lose the benefits of low-cost supplies (United Nations 1987). While the establishment of environmental limits has at times been based on scientific criteria, risk-based limits are more reflective of political considerations (UK Parliamentary Office of Science and Technology 2011).

The concept of environmental limits can also help us think about how to make trade-offs, including how much degradation society is willing to tolerate or accept as the price of economic and social development, and choices between alternatives that might be beneficial to some sectors while being detrimental to others. In this sense, environmental limits can be defined as the point or range of conditions beyond which the benefits are insufficient to warrant the costs and risks. While to some extent environmental limits may be defined based on the biophysical properties of a natural ecosystem, limits are also defined by the way that people value environmental benefits or ecosystem services. These two perspectives need to be reconciled in decision-making (Defra 2007).

Targets relate to critical loads and thresholds in the natural environment. Those that can only be delivered through government intervention can be 'aspirational' or 'political' (Defra 2007). Targets may be set on a precautionary basis where the aim is to deliver environmental protection, i.e. to prevent or limit degradation of existing environmental quality, or they may be more ambitious in order to achieve environmental improvement. Targets may be attached to particular indicators or ecosystem components, or may be framed as broad over-arching objectives (Defra 2007) and be applied to pressures (e.g. pollutant emissions, resource consumption, waste production, etc.), to elements of quality or state of the environment (e.g. biological quality of water) or to specific impacts (e.g. human health, ecosystem health).

Environmental targets have many attributes. They should be relevant, achievable, effective, socially acceptable and specific as to scale. Concerning scale, targets can be global (e.g. targets on the regulation of the climate system), regional (e.g. targets on the quality and distribution of fresh water); or local (e.g. targets applied to a unique landscape that has cultural significance to the local community) (Bourne & Fenn 2011). A key challenge to environmental managers is therefore how to accommodate these different conceptual frameworks into one workable system.

2.3. Global environmental limits

2.3.1. Planetary Boundaries framework and sustainable development

The concept of PB has become the dominant expression of environmental limits thinking over the last decade (Pickering & Persson 2019). Building on earlier concepts of 'limits to growth' (see Section 2.2.3), 'carrying capacity', 'critical loads', 'tolerable windows', and 'safe minimum standards' (Rockström et al. 2009b), the PB framework extends the idea of Earth's limited capacity to absorb human impacts across multiple environmental domains. In contrast to earlier issue-specific approaches, PB provides a framework for both consolidating knowledge on the global nature of environmental change and analysing the changes occurring across multiple domains and scales of

environmental policy. These ideas have been widely taken up within the scientific community[3] as well as by policy and governance theorists and a range of global policy organisations. For example, Häyhä et al. (2018) note that the PB concept was prominent in the recent development of the Sustainable Development Goals, and that several countries have discussed applying the framework in national policy making (including Germany, Switzerland and Sweden). Through this sustained interest in and development of the framework over the last decade, the PB literature provides some of the most recent and robust debate on the use of limits as a guiding framework for environmental management.

The concept of PB was proposed by scientists from the Stockholm Resilience Centre as a way of conceptualising the 'safe operating space for humanity with respect to the functioning of the Earth System' (Rockström et al. 2009a, p. 2; see also 2009b). They identify nine key processes (and associated control variables and thresholds) that are fundamental to Earth system functioning. For each process, they propose a global boundary level that should not be transgressed if we are to avoid unacceptable environmental change. 'Unacceptable change' is defined in relation to the risks to humanity if the planet shifts outside the relatively stable environmental conditions of the Holocene.

Each process has boundaries that are 'human determined values of the control variable set at a 'safe' distance from a dangerous level (for processes without known thresholds at the continental to global scales) or from its global threshold' (Rockström et al. 2009b p. 3). For some processes, boundaries may be set based on known thresholds—non-linear transitions in Earth system functioning—such as temperature thresholds for sea ice melting. However, many key processes do not exhibit threshold responses at the global scale; rather, local and regional scale changes occurring around the globe are of cumulative concern, particularly insofar as they undermine the wider Earth system's resilience. For these processes, boundaries are based on assessments of functional changes in system processes, feedbacks between processes, and/or the aggregate impacts of smaller-scale changes (Rockström et al. 2009b). Either way, all PB are set well below the identified threshold or dangerous level, creating a buffer zone that 'accounts for uncertainty in the precise position of the threshold with respect to the control variable but also allows society time to react to early warning signs that it may be approaching a threshold and consequent abrupt or risky change' (Steffen et al. 2015b, p. 1–2). As the authors stress, the designation of boundaries and size of buffer zones depend on normative judgements about acceptable levels of change, uncertainty, and risk, and are consequently social as well scientific decisions.

[3] A recent review of the academic literature identified 3,500 papers citing Rockström et al. (2009a,b) that established the concept of PB (Downing et al. 2019).

Quantitative limits have now been developed for seven of the nine Earth system processes identified (Table 1). There is evidence that the boundaries for four of these seven processes have been exceeded (Steffen et al. 2015b). The remaining boundaries (atmospheric aerosol loading and novel entities – i.e. new substances and modified life forms) have not been quantified at the planetary level due to their regional nature, diverse effects, and limited scientific knowledge. In their 2015 update to the PB framework, Steffen et al. proposed sub-global boundaries for five of the Earth system processes (indicated in the 'boundary scale' column of Table 1), reflecting their spatial heterogeneity and regional operating scales.

Table 1. The nine planetary boundaries proposed by Rockström et al. (2009a,b) and updated by Steffen et al. (2015). Boundaries that have been exceeded are indicated in red (processes have exceeded the buffer zone) and yellow (processes remain within the buffer zone), while processes operating within their boundary are in green. Grey colouring indicates boundaries that have not been identified or quantified.

Earth system process	Control variable	Boundary scale	Current state
Climate change	Atmospheric CO_2 concentration; change in radiative forcing	Global	Exceeded boundary (increasing risk)
Stratospheric ozone depletion	Stratospheric O_3 concentration	Global	Below boundary (safe)
Ocean acidification	Aragonite saturation state	Global	Below boundary (safe)
Biosphere integrity	Genetic diversity: Global extinction rate	Global	Exceeded boundary (high risk)
	Functional diversity: Biodiversity Intactness Index	Biome	Boundary not yet quantified
Biogeochemical flows	Nitrogen: human-induced biological N fixation	Global	Exceeded boundaries (high risk)
	Phosphorous: P flow from freshwater into the ocean	Global	
	P flow from fertilisers to erodible soils	Regional	
Land-system change	Percentage of forest cover remaining	Global	Exceeded boundaries (increasing risk)
	Percentage of potential forest cover	Biome	
Freshwater use	Consumptive blue water use	Global	Below boundaries (safe)
	Blue water withdrawal as percentage of mean monthly river flow	Basin	
Atmospheric aerosol loading	Seasonal aerosol optical depth	Regional	Only one region quantified - exceeded
Novel entities	No control variable or boundary currently identified		

Another key development of the PB framework involves the incorporation of basic social needs to delineate the 'safe and just operating space for humanity', also referred to as the Oxfam Doughnut. Raworth (2017a, 2017b) argues that the same global economic system that has been responsible for the observed exceedance of our environmental limits has also contributed to significant inequality, resulting in huge sections of the world's population living without the necessities of life. She therefore argues for a transformation of the global economy that upholds both environmental sustainability and social justice:

> For over 70 years, economics has been fixed on GDP, or national output, as its primary measure of progress. … For the twenty first century, a far bigger goal is needed: meeting the needs of every person within the means of our life-giving planet. And that goal is encapsulated in the idea of the Doughnut. (Raworth 2017a p. 22).

As illustrated in Figure 2, the Doughnut is comprised of two boundaries, between which lies the safe and just operating space for humanity. The inner boundary delineates our social foundation, the minimum standards for human wellbeing as defined by the UN Sustainable Development Goals. The outer boundary identifies the Earth's ecological ceiling, comprising the nine PB that must not be exceeded if Earth is to sustain Holocene-like conditions. The Oxfam Doughnut's key contribution to the PB and environmental limits literature is thus to conceptualise the requirements for human wellbeing alongside those of Earth's ecosystems, and their interconnections. Further, in contrast to the PB framework, which assumes all humanity will benefit from staying within a 'safe' operating space, the Doughnut emphasises the need to attend to how economic systems and associated environmental impacts contribute to (in)justice within and across societies. Accordingly, a growing number of PB publications examine the equity implications of boundary setting in a world of uneven economic development, and countries' resulting responsibility and capability to keep Earth's system within these inner and outer boundaries (see Häyhä et al. 2016; Lucas et al. 2020).

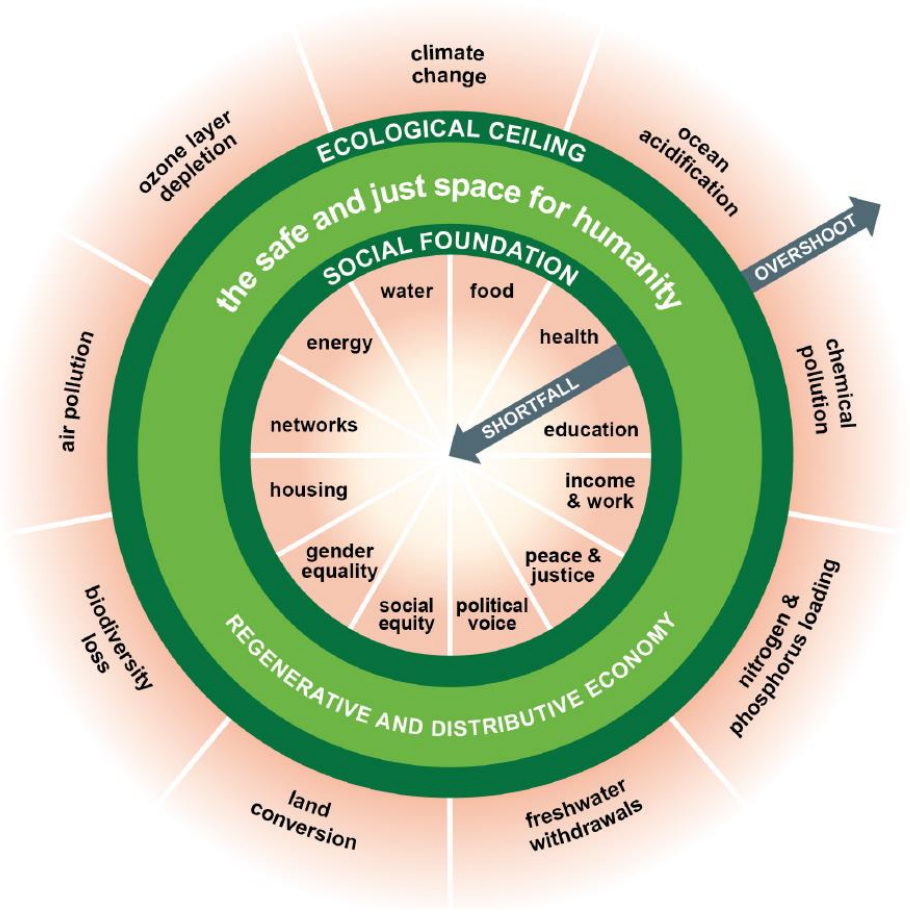

Figure 2. The doughnut of social and planetary boundaries. Source: Raworth (2017b) Supplementary Appendix p. 3.

Building on this increased attention to the societal aspects of PB, researchers have explored the governance and policy implications of global boundary setting. Publications have generally coalesced around two themes: the need for stronger global environmental governance and associated challenges (see for example the special issue by Galaz et al. 2012), and attempts to apply the PB/Doughnut framework at sub-global scales (e.g. Dearing et al. 2014; Cole et al. 2014; Nykvist et al. 2013). While the former theme has only limited relevance to the development of an environmental limits framework for New Zealand, the advances and debates emerging out of research on downscaling provides many relevant insights, as summarised in the next section.

2.3.2. From global to national and regional scale boundaries

A review by Downing et al. (2019) found that 32% of academic references that apply or build upon the PB concept seek to use the framework to evaluate sustainability at sub-global scales. Many of these publications attempt to identify national or regional environmental limits that are consistent with global PB, while a minority also

enumerate the societal minimums consistent with a safe and just operating space (see Table 2). The analyses typically assess the current state of indicators relative to the identified national/regional boundaries and discuss the policy implications of their findings, although with significant variability in the depth of policy insights.

This intense interest in downscaling the PB to sub-global scales and drawing policy insights from the framework is noteworthy given that the framework was not developed for this purpose. Indeed, the framework's creators state that 'the PB framework is not designed to be 'downscaled' or 'disaggregated' to smaller levels, such as nations or local communities' (Steffen et al. 2015b, p. 8). They

> emphasize that our subglobal-level focus is based on the necessity to consider this level to understand the functioning of the Earth system as a whole. The PB framework is therefore meant to complement, not replace or supersede, efforts to address local and regional environmental issues (ibid, p. 3).

Nevertheless, researchers and governments continue to use the planetary boundaries framework to evaluate and guide sub-global sustainability, arguing that

> although the PBs framework was not designed to be 'downscaled' or 'disaggregated' to smaller levels (Steffen et al. 2015), decisions regarding environmental management and resource use are not made on a planetary scale. Therefore, to enable the framework to guide environmental policy-making, its global biophysical information needs to be translated into measures related to human activities at the national level (Lucas et al. 2020, p. 2, see also Häyhä et al. 2016; Dao et al. 2018).

Table 2. Sub-global applications of the planetary boundaries or 'safe and just operating space' frameworks.

Citation	Case study	Domains included		Methodology
Nykvist et al. (2013)	Sweden	Climate change Nitrogen cycle Land use Freshwater use Stratospheric ozone depletion Biodiversity loss Phosphorus cycle		• Attempts to downscale the planetary boundaries framework as close to original definitions as possible • Perform a simple translation of the planetary boundaries to quantified national boundaries and indicators for four domains: climate change, nitrogen, land, and water • Suggest relevant alternative indicators that could be used to compare relative national performance for the remaining domains
Cole et al. (2014)	South Africa	Environmental: Climate change Ozone depletion Freshwater use Arable land use Nutrient cycle Biodiversity loss Marine harvesting Air pollution	Social: Electricity access Water access Sanitation Housing Education Health care Jobs Income Household goods Food security Safety	• Developed a decision-making methodology to select nationally-relevant dimensions, indicators and boundaries • Data for each indicator were taken from databases, reports, and academic papers, supplemented by expert judgement • Boundaries were determined based on policy commitments, scientific data and expert judgement • No direct comparison with global boundaries
Dearing et al. (2014)	Two regions in China: Shucheng County (Anhui Province), Erhai lake-catchment (Yunnan Province)	Environmental: Sediment regulation Upland soil stability Sediment quality Water quality Air quality Water regulation	Social: Energy Income Water & sanitation Jobs Food security Education Health care	• Extracts environmental time series data from monitoring records and lake sediment proxy records. Extracts social data from government social statistics • Boundaries and current status relative to boundaries were determined via time series analysis, informed by complex systems theory
Hoff et al. (2014)	European Union	Materials Climate Water Land Biodiversity loss Biogeochemical cycles: Nitrogen & Phosphorus		• Uses environmental footprints • For the six domains listed, examines consumption-based footprint indicators, and compares these with production-based indicators • Consumption is reported per capita to examine countries' relative contribution to global environmental issues • Comments on the availability of information and potential indicators for other planetary boundary domains

Citation	Case study	Domains included	Methodology
Fang et al. (2015)	28 countries	Carbon emissions Water use Land use	• Converts planetary boundaries to global footprints • Allocates footprint boundaries to countries • Calculates current national footprints • Calculates ratio of current footprints to footprint boundaries
Dao et al. (2018)	Switzerland	Climate change Ocean acidification Land cover anthropisation Biodiversity loss Nitrogen and Phosphorus losses	• Proposes transformations from state to pressure indicators i.e. 'activity/input limits' • Uses footprints • Uses a consumption-based methodology • Uses own dataset (vs global dataset)
Häyhä et al. (2018)	European Union	Climate change Biosphere integrity Land system change Freshwater use Biogeochemical flows (nitrogen & phosphorus) Novel entities (chemical pollution)	• Boundaries are downscaled based on an equal per capita allocation, consistent with the control variables suggested by Steffen et al. (2015) • Analyses consumption and production-based footprints for the European Union, and compares them with global average as well as planetary boundary
Lucas et al. (2020)	United States, European Union, China, India	Climate change Biogeochemical flows Biodiversity loss Land use change	• Compares three allocation approaches, each underpinned by a different principle of fairness: grandfathering, equal per capita, and ability to pay

As demonstrated in Table 2, sub-global applications vary widely in terms of their scale of analysis, the domains for which limits and targets are identified, and their methodology. Much of this variability reflects differences in their prioritisation of local *versus* global socio-ecological system definitions. While most analyses use or refine the global scale boundaries proposed by Rockström et al. (2009) and attempt to allocate these boundaries to sub-global scales (top-down approaches), several applications define boundaries and targets locally, while recognising their global significance (bottom-up approaches).

Top-down approaches typically attempt to allocate the global boundaries stated in Rockström et al. (2009a,b) or Steffen et al. (2015) across countries, in order to define specific country/ies' national environmental boundaries and compare them with existing levels of resource use or impacts (see Nykvist et al. 2013; Hoff et al. 2014; Fang et al. 2015; Häyhä et al. 2018; Lucas et al. 2020). These applications attempt to follow the PB framework as closely as possible, including the definition of boundaries, scales, and control variables. Consequently, they all only include a subset of the PB in their analyses,[4] due to the lack of definition of some global boundaries and unavailability of national-scale data for others. Similarly, the analyses note the limitations of current definitions and control variables for the biodiversity and freshwater boundaries, such that assessments of countries' current status with respect to these boundaries is indicative only.

Three key methodological quandaries for top-down approaches to downscaling recur across these studies. First, they note that the allocation of PB to countries has important equity considerations, given that countries vary significantly in their contribution to existing environmental issues, capability to address global environmental issues, and level of socio-economic development. Thus, while most studies default to allocating global boundaries on an equal *per capita* basis, Lucas et al. (2020) explore the implications of allocating according to three principles of fairness (sovereignty, equality, capability) for developed *versus* developing countries, as well as ramifications for intergenerational equity. Their analysis highlights that both the selection and parameterisation of allocation approaches results in very different levels of exceedance across economies and boundaries.

Second, and relatedly, the analyses highlight that quantification of a country's environmental impact varies considerably depending on whether impacts are defined as those resulting from the production or consumption of goods and services. Most analyses examine developed nations where a large proportion of goods and services are imported from other countries; they therefore focus on consumption-based measures of environmental impact to capture the impacts a country generates outside of national boundaries (e.g. Hoff et al. 2014). However, many analyses (e.g. Dao et al. 2018; Häyhä et al. 2018) examine impacts associated with both production

[4] Climate change and land use are the only boundaries included in all of the top-down studies.

and consumption; while consumption provides a better representation of a country's contribution to global changes, production-based analyses reflect the pressures and impacts on sub-global environmental systems.

Third, the analyses have all struggled with the question of how to quantify national resource use or environmental impacts in a way that enables comparison with the global boundaries. As Nykvist et al. (2013) note, there is a lot of variability in the way boundaries have been defined and therefore calculated, with some representing environmental states (e.g. atmospheric CO_2 concentration) while others describe environmental pressures (e.g. freshwater use) or impacts (e.g. biodiversity—global extinction rate). Most of the studies use environmental footprints to report on countries' environmental performance, where footprints quantify the pressures (cf. environmental states or impacts) generated by a country. Footprint analyses therefore do not allow a direct comparison with all boundaries, and some re-calculation of boundaries is required. For example, Fang et al. (2015) converted the PB to global footprints for climate, water, and land, while Dao et al. (2018) transformed the 'state' boundaries to 'pressure' indicators. Such transformations require a strong scientific understanding of the relationship between environmental pressures and states, which is complicated by spatial heterogeneity (Nykvist et al. 2013) and temporal lags (Fang et al. 2015b) in environmental processes.

Two of the applications took an alternative approach. Instead of assessing the commensurability of sub-global environmental impacts and the PB, Cole et al. (2014) and Dearing et al. (2014) focus on locally-relevant environmental impacts and boundaries. These bottom-up approaches use the PB framework to identify the main global environmental processes of concern, but modify boundary definitions in line with local environmental systems and priorities.

For example, Cole et al. (2014) provide a decision-making methodology to guide the selection of environmental and social dimensions, indicators, and boundaries based on national concerns and data availability. Based on this methodology, they substitute two nationally significant dimensions for those proposed by Rockström et al. (2009a,b)[5] and adjust all the remaining indicators and boundaries to align with national circumstances. Rather than focusing on the contribution of national environmental impacts to global boundaries, Cole et al. (2014) examine current indicators relative to national boundaries drawn from policy commitments and local environmental knowledge.

The analysis by Dearing et al. (2014) was similarly driven by regionally significant environmental issues and data availability, but without explicit selection criteria. Instead, Dearing et al. identified regional threshold effects (i.e. boundaries) through

[5] Ocean acidification is replaced with marine harvesting, and aerosol loading is replaced by air pollution.

time series analysis of monitoring and proxy data, which in turn determined the range of indicators and boundaries included in the study.

Both studies also grounded their approach in the socio-economic issues experienced in their jurisdiction, using socio-economic data alongside environmental indicators to describe incursions on the national/regional 'safe and just operating space'. The two studies reported on broadly similar social and economic dimensions, owing perhaps to reporting requirements from the UN Millennium Development Goals. Inclusion of social indicators allowed the authors to highlight the environmental justice dimensions of national/regional boundary exceedances, and more generally the interlinkages across social and environmental issues (including some shared drivers). The studies argue that their focus on nationally/regionally defined social and environmental boundaries provides greater policy relevance, while still promoting analysis of their jurisdiction's contribution to global environmental processes through the aggregation of sub-global changes. These bottom-up approaches consequently provide more relevant insights for environmental limit setting in New Zealand, where policies will need to prevent exceedance of local, national, and global-scale boundaries.

2.4. Operationalising environmental limits and targets

2.4.1. Limits and targets in practice

In this section, we discuss how limits and targets have been operationalised in environmental management generally and the issues and challenges associated with operationalisation of limits. In environmental systems, the consequences of exceeding a limit are often better understood than the mechanisms leading to that exceedance. When identifying values for limits, consideration needs to be given to the potential impact(s) of its exceedance and therefore the vulnerability or sensitivity of the system *versus* its resilience. In this regard, vulnerability is a measure of the potential for the environmental system to respond to change.

Linked to the concept of vulnerability is the idea of risk as the limit is approached (Bertrand et al. 2008). Resilience of an ecosystem is much more difficult to quantify because it requires measuring the thresholds or boundaries between the different Earth system domains (Carpenter et al. 2005). The main difficulty in this respect is the lack of evidence on thresholds of change. Walker and Meyers (2004) analysed a database of 14 socio-ecological system descriptors, containing information on variables along which they occur, the variables that changed, and the factors that drove the change. The examples in the database ranged from conceptual models and empirical evidence. Of the 64 examples listed in the database, the authors found that 24 had undergone irreversible regime shift, 32 a reversible shift, and 8 showed a

hysteresis[6] effect. They also found that threshold changes on a large scale (e.g. reversal of ocean currents) are more difficult to measure and that most of the regime shifts were small, i.e. at the local scale, and that the number of examples reduces as the scale becomes larger.

Usually, there are strong differences in the values ascribed to limits, both within and between regions, and these differences may influence the marginal costs and benefits associated with a change in indicator value for which a limit has been set (Bertrand et al. 2008). The dynamic nature and complexity of environmental systems also means that limits are often difficult to quantify. In many cases, it is only possible to identify levels of vulnerability for species or habitats as data may not be available and cumulative impacts may not be fully understood (Davies 2019). The gaps in knowledge that exist today cannot be addressed through uncoordinated studies of individual components by isolated traditional disciplines. Where there is any uncertainty over the accuracy of an environmental limit, the precautionary principle must be applied, i.e. action should be taken to ensure that human activity operates well below the limit where there is a risk that breaching the limit will bear unknown consequences.

Until recently, environmental managers have mainly incorporated limits and targets into permitting, planning or other regulatory decisions in a retrospective way, i.e. after the limit is crossed and its existence becomes relevant to policy. This may occur because a legal mandate is triggered only after a limit is crossed. A typical example of this is overfishing of managed fish stocks (Botsford et al. 1997; Murawski 2000; Rosenberg 2003). This retrospective form of limit and target setting remains an important management option in cases where ecosystem change is reversible.

Concerning the social dimension of targets, this originates from a compromise of perspectives and visions from policy makers and stakeholders, which are, in turn, based on the knowledge of the effects that are anticipated to occur as a result of the implementation of the targets (see Pickering & Persson 2019). When target setting is applied to simple environmental systems, i.e. those that can be described with low degree of uncertainty, the definition of a target (or limit) is often simple. In contrast, the process of target setting for complex systems, i.e. a sector of the economy with complex underlying drivers and high level of uncertainty, requires consideration of a range of stakeholder perspectives and values (see Cole et al. 2014). The values that people may identify in relation to environmental systems can be socio-cultural (e.g. philosophical, religious, equity, justice considerations), economic (monetary value that people attribute to different functions) and ecological (e.g. diversity, integrity of the ecosystem).

[6] In the context of ecological theory, hysteresis occurs when the return path between two ecological states can be different from the outgoing path.

Because of the difficulties in achieving a holistic and comprehensive view of all the relevant environmental and socio-economic dimensions, the process of limit and target setting can be constrained by:

- complex relationships between targets in different environmental domains
- agreement between different targets set at different scales
- scale of potential and actual effects of the target on the environmental system
- stakeholders' acceptance of targets (social license)
- stakeholders' acceptance of an 'evidence-based' target.

Some critics do not accept that crossing environmental thresholds will impact wellbeing and dispute the need for environmental limits. They argue that the benefits from continued economic growth will be used by future generations to reverse impacts on ecosystems or to substitute technology for goods and services arising from ecosystems (UK Parliamentary Office of Science and Technology 2011). However, others would argue that political decisions need to be made now to regulate the interaction of economic systems and natural resource use to avoid human wellbeing being significantly impacted (UK Parliamentary Office of Science and Technology 2011).

The Earth system is dynamic and complex. Yet, our scientific understanding of its processes and limits has increased markedly (NAP 2010). There is urgency in developing a framework that enables us to live within the planet's environmental limits. Meyer and Newman (2020) propose a multi-scale approach that integrates different scales, sectors, and timeframes. They propose an approach implemented through governance, privatisation, or self-organised management and coordinated by a general system of rules with different mechanisms at different centres of activity.

2.4.2. Using mātauranga Māori to inform limits and targets

Increasingly, indigenous knowledge is being recognised worldwide as a means to enhance understanding of our environment, to help find solutions to complex problems, and to provide a basis for strengthening cultural identity (Harmsworth and Awatere 2013). Examples where indigenous knowledge is informing environmental management, including setting limits and targets, include: the integration of indigenous Sahelian knowledge into climate change mitigation and adaptation strategies in the African Sahel (Nyong et al. 2007); spiritual practices of the Naxi people from the northeast of China, whose systems of beliefs and taboos lead to land use rules, such as 'no logging of trees around the ground for ritual ceremony, at water source area, and in the graveyard' (Mu-Xiuping & Kissya 2010); resource use rules of the Kankana-ey Igorot peoples in the Philippines including the concept of *innayan*, which means 'do not do it' based on the principle of *gawis ay biag*, which means good life (Tauli-Corpuz 2010); and, the establishment of harvest regulations for nontimber

forest products (i.e. medicinal fruit) by the Soliga communities of South India based on indigenous monitoring (Setty et al. 2008).

Using both indigenous knowledge (e.g. mātauranga Māori) and science to inform environmental management provides complementarity of two knowledge systems, which can enrich collective ecological knowledge and action (Moller et al. 2004; Ban et al. 2018). Alongside the global trend of recognising indigenous knowledge as a valuable constituent to inform environmental limits and targets is the national need to recognise Te Tiriti o Waitangi (Treaty of Waitangi) obligations. This will ensure Māori values, principles and practices are part of the picture when setting limits and targets.

Through the signing of the Treaty in 1840, Māori have been entitled to exclusive and undisturbed possession of 'their lands and estates, forests, fisheries and other properties' and in the Māori text, the guarantee of 'te tino rangatiratanga o rātou taonga katoa'—translated as Māori authority and control over all treasured things (Orange 2011; Waitangi Tribunal 2011). Further, through legislation such as the RMA 1991, Māori are regarded as decision-making partners.

There has been a history of Treaty breaches, grievances and redress which has affected the ability of Māori to fulfil their environmental management aspirations. Following Waitangi Tribunal settlements (post 1989), the elevated capacity, organising potential and levels of autonomy of iwi/hapū to manage environmental resources has become evident in the establishment of cultural practises regarding limit and target setting. However, many of the examples of cultural limits and targets (as outlined further in Section 4.3.2) are non-regulatory and reflect a lack of inclusion of kawa[7] and tikanga into formal legislation.

Māori regard for the environment is connected to cultural identity and the maintenance of Māori ideals, beliefs and way of life (Durie 2003). Cultural practices are key to fostering cultural identity and are based on principles such as kaitiakitanga, whakapapa, and rangatiratanga. At the heart of Māori principles and practices is te ao Māori, a holistic view of the world, acknowledging the interconnectedness and interrelationship of all living and non-living things, and the Māori place in it (Marsden 2003).

In accordance with key principles, the operationalisation of Māori environmental limits and targets is a place-based exercise. It reflects an inherent knowledge of the natural environmental gained by living in and being part of that environment for hundreds of years (i.e. whakapapa). It further reflects a right and responsiblity to care for the environment (i.e. rangatiratanga, kaitiakitaga) to ensure sustainability for future generations. Specific cultural practices 'operationalise' these principles.

[7] Kawa is the policy and tikanga are the procedures on how the policy is realised. To put it simply, kawa is what we do, tikanga is how we do it.

2.4.3. Summary of lessons learned

Human population growth combined with accelerated economic activities have exerted substantial impacts on the structure and functioning of Earth system processes. There is a large amount of scientific evidence indicating that these impacts, if continued, could have serious consequences for sustainable development, human wellbeing and resilience of the processes themselves. This prompts the question of whether these pressures are approaching or exceeding Earth's environmental limits.

The concept of environmental limits plays a central role in the environmental management philosophy worldwide. Environmental limits are embedded in many regulations that prohibit certain activities, set standards for discharges, allocate resources, or designate protected areas at local, national and supra-national levels. However, jurisdictions on how limits are set, implemented, and enforced vary widely between countries.

Environmental limits have also informed our thinking on the dynamic relationships between humans and the ecosystems on which they rely. They help define how much degradation society is willing to tolerate or accept as the price of economic and social development, and the choices between alternatives that might be beneficial to some sectors while being detrimental to others. Ideally, environmental limits must not be defined based solely on natural system dynamics and scientific analysis. Consideration needs also to be given to a normative assessment of acceptable levels of system change. In this regard, limits are not commonly set at the level at which conditions become unacceptable, but rather at a safe distance from this level, following the precautionary principle.

Aligned with the concept of environmental limits is the concept of environmental targets which are aspirational statements about the desired state of an environmental system and its outcomes for people. Environmental targets have been used to specify broader environmental goals or objectives, set short-term markers of progress towards longer-term goals, or identify the improvements required to stay within or return to the 'safe operating space' defined by environmental limits.

Environmental targets may be set on a precautionary basis where the aim is to prevent or limit degradation of existing environmental quality, or they may be more ambitious in order to achieve environmental improvement. Targets may be attached to particular indicators or ecosystem components, or may be framed as broad over-arching objectives and be applied to specific environmental pressures (e.g. pollutant emissions, resource consumption, waste production, etc.), to elements of quality or state of the environment (e.g. biological quality of water) or to specific impacts (e.g. human health, ecosystem health). Important attributes of environmental targets are their relevance, achievability, effectiveness, social acceptance and specificity.

Our review of the international practice of limit and target setting suggests that the consequences of exceeding a limit are often better understood than the processes leading to that exceedance. Another difficulty faced by environmental managers is the lack of scientific evidence on thresholds of change. In many cases, it is only possible to identify levels of vulnerability for certain species or habitats, but significant information gaps prevent full quantification of cumulative impacts. In cases of reversible ecosystem change, environmental managers have commonly incorporated limits and targets into regulatory decisions retrospectively.

From our review, it is also apparent that the process of limit and target setting can be constrained by a number of factors, including the complexity associated with different targets set for different environmental domains, agreement between different targets set at different scales, the spatial and temporal scales of potential and actual effects of the target on the environmental system and social license considerations.

Over the last decade, the PB framework has dominated the debate on environmental management and attracted increasing interest from many governments and international organisations. It applies the idea of Earth's limited capacity to absorb human impacts across multiple environmental domains and specifies a 'safe operating space' for humanity. The PB theory provides a holistic framework for both consolidating knowledge on the global nature of environmental change and analysing the changes occurring across multiple domains and scales (global, regional, biome) of environmental policy.

Efforts to downscale the PB framework to the national or regional scale suggest the following lessons for the development of just and sustainable environmental limits:

1. Large scale socio-economic change will be required to keep human impacts on environmental systems within national and planetary limits. All of the PB analyses reviewed—whether global, national, or regional in scale—reported the transgression of one or more environmental boundaries. These findings suggest that existing efforts to manage and mitigate environmental impacts are not sufficient to prevent the disruption of key Earth system processes that are essential to maintaining our current Holocene conditions (see also Meadowcroft 2013; Raworth 2017a). Analyses by Cole et al. (2014) and Dearing et al. (2014) also highlight that basic human needs are not being met under current political and economic systems, and that significant disparity in access to necessities exists both within and across jurisdictions. Given existing transgressions of Earth's ecological ceiling and social foundations, significant changes to prevailing socio-economic systems will be required to reduce and reverse impacts on earth systems, and thus maintain humanity's 'safe and just operating space' (Raworth 2017a; Hickel 2019). Any rigorous environmental limits framework must therefore recognise the scale of changes it will need to institute to protect local to global socio-ecological systems.

2. The planetary boundaries framework identifies and enumerates nine key Earth system processes that should be considered in sub-global limit setting processes (see Steffen et al. 2015b). Rather than simply focusing on a jurisdiction's prominent environmental issues at present, the PB framework encourages policy makers to situate local interventions within larger scale and longer-term changes in environmental systems. The framework provides domains, indicators, boundaries, and current transgressions that can inform national scale limit setting processes. However, Dao et al. (2018) caution that the framework only includes globally important issues, and even then it does not include all such issues, citing plastic pollution as a current omission (see also Villarrubia-Gomez et al. 2018). The national decision-making methodology proposed by Cole et al. (2014) provides one possible approach to reviewing and revising the planetary boundaries framework to identify nationally-relevant (while globally informed) environmental limits.
3. Relatedly, the PB framework provides an important reminder of the socio-economic and environmental interconnections between national and global scales. As highlighted by consumption-based footprint analyses, a significant proportion of developed countries' environmental impacts are likely to occur outside of their territory through international trade. Instituting strong environmental limits within a country could (and has) resulted in the displacement of high impact activities overseas, resulting in a redistribution rather than a reduction in environmental pressures (Nykvist et al. 2013). Similarly, transcontinental environmental connections (e.g. animal migrations, oceanic and atmospheric circulation) may mean that the impacts of activities within a country are expressed elsewhere. National scale environmental limit and target setting processes should therefore attempt to account for the external environmental impacts of both the production and consumption of goods and services within the country. While multiple methodologies for analysis of internal versus external impacts (e.g. environmental footprints) exist, to date the primary mechanism for limiting external impacts has been through issue-specific international agreements. Some countries have attempted to incorporate their international commitments into national environmental policies, such as Sweden's 16th national environmental objective 'to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders' (see Nykvist et al. 2013).
4. Efforts to refine and apply the PB framework show that environmental limit and target setting will necessarily take different forms across different domains. Rockström et al. (2009b) stated from the beginning that while some Earth system processes are truly global, such as climate change and ocean acidification, others operate at regional scales but cumulatively have global effects (e.g. biodiversity loss). Further, while some processes demonstrate threshold effects at local or global scales, providing clear guidance for limit setting, others exhibit more

incremental or complex responses to increasing pressures (see Dearing et al. 2014; Steffen et al. 2015b). And while available scientific knowledge and data have enabled some boundaries to be defined in terms of environmental states (e.g. we need to avoid surpassing a particular chemical concentration), in other cases it has made more sense to define boundaries in terms of environmental pressures or impacts (see Nykvist et al. 2013). A lack of knowledge and data has resulted in simplistic indicators (e.g. freshwater use) for some boundaries, and none so far for others (e.g. novel entities). This variability in boundary and indicator types across different domains underscores that any environmental limits framework will need to evaluate the appropriate scale, indicator type, and limit type for each environmental domain, based on existing scientific knowledge, available data, and socio-ecological priorities. Ongoing research on specific planetary boundaries—e.g. fresh water (Gleeson et al. 2020), biodiversity (Mace et al. 2014), chemical pollution (e.g. Persson et al. 2013)—may be useful in informing country-specific assessments of appropriate indicators and limits for these domains.

5. Raworth's (2017a) concept of the safe and just operating space and subsequent applications (e.g. Cole et al. 2014;, Dearing et al. 2014; Hickel 2019) have reinforced the importance of integrating social considerations into environmental limit-setting. The Doughnut model highlights the interconnections between social and environmental issues and need to secure basic human needs while pursuing environmental sustainability. Kahiluoto et al.'s (2014) analysis for example highlights potential trade-offs between reducing nitrogen and phosphorus flows to stay within PB, and maintaining the food supply and dietary requirements of particular populations. It is therefore important to critically evaluate the socio-ecological consequences of environmental limits and modes of implementation so that policy measures seek to address, or at least do not add to, existing social and environmental injustice.
6. Further, research on the sub-global allocation of PB reveals that the choice of allocation methods for downscaling has important equity implications. Similarly, the downscaling of responsibility for meeting national limits to regional or local levels must consider historical responsibility for current environmental issues and the unequal capacity of different communities to reduce human impacts. Lucas et al. (2020) suggest one way of critically examining the distributional consequences of methodological choices, by testing allocation scenarios based on different fairness principles. Planetary boundaries and environmental limits are inherently socio-political as well as scientific decisions, involving human judgement regarding acceptable levels of risk (Rockström et al. 2009b). The PB literature therefore highlights the need for environmental limit frameworks to integrate opportunities for democratic input into limit setting and policy making processes (see Häyhä et al. 2016; Pickering & Persson 2019).
7. Finally, the PB framework offers some insights into the policy relevance of environmental limit frameworks. Most of the national or regional scale applications

argued for downscaling as a mechanism to increase the policy relevance of boundary setting (see Nykvist et al. 2013; Cole et al. 2014; Dao et al. 2018; Häyhä et al. 2018). However, the authors note that even at the national scale, the current state and boundaries identified remain too high level to provide clear policy guidance. Cole et al. (2014 p. E4405) conclude that

> indicators are limited and can oversimplify complexities, making them better suited to conveying broad messages and encouraging discourse. Indeed, a criticism of the barometer from some experts was that it hides the complexity of the local scale (i.e., the geography of social deprivation and environmental stress)... Specific subnational analysis is needed to investigate if and how national thresholds could be determined that incorporate and do not mask this heterogeneity.

These findings suggest that national-scale limits and targets can be important policy communication and prioritisation tools, but will need to be supported by local/biome assessments if they are to provide direction for specific policy interventions. National-scale applications also indicate opportunities to increase the policy relevance of limit setting approaches by working with a country's regulatory framework from the outset. For example, Nykvist et al. (2013) used their PB assessment to examine Sweden's progress on meeting its national environmental objectives, as well as its capacity to meet those objectives (further detail on these objectives is in Section 3.2). Its finding that Sweden has a limited capacity to meet air quality, climate change and other objectives due to global environmental pressures suggested the country redirect its policy efforts towards international agreements. Nykvist et al. (2013) also used the PB framework to critically examine its existing regulatory framework. By examining whether existing regulations would keep the country within its downscaled environmental boundary, and whether they were currently within that boundary, they identified that current implementation of regulations—rather than the strength of regulations—was lacking. Finally, analyses such as Cole et al. (2014) demonstrate opportunities to integrate existing regulations into an environmental limits framework by setting national-scale limits based on the policy commitments contained within international environmental agreements.

3. INTERNATIONAL FRAMEWORKS AND POLICIES FOR IMPLEMENTING LIMITS AND TARGETS

3.1. Section overview

In this section, we present the findings of our scan of international frameworks and practices for implementing limits and targets. Specifically, we present information on the legislative framework, governance structure, implementation, and outcomes for nine international case studies. The main features of these case studies are summarised in Table 3. The case studies were selected to represent a range of environmental subject areas and limit and target setting approaches to provide perspectives on the use of limits and targets frameworks around the world.

Firstly, we present findings for three comprehensive policy frameworks, i.e. frameworks that have instituted a limit or objective-based approach to environmental management across multiple policy realms. We then present information on six approaches to limit, objective, or standard setting for a specific realm of environmental management.

3.2. Swedish Environmental Code

The Swedish Environmental Code (the Code) entered into force on 1 January 1999 and consolidates provisions from 15 Swedish statutes and relevant pieces of European Union (EU) legislation (Karlson & Kuznetsova 2007). The aims of the Code are to ensure environmental protection and promote sustainable development and give environmental courts both civil and administrative jurisdiction and a range of enforcement powers (Bjällås 2010). This framework law contains provisions on the management of land and water, nature conservation, protection of flora and fauna, environmentally hazardous activities and health protection, water operations, genetic engineering, chemical products, biotechnology, and waste management, among others. The law sets out procedures, supervision, sanctions, compensation and environmental damages in relation to these matters (Government Office of Sweden 2000).

Table 3. Summary of international case studies of environmental limit and target-based approaches that were reviewed.

	Subject area	Case study	Key features
Comprehensive frameworks	Holistic	Swedish Environmental Code	• 16 non-binding environmental quality objectives • Long-term generational objectives • Milestone targets to define changes needed to meet objectives • Environmental quality standards (for air, water, and noise)
	Holistic	UK Environment Plan & Bill	• Ten 25-year goals • Environmental targets • Actions for six action areas • Bill requires legally binding targets for four priority areas (air, waste & resource efficiency, water, biodiversity)
	Holistic	European Union 7th Environment Action Programme	• Nine priority objectives for 2013–2020 • Strategies for achieving objectives • Legally binding, must be implemented by member states • Lack specific, measurable limits or targets
Subject area case studies	Freshwater	USA Clean Water Act (Chesapeake Bay)	• Ambient water quality standards • Total Maximum Daily Load for each pollutant of concern
	Marine/coastal	Great Barrier Reef water quality protection/ improvement plans	• Qualitative reef objectives • Quantitative water quality & land/catchment management targets • Long term sustainability planning • Best management practice programs
	Air	European Union vehicle emission limits	• EU ambient air quality standards • EU vehicle emissions standards • Member States create low emission zones in polluted cities and regions
Subject area case studies	Biodiversity	National biodiversity strategies and action plans (Canada, European Union)	• High-level goals • Measurable 2020 biodiversity targets • Action plans to meet targets
	Land use	USA soil conservation and farmland protection programmes	• Tax concessions for agricultural land use • Agricultural protection zoning • Purchase of development rights – perpetual easements
	Built environment	Vancouver's Greenest City 2020 Action Plan	• Ten goals (+1 in 2015 update) • 15 SMART targets (+7 in update) • 125 priority actions (+50 in update) • Combines environmental and social wellbeing targets

The Code applies in principle to all human activities that may affect the environment and human health. Independently of the Code, the Swedish Parliament adopted national environmental quality objectives which align closely with the generic objectives of the Code. These are:

- Environmental quality: these non-binding qualitative objectives provide the policy drivers for government agencies and other organisations to apply the environmental legislation. There are 16 environmental quality objectives which describe environmental states that are a pre-condition for sustainable development (Table 4).
- Generational: these long-term objectives guide environmental action at all levels in society, including the shorter-term the environmental quality objectives. The generational objectives focus on the recovery of ecosystems, conservation of biodiversity and the natural and cultural environment, protection of human health, production of materials free from dangerous substances, sustainable use of natural resources, efficient use of energy, and sustainable consumption patterns (Swedish Environmental Protection Agency 2018).
- Milestone: these targets define the changes in society required to achieve the generational and the environmental quality objectives (Swedish Environmental Protection Agency 2018).

Table 4. Summary of Sweden's environmental quality objectives. Source: Swedish Environmental Protection Agency (2018).

Environmental objective	Environmental statement
Reduced climate impact	In accordance with the UN Framework Convention on Climate Change, concentrations of greenhouse gases in the atmosphere must be stabilised at a level that will prevent dangerous anthropogenic interference with the climate system. This goal must be achieved in such a way and at such a pace that biological diversity is preserved, food production is assured, and other goals of sustainable development are not jeopardised. Sweden, together with other countries, must assume responsibility for achieving this global objective.
Clean air	The air must be clean enough not to represent a risk to human health or to animals, plants or cultural assets.
Natural acidification only	The acidifying effects of deposition and land use must not exceed the limits that can be tolerated by soil and water. In addition, deposition of acidifying substances must not increase the rate of corrosion of technical materials located in the ground, water main systems, archaeological objects and rock carvings.
A non-toxic environment	The occurrence of man-made or extracted substances in the environment must not represent a threat to human health or biological diversity. Concentrations of non-naturally occurring substances will be close to zero and their impacts on human health and on ecosystems will be negligible. Concentrations of naturally occurring substances will be close to background levels.
A protective ozone layer	The ozone layer must be replenished to provide long-term protection against harmful UV radiation.
A safe radiation environment	Human health and biological diversity must be protected against the harmful effects of radiation.
Zero eutrophication	Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water.
Flourishing lakes and streams	Lakes and watercourses must be ecologically sustainable, and their variety of habitats must be preserved. Natural productive capacity, biological diversity, cultural heritage assets and the ecological and water-conserving function of the landscape must be preserved, at the same time as recreational assets are safeguarded.
Good quality groundwater	Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses.
A balanced marine environment, flourishing coastal areas and archipelagos	The North Sea and the Baltic Sea must have a sustainable productive capacity, and biological diversity must be preserved. Coasts and archipelagos must be characterised by a high degree of biological diversity and a wealth of recreational, natural and cultural assets. Industry, recreation and other utilisation of the seas, coasts and archipelagos must be compatible with the promotion of sustainable development. Particularly valuable areas must be protected against encroachment and other disturbance.
Thriving wetlands	The ecological and water-conserving function of wetlands in the landscape must be maintained and valuable wetlands preserved for the future.

Environmental objective	Environmental statement
Sustainable forests	The value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded.
A varied agricultural landscape	The value of the farmed landscape and agricultural land for biological production and food production must be protected, at the same time as biological diversity and cultural heritage assets are preserved and strengthened.
A magnificent mountain landscape	The pristine character of the mountain environment must be largely preserved, in terms of biological diversity, recreational value, and natural and cultural assets. Activities in mountain areas must respect these values and assets, with a view to promoting sustainable development. Particularly valuable areas must be protected from encroachment and other disturbance.
A good built environment	Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to a good regional and global environment. Natural and cultural assets must be protected and developed. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way as to promote sustainable management of land, water and other resources.
A rich diversity of plant and animal life	Biological diversity must be preserved and used sustainably for the benefit of present and future generations. Species habitats and ecosystems and their functions and processes must be safeguarded. Species must be able to survive in long-term viable populations with sufficient genetic variation. Finally, people must have access to a good natural and cultural environment rich in biological diversity, as a basis for health, quality of life and wellbeing.

The Code also has several fundamental principles:

- Burden of proof: the party who pursues an activity must prove that the obligations arising out of the Code are complied with.
- Proportionality: the general rules of consideration apply as long as they are not unreasonable. The application of the general rules of consideration should be environmentally justifiable and financially reasonable in each case.
- Precautionary: anyone who pursues an activity should take all necessary environmental precautions in order to limit the impact on human health and the environment. Such precautions may, for example, involve limiting the scale of operations or applying the best possible technique.
- Knowledge requirement: everyone who intends to undertake an activity must obtain the knowledge necessary to protect human health and the environment against damage or detriment.
- Appropriate location: the activity must be undertaken in a suitable location with respect to the purpose of the activity and achieved with minimal damage, detriment or nuisance to the environment and human health.

- Product choice: operators must refrain from the use or sale of chemical products that could involve hazards to human health or the environment if other less dangerous products can be used instead.
- Polluter pays: anyone who undertakes an activity that could have an impact on human health or the environment is responsible for complying with the provisions concerning remediation set out in the Code and to pay any resulting expenses.
- Reuse and recycling: an activity must be carried out in a way that ensures the efficient use of raw materials and energy and minimises waste generation.
- Stopping rule: this rule applies to all activities under the Code and stipulates that any activity that is considered to be detrimental to the environment or human health may only be undertaken if the Government deems that special circumstances apply. Furthermore, an activity must not be undertaken if it is likely to considerably deteriorate the living conditions of a large number of people or the environment.

The Swedish government issues Environmental Quality Standards (EQS) to address actual or perceived environmental problems. These EQS are established based on scientific evidence and may determine levels of pollution or other impacts that humans or the environment may be exposed to without risk of significant detriment. EQS have been identified for air, water and noise for specific geographical areas or the whole country. Permits and exemptions cannot be granted for activities that are deemed to lead to non-compliance with EQS.

In general, the Code does not specify limits on emissions for various activities. More detailed provisions are laid down in ordinances issued by the government or in regulations issued by the Swedish Environmental Protection Agency (Swedish EPA) or other government agencies. This is also the process for transposing EU environmental law into national legislation. Public authorities also issue general guidelines for implementation and enforcement (Bjällås 2010).

Currently, about 5,000 activities or operations may not be initiated without a permit issued by the competent authority, e.g. the Land and Environment Court (Bjällås 2010). The permit authorises the activity and specifies conditions, and then provides legal protection from claims or legal actions taken due to environmental disturbances, provided that the activity is carried out in compliance with the conditions of the permit. The permitting authority may reject a permit application if it deems that the activity is not permissible under the Code. Environmentally hazardous activities are classified into one of three categories based on their potential impact:

- activities with a significant environmental impact
- activities that, despite their small scope and/or lower environmental impact, require a permit
- activities that do not require a permit but fall under a specific notification regime.

The Code also contains provisions for Environmental Impact Statements, which describe the actual and potential effects of the proposed activity on the environment and the need for a full Environmental Impact Assessment (EIA), if required. The process is activity-specific and subject to a consultation process. For activities that are deemed to represent a significant environmental impact, the applicant must consult with the relevant Government agency(ies), local authority, members of the public and organisations that are likely to be affected by the proposed activity.

Permit holders must submit an annual environmental report to the supervisory authorities through an electronic reporting system, the Swedish Portal for Environmental Reporting. The data in the Portal are used for the monitoring and follow-up of environmental quality objectives and for compiling official environmental statistics, as well as for reporting emissions in Sweden to satisfy various international obligations.

3.2.1. Discussion

The Swedish Environmental Code is a type of umbrella legislation that consolidates provisions from a large number of statutes and legislation covering a large number of environmental issues derived from national legislation, EU legislation and international environmental law. Despite this, the scope of the Code does not include provisions governing planning and land use issues. Furthermore, the scope of the Code excludes laws relevant to the exploitation of natural resources such as the Minerals Act, the Hunting Act and the Fisheries Act (Mannheimer Swartling 1999).

The Swedish model is also an illustrative example of how environmental quality objectives can be related to interim targets. The environmental quality objectives define the state of the environment which specific measures seek to achieve, while the interim targets set the direction and timeframe for the corresponding measures. In setting the environmental objectives, the Swedish Government consulted with many individuals and organisations through focus groups. Wibeck (2012) reports that participants ‘often saw themselves as located at a certain “level”, i.e., “higher” or “lower”, in this management by objectives (MBO) system - that is, their conceptions corresponded to a traditional, hierarchical interpretation of MBO.’ This contributed to sentiments of inclusion/exclusion and ongoing competition for the right to interpret how the system of environmental objectives should best be managed. Wibeck proposes that any organisation applying an MBO system would benefit from finding new ways of involving relevant stakeholders, more research into the types of metaphors to support efficient environmental management and suggests more effective debate about hierarchies and their roles and responsibilities in an MBO system.

The EIA is an integral part of the permitting process and is part of the decision on granting approval for the activity. It has been acknowledged that there is lack of

understanding and guidance on how to address cumulative effects in EIAs (Wärnbäck & Hilding-Rydevik 2009).

Perhaps one of the most innovative aspects of the Code is the civil and administrative jurisdiction and enforcement powers given to environmental courts. Another important characteristic is the vertical distribution of competencies given to the permitting system. For many activities, permitting decisions made by the Government are binding on all permitting authorities including the Environment Courts and can only be challenged before the Supreme Administrative Court. Furthermore, the Government may not issue a permit unless the local authority (Council) has given its approval to the project. Essentially, this model helps ensure that activities considered to be particularly intrusive or damaging to the environment are given extra consideration (Bohne 2006).

3.3. United Kingdom Environment Plan and Bill

Following the United Kingdom's decision to leave the European Union ('Brexit'), the Department of Environment, Food and Rural Affairs (Defra) developed a 25-year plan and novel environment bill to guide the UK's environmental management into the future (Defra 2018). The plan, released in 2018, sets out environmental goals and targets and how the government will meet those goals. The subsequent Environment Bill, first presented to Parliament in 2019, is intended to deliver on the goals in the 25-year plan by establishing environmental principles for policy making and instating a new statutory cycle of target setting, monitoring, planning and reporting (House of Commons 2020). While the UK Environment Plan and Bill are relatively recent developments, and the Bill does not yet have the force of law, the design of these policy instruments is instructive for New Zealand's proposed development of an environmental limits and targets framework. Specifically, the Plan and Bill provide policy models for integrating multiple environmental limits and objectives under a coordinating target setting and planning framework. The Bill also proposes new governance entities and responsibilities to implement this framework.

3.3.1. A green future: the 25-year plan to improve the environment (2018)

In 2018, the UK government introduced its 25-year plan to improve the environment, targeted towards achieving a 'green Brexit' (House of Commons 2020). The plan:

> sets out government action to help the natural world regain and retain good health. It aims to deliver cleaner air and water in our cities and rural landscapes, protect threatened species and provide richer wildlife habitats. It calls for an approach to agriculture, forestry, land use and fishing that puts the environment first (ibid p. 9).

Notably, the plan is informed by a natural capital approach.

The plan is organised around ten 25-year goals (see Table 5) focused on achieving good environmental outcomes and managing pressures on the environment. Each goal has a number of corresponding targets, many of which are framed in terms of limits on environmental impacts or meeting environmental standards or objectives. For example, the targets under the clean air goals include meeting legally binding targets to reduce emissions and ending the sale of new conventional petrol and diesel passenger vehicles by 2040. As in these examples, some targets clearly specify the environmental outcome, change in pressure, or impact they seek to achieve by a set date. Most such specific targets build on existing policies (e.g. air quality targets, the Stockholm Convention). The plan also includes a range of targets that are phrased in more general terms as action or outcome objectives (see for example the targets for biosecurity and climate change) and are not easily measurable. The plan notes that while some of the targets derive from membership of the EU and/or are already legally binding, others are not.

The plan sets out actions the government will take to meet the goals across six action areas:

- using and managing land sustainably
- recovering nature and enhancing the beauty of landscapes
- connecting people with the environment to improve health and wellbeing
- increasing resource efficiency, and reducing pollution and waste
- securing clean, productive and biologically diverse seas and oceans
- protecting and improving the global environment.

These action areas provide an integrative framework for living within local environmental limits, restoring degraded landscapes, improving environmental justice, and reducing the UK’s contribution to global environmental issues.

Table 5. Goals and targets in the United Kingdom's 25-year plan to improve the environment (2018).

Goal	Example target
Clean air	Meeting legally binding targets to reduce emissions of five damaging air pollutants; this should halve the effects of air pollution on health by 2030
Clean and plentiful water	Reducing the damaging abstraction of water from rivers and groundwater, ensuring that by 2021 the proportion of water bodies with enough water to support environmental standards increases from 82% to 90% for surface water bodies and from 72% to 77% for groundwater bodies
Thriving plants and wildlife	Restoring 75% of our one million hectares of terrestrial and freshwater protected sites to favourable condition, securing their wildlife value for the long term
Reducing the risks of harm from environmental hazards	Making sure that decisions on land use, including development, reflect the level of current and future flood risk
Using resources from nature more sustainably and efficiently	Ensuring that all fish stocks are recovered to and maintained at levels that can produce their maximum sustainable yield
Enhancing beauty, heritage and engagement with the natural environment	Making sure that there are high quality, accessible, natural spaces close to where people live and work, particularly in urban areas, and encouraging more people to spend time in them to benefit their health and wellbeing
Mitigating and adapting to climate change	Continuing to cut greenhouse gas emissions including from land use, land use change, the agriculture and waste sectors and the use of fluorinated gases
Minimising waste	Working towards our ambition of zero avoidable waste by 2050
Managing exposure to chemicals	Seeking in particular to eliminate the use of Polychlorinated Biphenyls by 2025, in line with our commitments under the Stockholm Convention
Enhancing biosecurity	Managing and reducing the impact of existing plant and animal diseases; lowering the risk of new ones and tackling invasive non-native species

Key steps in putting the plan into practice were:

- to set up a new independent statutory body to hold government to account for upholding environmental standards, and to establish a new set of environmental principles to underpin policymaking. The government has since acted on these steps through the drafting and presentation of an Environment Bill to Parliament.
- to develop a set of metrics to assess progress towards the 25-year goals. In 2019 the government released its outcome indicator framework for the 25 Year Environment Plan (Defra 2019a).

The outcome indicator framework comprises 66 indicators across 10 broad themes related to the goals in the 25-year plan. According to Defra (2019b, p. 71) 'the outcome indicators are designed to measure what is important, rather than what we already measure.' Thus, while data are already available and published for 27 of the indicators, the remaining indicators require further development to become fully operational, including work to develop measures for those indicators without established datasets. For each indicator, the framework identifies the 25-year goals, targets, and natural capital assets to which the indicator relates; any international reporting commitments; the readiness of the indicator; and, where indicators are still under development, any interim indicators. The framework will be reviewed and updated over time to reflect the development of new indicators.

The first progress report on the implementation of the 25 Year Environment Plan was published in 2019 (Defra 2019b), summarising progress on goals and priority actions over the period January 2018 to March 2019. The report dedicates a chapter to each of the 10 goals in the Plan, describing progress on the delivery of actions towards the goal, trends in a relevant indicator from the framework, and the government's priorities for the coming year. The report also finds that for the 40 'priority actions' expected to make the most significant contribution to the plan, four actions have been completed, 32 are on track for delivery, and four are subject to delays due to Brexit. It should be noted that the 'priority actions' were not identified as such in the original plan.

3.3.2. Environment Bill (2020)

Defra presented the Environment Bill to Parliament in October 2019, and then again in January 2020 due to a change in government. The Environment Bill (House of Commons 2020) was being considered by a committee of the House of Commons in March 2020 but has a long way to go before receiving royal assent and can be expected to undergo amendments. The Bill provides an overarching legal framework for environmental governance, and further outlines detailed provisions for the improvement of specific environmental sectors, including waste and resource efficiency, air quality, water, nature and biodiversity, and conservation covenants. This summary focuses on the first half of the Bill, concerning the proposed environmental governance framework.

The Bill sets out a new national-scale framework for environmental governance in a post-Brexit world. It focuses on preventing environmental damage by making environmental considerations central to the policy development process (Defra 2020). The Bill requires the development of a policy statement on environmental principles that explains how the environmental principles should be interpreted and applied by ministers when making policy. The principles are:

- environmental protection should be integrated into policy making
- preventative action to avert environmental damage

- precautionary action, so far as relating to the environment
- environmental damage should as a priority be rectified at source
- the polluter pays.

Once the policy statement is published, it will legally oblige policy makers to have due regard to the environmental principles when choosing policy options, for example by considering the policies which cause the least environmental harm. The policy statement will apply to most policies, with exceptions for national security, taxation and spending, and policies on Wales. The Bill also requires ministers introducing bills to Parliament that contain provisions that would become environmental law to make a statement that the bill will not reduce existing levels of environmental protection.

The Bill will instate a new statutory cycle of target setting, monitoring, planning, and reporting to help deliver long term environmental improvement and improve accountability. Statutory Environmental Improvement Plans (the first being the 25 Year Environment Plan) and a new target-setting framework will be integral to this cycle. The Bill states that the government may by regulation set long-term[8] targets for any matter relating to the natural environment or people's enjoyment thereof. It further *requires* the creation of regulations to set long-term targets for four priority areas:

- air quality
- water
- biodiversity
- waste and resource efficiency

as well as a target for the annual mean level of particulate matter 2.5 micrometres or less in diameter ($PM_{2.5}$) in ambient air. Unlike the other targets, the $PM_{2.5}$ target does not need to be a long-term target. The draft regulations setting targets for the four priority areas and $PM_{2.5}$ must be presented to Parliament by 31 October 2022.

All targets must specify the environmental standard to be achieved, which must be able to be objectively measured; a date by which that standard is to be achieved; and a reporting date for the target. The regulations may also specify how the matter with respect to the target is to be measured. The Bill states that targets must be based on independent expert advice and must be able to be met within the proposed timeframe. The Bill allows for amendments to the targets but creates procedural barriers to reducing targets (see Part 1, Chapter 1, Section 3).

Government is responsible for ensuring that the long-term environmental and $PM_{2.5}$ targets are met and is required to report to Parliament on whether each target has been met or not by the reporting date set for that target. Where a target has not been met, the government must publish a report explaining why the target has not been

[8] i.e. of at least 15 years' duration.

met and what steps they have taken or intend to take to ensure the specified standard is achieved as soon as reasonably practicable.

The Bill also requires the government to review the targets every 5 years to determine whether the 'significant improvement test' is met, whereby it is determined that meeting the targets would significantly improve the natural environment in England.[9] Based on the review, the government must present a report to Parliament stating whether the test is met. If the test is not met, the government must amend the environmental targets or set new targets to ensure that the test is met.

Further, the government is required to have and maintain an Environmental Improvement Plan, which sets out the actions the government will take to improve the natural environment and interim targets towards meeting the long-term targets. Government will be required to produce an annual report on the plan, outlining progress towards improving the natural environment and meeting the targets. Government must also review and revise the plan periodically to ensure that it is contributing towards improving the natural environment and meeting the targets.

To oversee the new target setting and planning system, the Environment Bill establishes a new public body—the Office for Environmental Protection (OEP)—as an independent, domestic watchdog. The new body will hold government to account by: monitoring progress in improving the natural environment in accordance with the government's Environmental Improvement Plans and targets; providing government with advice on any proposed changes to environmental law; and managing compliance with environmental law and climate change law. The public will be able to complain to the OEP if they think the government or another public authority has broken environmental laws; the OEP will investigate alleged serious breaches of environmental law by public authorities and undertake legal action if necessary.

3.3.3. Discussion

The UK Environment Plan and Environment Bill remain in their early stages, with limited information available on the implementation or effectiveness of approaches. However, statements by government and environmental organisations on the new Plan and Bill, along with media commentary, provide insight on the strengths, weaknesses, and areas of uncertainty regarding the UK's approach to environmental targets. These insights—together with our own analysis of what is distinctive about the UK's approach—are summarised in the remainder of this section.

First, the proposed statutory cycle of target setting, monitoring, planning, and reporting provides a model for the development of an integrative framework of environmental targets. In contrast to the EU, where varying environmental domains

[9] While the Environment Bill is UK legislation, it contains provisions that would be within the legislative competence of the National Assembly of Wales, and therefore only apply to England – see S1(9)

are governed by separate legislative instruments, the new Bill and Plan provide for an integrated system of target setting, planning, reporting and oversight across multiple domains and scales. The Bill allows for targets to be set for any aspect of the natural environment or people's enjoyment of it, enabling a comprehensive and coordinated approach to target setting and review. However, critics remain concerned that the limited requirements for target setting[10] may result in weaker environmental standards than those set by the EU (Jennings 2020). The 'significant improvement test' could be used to identify any inadequate or lack of targets during future reviews.

In contrast to many of the environmental targets reviewed in Section 3 of this report, the targets set under the Environment Bill will be legally binding. The Bill confers a legal duty on the Secretary of State to ensure that the targets are met by their nominated date, and sets out requirements if they are not met. These provisions clarify governance responsibilities and accountability frameworks, which are often lacking in environmental target frameworks. Furthermore, the Bill requires the creation of SMART targets—they must specify a standard to be met; be measurable, achievable, and realistic; have clear timeframes for achievement and reporting; and be informed by expert advice. Targets set in regulation will therefore be significantly stronger than those in the UK's first environmental plan, many of which are ambiguous, unambitious, and/or lack clear indicators (Wildlife and Countryside Link 2018). Indeed, the lack of congruence between the plan's goals and targets and the measures included in the outcome indicator framework highlights the need for targets to be designed with measurement and data availability in mind, so that it is possible to track progress towards targets. Once long-term targets have been set by regulation, future updates to the environmental plan could strengthen target-driven environmental governance by creating and reporting on SMART interim targets.

The UK approach also offers several new approaches to integrating environmental considerations across government policy making and holding government to account. The policy statement on environmental principles is a novel attempt to ensure that environmental protection is upheld across a wide range of government policy, rather than simply being the purview of environmental law. The principles themselves—especially the precautionary principle and preventative action—suggest an effort to avoid (further) transgressing environmental limits in the context of uncertainty.

This emphasis on whole-of-government responsibility for environmental protection is further reinforced by public reporting requirements for policy impacts, planning processes, and progress towards targets, as well as the creation of an environmental watchdog organisation to monitor and report on government compliance. However, environmental groups and MPs have questioned the purported independence of the proposed 'office for environmental protection', noting that the Secretary of State will

[10] Government is required to set a long-term target in respect of at least one matter within each of four priority areas, together with a fine particulate matter target

appoint its board members and decide its budget (Envirotec Magazine 2020). Rafe Jennings (2020) summarises

> Evidence presented in pre-legislative scrutiny argued that non-departmental public bodies structured in this way are often subject to significant governmental oversight as a result of the appointment process and financial allocation. It doesn't take too much of a cynic to see how this could hamper the goal of "robustly hold[ing] the Government to account".

Commentators also argue that the new office will lack the powers to properly enforce its functions (Jennings 2020). The strongest recourse available to the office will be to launch a judicial review against a non-complying public authority; unlike similar EU watchdogs, the office will not be able to fine authorities for non-compliance. These critiques highlight challenges in institutionalising independence and enforcement powers for environmental watchdogs while ensuring that those powers remain democratically accountable.

Finally, a strength of the Bill is its requirements to report on progress towards targets and actions to Parliament on a regular basis, promoting government accountability to the public for environmental performance. The government must also report to parliament on the 5-yearly review of targets to determine whether they meet the significant improvement test, and any changes to targets. While this level of reporting is important in promoting public access to information on the state of the environment and actions to improve it, this also creates a significant operational burden for councils and other authorities responsible for data collection and reporting. Commentators therefore highlight the need for Bill and plan implementation to be supported through significant funding and institutional support (Wildlife and Countryside Link 2018).

3.4. European Union's 7th Environment Action Programme

Since the mid-1970s, high-level environment policy in the European Union (EU) has been expressed through a series of Environment Action Programmes (EAPs) that identify priority objectives to be achieved over several years. EAPs are adopted jointly by the European Parliament and the European Council. Although a form of majority voting applies to adoption of EAPs, policy on some areas, such as land use planning, energy and water management, still requires consensus. In contrast to other EU policy areas, EAPs are legally binding and must be implemented by each EU Member State (Epiney 2013).

The current policy, the 7th Environment Action Programme (EAP7), was adopted in late 2013 and covers the period until the end of 2020. The Council of the EU has

directed the Commission to prepare a draft 8th programme for consideration in early 2020.

EAP7 consists of a relatively brief Council Decision, which specifies nine priority objectives, and a lengthy Annex that presents strategies for achieving them (EC 2014). EAP7's objectives and the associated actions are broad, qualitative and non-specific (See Box 1), and stop well short of specifying limits or targets. These are generally left to EU directives and other policy mechanisms. The EAP7 references the objectives of several environment strategies and directives already established, for example, the EU Biodiversity Strategy to 2020:

> The Union has agreed to halt the loss of biodiversity and the degradation of ecosystem services in the Union by 2020, and restore them in so far as feasible (European Commission 2014, p. 6).

Regarding management of freshwater and coastal waters, EAP7 refers to commitments already agreed to in the Water Framework Directive (WFD):

> The Union has agreed to achieve good status for all Union waters, including freshwater (rivers and lakes, groundwater), transitional waters (estuaries/ deltas) and coastal waters within one nautical mile of the coast by 2015 (EC 2014, p. 6).

Box 1. Broad language in EAP7

The objectives and the associated actions of EAP7 are broad, qualitative and non-specific. For example, the first three thematic priorities are -

1. to protect, conserve and enhance the Union's natural capital
2. to turn the Union into a resource-efficient, green, and competitive low-carbon economy
3. to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing

Some of the actions to achieve the first objective, regarding natural capital, include:

(i) stepping up the implementation of the EU Biodiversity Strategy without delay, in order to meet its targets

(ii) fully implementing the Blueprint to Safeguard Europe's Water Resources, having due regard for Member States' specific circumstances, and ensuring that water quality objectives are adequately supported by source-based policy measures

…

(v) strengthening efforts to reach full compliance with Union air quality legislation and defining strategic targets and actions beyond 2020

(vi) increasing efforts to reduce soil erosion and increase soil organic matter, to remediate contaminated sites and to enhance the integration of land use aspects into coordinated decision-making involving all relevant levels of government, supported by the adoption of targets on soil and on land as a resource, and land planning objectives

(vii) taking further steps to reduce emissions of nitrogen and phosphorus, including those from urban and industrial wastewater and from fertiliser use, inter alia through better source control, and the recovery of waste phosphorus

The EAP7 has been strongly criticised for being 'an action plan without actions' (Krämer 2020). In recent EAPs, according to Krämer (2020), objectives have become more and more vague. He cites the example of air pollution:

> The 5th EAP stated that the "WHO values [on air quality] become mandatory et EU level" by the year 2000. The 6th EAP declared that WHO standards, guidelines and programmes "will be taken into consideration." The 7th EAP declared that by 2020, "outdoor air pollution is significantly improved", without mentioning that the binding limit values had to be respected by 2010 already (by 2015 for PM2.5) (Krämer 2020, p. 13).

A mid-term review of EAP7 found that 'while the EAP scope remains relevant to current needs and adds value to EU and national policy-making efforts, its objectives are unlikely to be fully met by 2020, despite sporadic progress in some areas' (EPRS 2017, p. 1). The findings for Objective 1 are typical; only one out of the nine initiatives was assessed as being sufficiently implemented at both EU and Member State level, and that concerned water resources (EPRS 2017, p. 21). Even for water, despite the requirement in WFD that all surface water should have good ecological status by 2015 (and by 2020 in some areas), the review noted that in only one third of EU member states were more than 50% of surface waters in good or excellent ecological status, and in five member states less than 20% of surface water had good status (EPRS 2017, p. 23).

The EAP7 is a sweeping document that encompasses virtually all aspects of the EU environmental policy but identifies no concrete limits or actions other than those already adopted in other EU policy. EAP7 thus represents more of a strategy paper for EU environmental policy than an action programme that provides for limits.

3.4.1. Discussion

New Zealand has an institutional structure for environmental policy that bears some resemblance to the EU, that is, a central body with responsibility for setting high level policy and objectives, with implementation delegated to regional and local jurisdictions. In both cases, the central body has the power to set clear limits and targets but has only occasionally exercised this authority. In the case of New Zealand, the central government, acting through MfE, can also specify measures that must be implemented to achieve targets or limits, e.g. requiring measurement of water abstractions and requiring all domestic wood burners to meet air emission standards.

The experience of the EAP demonstrates that statements of broad objectives will be ineffective if not backed up by more specific targets and policies. Indeed, even in the case of EU water policy, deemed one of the more successful examples of EU environmental policy, achievement is lagging far behind the policy goals. Although the

WFD identifies a clear target, ‘good ecological status by 2020’, it is left to national governments to adopt programmes and measures to achieve this, and these have been of limited effectiveness.

The requirement for consensus on policy for key areas such as energy policy and water management, along with the principle of subsidiarity, appears to be constraining the EU from adopting EAPs with more specific limits and targets and from specifying effective measures for their achievement.

3.5. Subject area case studies

3.5.1. United States Clean Water Act and the Total Maximum Daily Load programme

The Total Maximum Daily Load (TMDL) programme originated from the Clean Water Act (CWA) and has been the main driver of efforts to achieve ambient water quality standards (WQS) in the USA. These WQS are developed based on the ‘beneficial uses’ of the waters, the identification of water quality criteria (WQC) necessary to protect their beneficial uses, and the implementation of pollution prevention measures to maintain and protect water quality. Waterbodies that do not meet WQS are classified as ‘impaired’ for the pollutant(s) of concern (Figure 3). The TMDL sets the total loading of each pollutant.

In simple terms, a TMDL is a numerical quantity determining the current and future maximum load of pollutants from point and nonpoint sources as well as from background sources, to provide an adequate margin of safety that receiving waterbodies will not violate the state WQS. The permissible load is then allocated by the state authority among contributing point source discharges and nonpoint and natural sources (Andreen & Jones 2008; National Research Council 2001).

Assessment of impaired waterbodies and identification of those requiring a TMDL is primarily carried out by states and tribal nations, with oversight and final approval by the United States Environmental Protection Agency (USEPA) (Keller & Cavallaro 2008). The USEPA recommends that states develop TMDLs using a more holistic catchment-based approach to ensure more cost-effective implementation, particularly in catchments with multiple impaired waterbodies (Cooter 2004). In cases where the catchment includes more than one state, TMDLs are developed jointly. USEPA regulations also specify that TMDLs be developed using a pollutant-by-pollutant or biomonitoring approach and that the process supports the development of WQC to quantify deviations from baseline environmental reference conditions, rather than pollutant concentrations in the environment (Adler 2019).

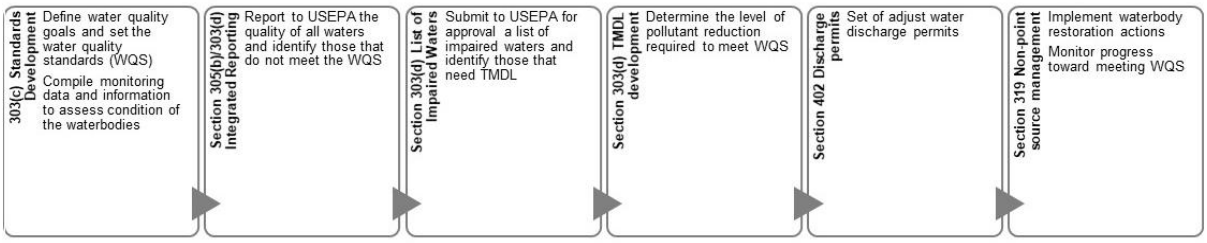

Figure 3. Approach used to protect and restore water quality under the Clean Water Act in the USA. Adapted from: https://www.epa.gov/tmdl.

Meeting these requirements, many of which have been imposed by court order or consent decree, has been the most pressing and significant regulatory water quality challenge for the individual states since the passage of the CWA (National Research Council 2001). Progress with implementation of the TMDL requirements was modest in the initial years following enactment when many States and the USEPA faced lawsuits. Currently, over 58,000 miles of coastal shoreline and 54,000 square miles of ocean and near coastal areas have been assessed under the programme (Figure 4). The percentage of waters assessed varies substantially between type of waterbody and between state (USEPA 2020) and it is estimated that over 40,000 TMDLs are required for impaired waters (National Research Council 2001).

	Size of Water							
	Rivers and Streams (Miles)	Lakes, Reservoirs, and Ponds (Acres)	Bays and Estuaries (Square Miles)	Coastal Shoreline (Miles)	Ocean and Near Coastal (Square Miles)	Wetlands (Acres)	Great Lakes Shoreline (Miles)	Great Lakes Open Water (Square Miles)
Good Waters	518,293	5,390,570	11,516	1,298	726	569,328	106	1
Threatened Waters	4,495	30,309						
Impaired Waters	588,173	13,208,917	44,625	3,329	6,218	672,924	4,354	39,230
Total Assessed Waters	1,110,961	18,629,795	56,141	4,627	6,944	1,242,252	4,460	39,231
Total Waters	3,533,205	41,666,049	87,791	58,618	54,120	107,700,000	5,202	196,343
Percent of Waters Assessed	31.4	44.7	63.9	7.9	12.8	1.2	85.7	20.0

Figure 4. Status of waterbodies and percentage of waters assessed in the USA. Source: https://ofmpub.epa.gov/waters10/attains_nation_cy.control.

The initial focus of the TMDLs was the control of direct pollutant discharges from municipal and industrial sources to surface waters. As these sources were reduced, uncontrolled nonpoint sources became the focus of pollution reduction measures. In recent years, TMDLs have incorporated other issues such as ocean acidification and climate change. Instead of the traditional technology-based, end-of-pipe approach to water quality monitoring and standards, regulation and reporting has increasingly focus on ‘ambient’ monitoring and the quality of the waterbodies themselves (Boyd 2000).

Implementation issues

The implementation of the TMDL requirements has been controversial. This is in part related to the fact that the CWA does not specify how the requirements should be implemented. Consequently, implementation varies considerably between states. Another major limitation is the insufficient funding and resources available to state authorities to develop TMDLs and implement pollution reduction measures (Andreen & Jones 2008; National Research Council 2001). In 1999, the USEPA proposed revisions to the 1992 TMDL requirements in an attempt to improve the situation. The revisions included new requirements for states, territories and Indian tribes to:

- produce a more exhaustive list of 'impaired' waterbodies
- develop an implementation plan
- develop guidance on public participation requirements
- develop an implementation schedule
- provide further details of methods used to develop the TMDL; and
- consider 10 specific elements in the TMDLs.

Despite much criticism, the text of the final rule was published in July 2000. However, the Bush Administration announced in October 2001 that it would delay the effective date of the rule until May 2003 to allow for further review. In October 2000, the US Congress requested the establishment of a Federal Advisory Committee to review the scientific basis of the TMDL programme. From this review, the Committee identified several science and policy areas for improvement, including:

- stronger focus on improving the condition of waterbodies through achievement of designated uses, not on the numbers of TMDL completed or discharge permits issued or other administrative performance measures
- need to consider both pollutants and pollution when determining the condition of a waterbody
- need to acknowledge that scientific uncertainty is part of the TMDL process and should be reported in modelling results
- development of better use designations for waterbodies in advance of TMDL assessments
- development of models linking environmental stressors to biological responses
- consideration of adaptive implementation to ensure that the programme is not halted because of a lack of data and information
- undertake post-implementation compliance monitoring for verification data collection
- better coordination between monitoring and data collection programmes and modelling activities.

In March 2003, the USEPA withdrew the 2000 rule to consider whether to initiate an entirely new rule or alternative options. Meanwhile, programme requirements under the 1992 regulations and court-sanctioned TMDL schedules remain in place and are the drivers of much of the current TMDL activity.

While guidelines produced by state authorities have been effective in addressing local issues, such as variations in climate, land use, and water quality objectives, as well as social and economic preferences, the variation in criteria used to list impaired waters has led to inconsistencies across state boundaries in the levels of attainment of national water quality objectives (Keller & Cavallaro 2008). Furthermore, stakeholders that participate in the listing process for multiple States have to deal with differing and often conflicting requirements (Keller & Cavallaro 2008).

From a science perspective, the TMDL programme has been constrained by two main issues. First, evidence of water quality impairment may involve a larger number of pollutants than those that are assessed for compliance with their specific limit(s). Second, the causes of non-compliance may originate from stressors other than the specific pollutant(s) that are subject to analysis. This has raised questions about the authority that States or the USEPA have to enforce water quality management and control actions beyond pollutant-specific limits (Adler 2019). Furthermore, lawmakers have been concerned with the paucity of data and information available to State authorities to comply with programme requirements and meet WQS (National Research Council 2001).

To reduce the administrative burden on the states, the USEPA has recommended measures to implement overlapping provisions by means of an Integrated Report (IR). The IR format considers a categorisation approach for classifying the status of waterbodies, ranging from Category 1 (all designated uses are supported, and no use is threatened) to Category 5 (at least one designated use is not supported or is threatened, and a TMDL is needed) (USEPA 2018)[11].

Farming and forestry groups have expressed concern over the ways their activities are addressed in TMDLs and contend the law does not give USEPA regulatory authority over nonpoint sources. In fact, Section 303(d) of the Act does not specify whether TMDLs should cover nonpoint sources (Adler 2019) and the USEPA can only mitigate effects from nonpoint sources of pollution through grants and funding. Therefore, the management of nonpoint pollution has been a difficult topic because pollution reduction measures are voluntary and there is no mechanism to share costs between the federal government and states. However, the USEPA contends that if a state fails to implement controls on an activity that is the source of an ongoing water

[11] Category 2: Available data and/or information indicate that some, but not all of the designated uses are supported; category 3: There is insufficient available data and/or information to make a use support determination; category 4: available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed (USEPA 2018).

quality impairment, the CWA gives the Agency the authority to issue best management practices or other controls to reduce nonpoint pollution (Boyd 2000).

Chesapeake Bay TMDL and nutrient management

The Chesapeake Bay (the Bay) watershed is the largest catchment for which the USEPA has developed TMDLs (USEPA 2010). The TMDL plan identifies pollution reductions from major sources of nutrients (nitrogen, phosphorus) and sediment across several Bay jurisdictions (Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, District of Columbia) and sets pollution limits and pollution reduction measures to meet water quality standards across a 64,000-square-mile catchment by 2025. Nutrients are the main pollutants causing impairment of the waters in the bay.

The Bay TMDL includes some novel elements such as Watershed Implementation Plans (WIP) which outline the controls and best management practices required to achieve the relevant WQS and though which the jurisdictions report to the public on implementation progress (USEPA 2015). These WIP and are a more flexible approach than initiatives based only on stakeholder engagement used in other TMDLs.

A success of the Bay's TMDL has been the establishment of collaborative catchment groups. It has been shown that these groups improve TMDL implementation. It is considered that catchments with more active groups are more likely to achieve measurable reductions in pollutant loadings and perceived water quality improvements. However, while actions from catchment groups are important to achieve the objectives of the TMDL programme, they do not replace traditional regulatory efforts (Hoornbeek et al. 2013).

A number of groups have expressed concern about the high costs of implementation. In the Bay's TMDL, consideration is given to nutrient trading as a process for meeting loading limits. In this process, pollution sources such as municipal wastewater treatment plants achieve their individual load limits by purchasing load reductions from other sources such as farmers for a lower cost than if the plant were to install expensive technology to address pollutant reductions on-site. Positive aspects of this trading scheme are cost savings on implementation and opportunity for stronger engagement from the agricultural sector on pollution reduction measures—a water utility may pay a farmer to implement best management practices for nutrient removal which would otherwise be paid by the utility. However, there is large uncertainty in cost saving estimates because these depend on numerous factors such as transaction costs, trading ratios, limits on total credit trades, or potential tradeable loads (van Houtven et al. 2012). There are other constraints associated with different State requirements and difficulties in verifying implementation to best management practices 'on the ground' (EPRI 2013; Willamette Partnership et al. 2012)

Over the last 30 years, treatment upgrades at the largest wastewater treatment plants in the catchment had cumulatively prevented 108,862 tonnes of nitrogen and 21,772 tonnes of phosphorus from entering the Bay. In 2016, the wastewater sector had reduced annual nitrogen levels from 23,587 tonnes estimated in 2010 to 17,237 tonnes. This reduction had exceeded the 2017 interim pollution goal for the wastewater sector under the Bay TMDL. The Chesapeake Bay Program has reported water quality improvements in river stretches and estuaries, as indicated by higher abundance of juvenile crabs, higher water clarity and higher coverage of submerged vegetation (USEPA 2016). Compliance with WQS has been the highest in more than 30 years (USEPA 2018). However, the latest midpoint review reports that the objective of nitrogen reduction set for 2017 for the whole catchment area had not been achieved (USEPA 2018). According to CAST, pollution controls put in place in the Chesapeake Bay catchment between 2009 and 2018 reduced nitrogen loads 10% and phosphorus loads by 13% (Figure 5). According to data supplied by state authorities, these reductions were mostly due to upgrades to waste treatment plants. During the period 2017–2018, 55% of the nitrogen load reductions originated from the agricultural sector.

Conclusions

The TMDL programme has been the main mechanism of efforts to protect and restore water quality in the United States. The programme has been in constant development with many States increasingly addressing new and more complex pollution source and related impacts, having to deal with larger scale impairments, and implementing more complex and resource-intensive TMDLs. The programme has been controversial, partly because of the increasing number of requirements and higher costs imposed on State authorities to deliver the programme, as well as on industries, farming sector and others in dealing with the consequences of pollution reduction measures. Approaches for implementation vary markedly between states. Other barriers to implementation are lack of empirical data to support the assessments, insufficiency of resources and poor engagement from stakeholders. The multi-jurisdictional TMDL developed for the Chesapeake Bay catchment has been successful in tackling these issues and has introduced a number of novel elements, including Watershed Implementation Plans, which identify measures to achieve target pollutant reductions and facilitate communication between stakeholders. A nutrient trading scheme has also been an effective way of meeting nutrient load limits and new revenue for some sectors, although operational difficulties in trading and difficulties in verifying the results of the trading scheme on the ground have also hampered the process.

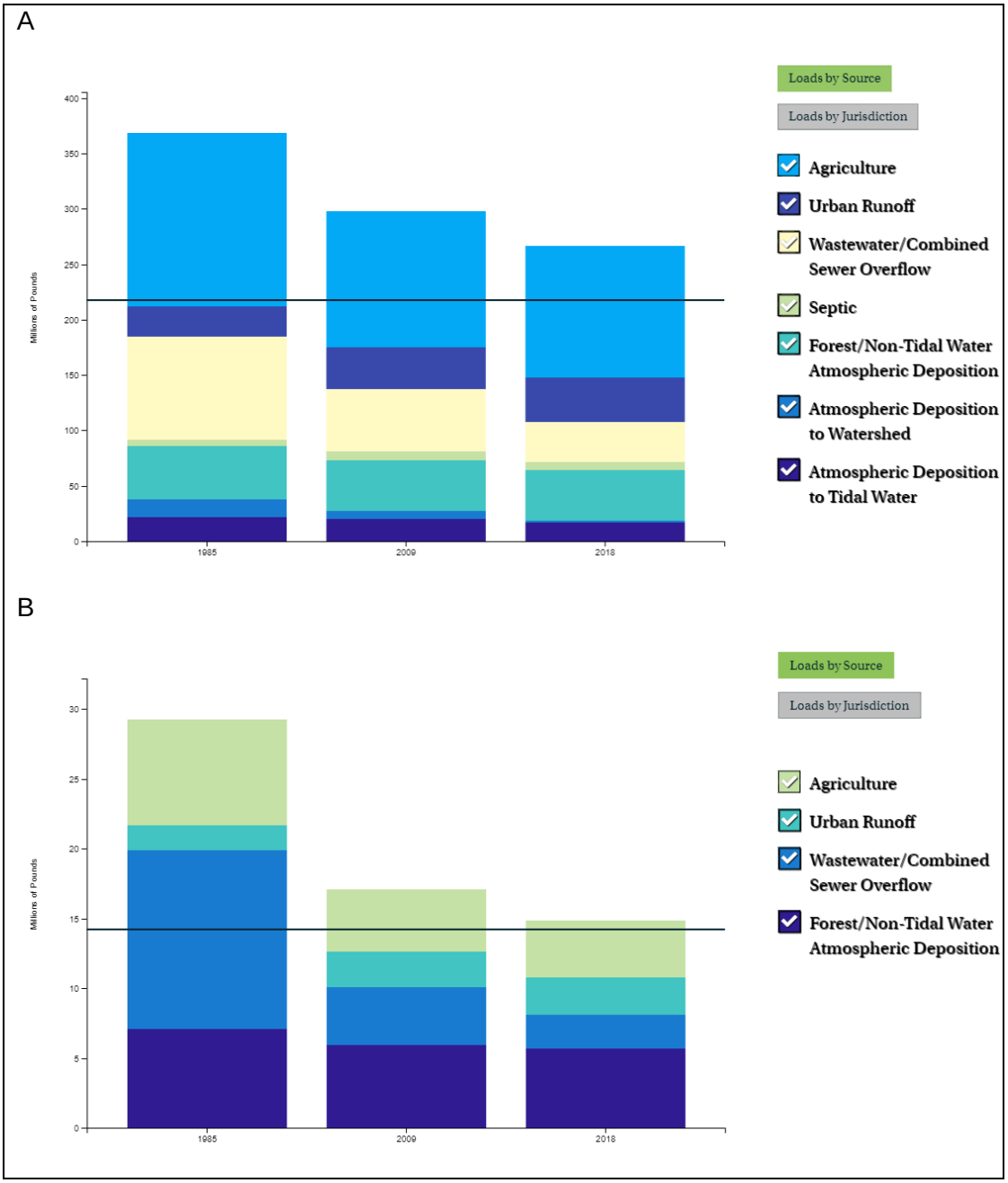

Figure 5. Modelled nitrogen (A) and phosphorus (B) loads from seven types of pollution sources to the Chesapeake Bay in 1985, 2009 and 2018. The reference lines in the graphs indicate the targets of 217 million pounds of nitrogen and 14 million pounds of phosphorus planned for 2025. Nutrient loads simulated using Watershed Model (Phase 6) and data on wastewater discharges reported by State authorities. Data from Chesapeake Progress (https://www.chesapeakeprogress.com/clean-water/watershed-implementation-plans) (2020).

3.5.2. Measures to protect the Great Barrier Reef in Australia

The Great Barrier Reef (GBR) was included in the World Heritage List in 1981 in recognition of its 'Outstanding Universal Value' (UNESCO 1981). As such, the Australian Government is obligated to 'ensure the identification, protection,

conservation, presentation and transmission of the World Heritage Area for current and future generations.' (Commonwealth of Australia 2015, p. 8).

The GBR is noted for its unique ecosystems, which are particularly sensitive to environmental stressors and fluctuations. It is a large area, spanning 348,000 km^2, and holds strong social, cultural and economic value to the communities in the GBR region (Commonwealth of Australia 2015). There is a unique connection between traditional owners (Aboriginal and Torres Strait peoples) and the GBR, which stems back millennia and interweaves with many aspects of their wellbeing (Commonwealth of Australia 2015).

Threats to the Great Barrier Reef

One of the greater threats to many coastal areas, including the GBR, is the excess load of nutrients, pesticides and sediment from adjacent catchments (Great Barrier Reef Marine Park Authority (GBRMPA) 2019; Gruber et al. 2019; Waterhouse et al. 2017b). Although nutrient and sedimentation run-off is a natural process, it has increased substantially since European settlement and the development of land for agriculture (Waterhouse et al. 2017b; Fabricius et al. 2016). The effects of these pollutant loads include changes in species composition and food chains, such as observed increases in phytoplankton blooms which fuel crown-of-thorn outbreaks (Brodie et al. 2013; Commonwealth of Australia 2015; Pratchett et al. 2017; Waterhouse et al. 2017b). Increases in sedimentation and pesticides also inhibit the growth of seagrass, which is a primary producer and acts as a nursery for other species (McKenzie et al. 2019; Waterhouse et al. 2017b).

The cumulative impacts of low water quality and other stressors to the GBR, such as the effects of fishing and tourism (Commonwealth of Australia 2015), will reduce the GBR ecosystems' resilience to the effects of climate change, which is expected to increase in severity over time (Australian and Queensland Governments 2019; GBRMPA 2019; Waterhouse et al. 2017b). Marine coral, an iconic and main feature of the GBR (GBRMPA 2019), is highly susceptible to the effects of climate change, such as thermal fluctuations, and ocean acidification (Hopley & Smithers 2019; Thompson et al. 2019).

Plans to improve water quality

The Great Barrier Reef Water Quality Protection Plan (Reef Plan) 2003 was released as a joint initiative by the Australian and Queensland governments to address water quality issues in the GBR region (The State of Queensland and Commonwealth of Australia 2003). The Reef Plan was revised and updated in 2009, 2013 and 2017 following the release of independently reviewed scientific reports and Reef Outlook Reports, which are released every four years (Kroon et al. 2016). While specific objectives and targets vary between each iteration of the Reef Plan, the continuous theme throughout is the need to improve water quality exiting adjacent catchments, with the primary focus on improving agricultural land management practices (Reef

Water Quality Protection Plan Secretariat 2009, 2013; The State of Queensland and Commonwealth of Australia 2003, 2018).

The results of each Reef Plan are assessed against qualitative objectives for water improvement, and further numerical targets for water quality and land management were introduced under Reef Plan 2009 (Reef Water Quality Protection Plan Secretariat, 2009; Queensland Government 2015). The results are presented in annual Great Barrier Reef Water Quality Report Cards, which measure progress towards water quality targets and the success of management actions, and identify further measures that need to be taken to meet targets (Australian and Queensland Governments 2019)

The Reef 2050 Water Quality Improvement Plan 2017–22 (Reef 2050 WQIP) is the most recent Reef Plan (The State of Queensland and Commonwealth of Australia 2018). It operates under the Reef 2050 Long-Term Sustainability Plan (Reef 2050 LTSP) (Commonwealth of Australia 2015), which provides an umbrella framework for addressing a wider range of issues (ecosystem health, biodiversity, heritage, water quality, community benefits, economic benefits and governance). The Reef 2050 LTSP was created following a recommendation from the World Heritage Committee that a long-term plan for sustainable development was needed (Leverington et al. 2019; UNESCO 2014).

There is an increased recognition in both Reef 2050 LTSP and Reef 2050 WQIP of the cumulative effects of multiple stressors (Leverington et al. 2019). The plans also recognise the need for greater resilience to strong pressures from climate change, ocean acidification, and related events (such as recent mass bleaching and crown-of-thorns starfish outbreaks) (GBRMPA 2019). In addition, both plans take a more holistic approach to setting objectives and targets which incorporate human (social and cultural) values and economic factors (Figure 6) (Commonwealth of Australia 2015; Leverington et al. 2019; The State of Queensland and Commonwealth of Australia 2018).

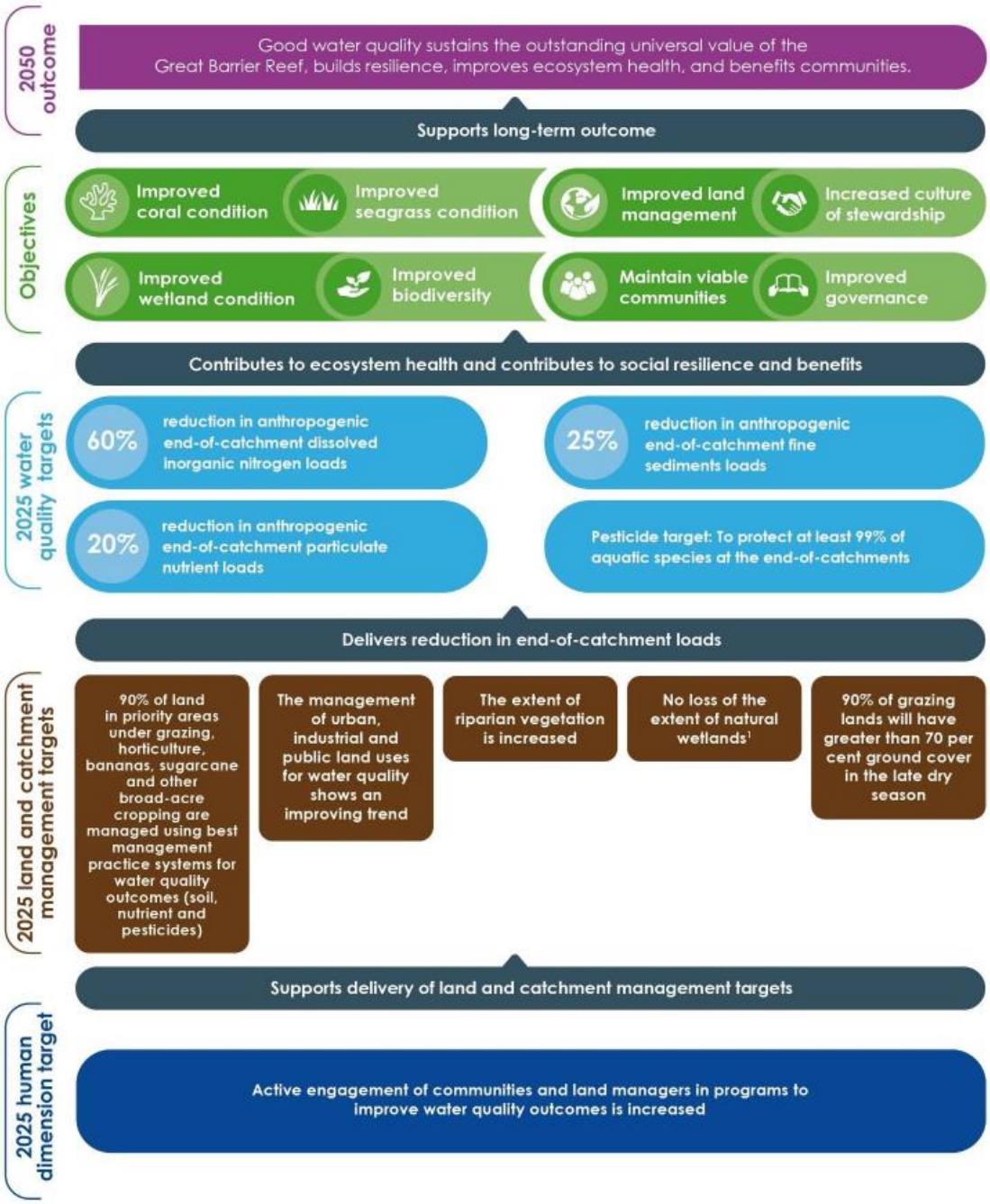

Figure 6. Framework for setting targets, objectives and outcomes under Reef 2050 WQIP to address the cumulative impacts of multiple stressors and increase the GBR's resilience to long-term threats such as climate change and ocean acidification. Source: The State of Queensland and Commonwealth of Australia (2018).

Water quality targets and implementation of Reef 2050 WQIP

The 2018 five-year evaluation of Reef 2020 WQIP noted that:

> Targets were set by using a combination of catchment modelling (to estimate reductions needed from improved land management practices) and eReefs marine water modelling (to calculate how pollutants impact the Reef). Expert scientific advice and technical knowledge

> complemented the outputs of the modelling. These targets provide an unprecedented level of scientific understanding. They are consistent with the framework of targets identified in previous plans but are now drawn from a scientific understanding of the specific water quality needs for each river catchment, based on the parts of the Reef each river affects.(The State of Queensland and Commonwealth of Australia 2018, p. 17).

Reef 2050 WQIP incorporates additional water quality targets from all main sources of water pollution (including industry and urban and public lands), while acknowledging that pollution from agriculture and sedimentation remain the biggest threats to water quality (The State of Queensland and Commonwealth of Australia 2018). The latest water quality targets are:

- 60% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads
- 20% reduction in anthropogenic end-of-catchment particulate nutrient loads
- 25% reduction in anthropogenic end-of-catchment fine sediments loads
- pesticide target: to protect at least 99% of aquatic species at the end-of-catchments.

The targets are used to track and assess the overall performance of Reef Plans. Each water quality (nutrient and sediment) target is tailored to individual catchment areas based on local data and modelling (Figure 7) (GBRMPA 2010). This provides for more accurate reporting and a more strategic determination of management priorities and investment decisions (GBRMPA 2019). Based on priorities, funding can be focused in areas where it is most needed and/or of the most benefit (Australian and Queensland Governments 2016). Assessing the effectiveness of the targets is complex, given the increase in frequency of climate change related events, such as severe storms and disease. However, modelling offsets some of this uncertainty (Gruber et al. 2019).

Another focus under Reef 2050 LTSP and Reef 2050 WQIP is to provide a more strategic and coordinated investment framework (The State of Queensland and Commonwealth of Australia 2018; Queensland Audit Office 2018). The Reef 2050 Plan Investment Framework sets aside $1.28 billion for 2015–20 including $212.4 million and $272 million towards Reef 2050 WQIP from the Australian and Queensland Governments respectively, in addition to $65.8 million from ‘other investment’ (Australian and Queensland Governments 2016). Funding is set aside for research and evaluation, governance, monitoring and reporting, and implementing minimum practice standards (Australian and Queensland Governments 2016). The primary focus for implementing minimum practice standards is through Best Management Practice Programs (BMPPs) (Queensland Audit Office 2015, 2018).

Management priority					
	Very high		Moderate		Minimal
	High		Low		Not assessed

Region	Catchment/ Basin	Area (ha)	Targets								Pesticide target to protect min 99% of aquatic species at end-of-catchment
			Dissolved inorganic nitrogen		Fine sediment		Particulate phosphorus		Particulate nitrogen		
			tonnes	% reduction	kilo-tonnes	% reduction	tonnes	% reduction	tonnes	% reduction	
Cape York	Jacky Jacky Creek	296,330	MCL	MCL	MCL	MCL	MCL	MCL	MCL	MCL	
	Olive Pascoe River	417,950	MCL	MCL	MCL	MCL	MCL	MCL	MCL	MCL	
	Lockhart River	288,330	MCL	MCL	1	2	2	2	5	2	
	Stewart River	274,280	MCL	MCL	2	6	2	6	7	6	
	Normanby River	2,439,490	MCL	MCL	15	10	5	10	15	10	
	Jeannie River	363,750	MCL	MCL	2	6	2	6	9	6	
	Endeavour River	218,240	MCL	MCL	3	10	3	10	11	10	
Wet Tropics	Daintree River	210,670	MCL	MCL	MCL	MCL	MCL	MCL	MCL	MCL	
	Mossman River	47,240	52	50	MCL	MCL	MCL	MCL	MCL	MCL	
	Barron River	218,880	52	60	MCL	MCL	MCL	MCL	MCL	MCL	
	Mulgrave-Russell River	194,400	300	70	16	10	19	10	53	10	
	Johnstone River	232,390	350	70	100	40	250	40	490	40	
	Tully River	168,350	190	50	17	20	23	20	68	20	
	Murray River	110,840	120	50	8	20	11	20	32	20	
	Herbert River	984,590	620	70	99	30	57	30	200	30	
Burdekin	Black River	105,970	ND	ND	ND	ND	ND	ND	ND	ND	
	Ross River	170,820	74	60	ND	ND	ND	ND	ND	ND	
	Haughton River	405,080	640	70	MCL	MCL	MCL	MCL	MCL	MCL	
	Burdekin River	10,310,940	100	60	840	30	440	30	720	30	
	Don River	373,620	MCL	MCL	55	30	43	30	75	30	
Mackay/ Whitsunday	Proserpine River	249,440	110	70	MCL	MCL	MCL	MCL	MCL	MCL	
	O'Connell River	238,760	130	70	96	40	120	40	250	40	
	Pioneer River	157,360	140	70	35	20	23	20	61	20	
	Plane Creek	253,870	260	70	MCL	MCL	MCL	MCL	MCL	MCL	

Figure 7. End-of-catchment anthropogenic water quality targets for Reef 2050 WQIP by 2025. Targets are set at catchment level and reflect the limits at which, if exceeded, there is deterioration in ecosystem health (as shown in Australian and Queensland Governments 2019). Priorities are based on the relative levels of risk identified in the 2017 Scientific Consensus Statement (Waterhouse et al. 2017b)

Effectiveness of the Water Quality Targets

> Despite significant efforts, the rate of voluntary adoption of best management practices by producers is not yet sufficient to achieve water quality targets. (Queensland Audit Office 2018, p. 11)

As with previous Reef Plans, Reef 2050 WQIP has relied predominantly on voluntary and industry-led BMPPs as the primary mechanism for on-the-ground actions to reduce run-off and pollution. BMPPs provide incentives (in the form of workshops, financial incentives, etc) for farmers to switch to environmentally better management practices (Queensland Audit Office 2015, 2018). However, this approach has been criticised in government audits and by a comprehensive review (Kroon et al. 2016) which considered a focus on BMPPs to be of limited effectiveness. The approach has been characterised as 'disparate projects with no central authority and no clear accountability for delivery or achievement' (Queensland Audit Office 2015, 2018).

While there is research to show that farmers who adopt BMPPs have better financial returns, issues such as upfront costs and cash-flow problems (particularly during droughts) contribute to the slow up-take of the programs (Queensland Audit Office 2015, 2018). Meaningful improvements to water quality will require changes to what and how people farm, better alignment between government policies and priorities (some of which encourage the behaviours that need to change), and greater support for farmers to implement changes (Kroon et al. 2016). The most recent government audit recommended the following improvements to the lead government department in Queensland:

- acquit actual expenditure against planned investment for Queensland's Reef Water Quality Program, in future annual investment reports, to increase transparency and accountability
- obtain reliable, timely, and adequate practice change information from relevant industry groups to understand the progress made, measure the degree of practice change, and account for outcomes for the public funds invested
- work… to refine over time the land management targets in the Reef 2050 Water Quality Improvement Plan 2017–22 to define the increase in the percentage of riparian vegetation and the increase in stakeholder engagement targeted (Queensland Audit Office 2018, p. 12).

The modest results of BMPPs are reflected in a slow rate of reduction in pollutant loads (Australian and Queensland Governments 2019; GBRMPA 2019; Queensland Audit Office 2018). Noting that this study was published prior to the most recently updated Reef Plan, Kroon et al. (2016) anticipate that even if there is full uptake of BMPPs, the measures set out in the Reef Plans may not be adequate to stem, let alone reverse, degradation to GBR.

> The proposal to broaden and enhance the existing reef protection regulations seeks to ensure that minimum practice standards are utilised across key industries and land uses in all reef catchments. (Queensland Audit Office 2018, p. 36)

The new Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Regulation 2019, which will come into effect over the next three years, is intended to improve industry record keeping and mandate compliance with industry-specific minimum practice standards (Queensland Audit Office 2018). While this regulation should improve the effectiveness of BMPPs, it is too early to comment on the effectiveness of its implementation.

> It takes a significant period of time for improved land practices to influence the condition of inshore ecosystems. (GBRMPA 2019, p. 172)

It is difficult to measure the effects of improved land management over short time periods (GBRMPA 2019). While fluctuations in natural cycles (flooding and drought events, annual variation in rainfall, etc.) are likely to disproportionately influence results over shorter time periods, there is evidence that some parts of GBR have experienced long-term declines in water quality (Gruber et al. 2019; Waterhouse et al. 2017a; Australian and Queensland Governments 2019). Adequate time is needed to directly link changes in water quality to changes in land management practices. For example, it is estimated that it will take 50 years to measure load reductions at end-of-catchments in the Burdekin and Tully catchments (Darnell et al. 2012). Until the most recent changes in monitoring, there were not enough *in situ* monitoring sites to verify modelling data, making it difficult to verify any reported improvements to water quality (Queensland Audit Office 2018).

> Key Great Barrier Reef ecosystems continue to be in poor condition. This is largely due to the collective impact of land run-off associated with …extreme weather events and climate change impacts such as the 2016 and 2017 coral bleaching events." (Waterhouse et al. 2017b, p. 7)

The latest Reef Outlook Report indicates that seagrass meadows and coral reef are in poor health and very poor health, respectively (GBRMPA 2019). This is demonstrated in Figure 8, which shows a decline in coral and seagrass health between the reporting years 2016–2017 and 2017–2018 (Australian and Queensland Governments 2019). Notably, the score for coral at Mackay Whitsunday for 2017-2018 is the lowest since monitoring began (Australian and Queensland Governments 2019). These declines in coral health were attributed to tropical cyclone Debbie and high water turbidity (Thompson et al. 2019) and long-term effects of tropical cyclone Yasi in 2011–2012 on seagrass meadows (McKenzie et al. 2019).

> Our capacity to comprehensively report on the link between concentrations of water quality parameters and end-of-catchment loads and the ability to make conclusions regarding the intensity of potential impacts of flood plumes on reef ecosystems is currently constrained by the spatial and temporal extent of water quality condition and trend data,

and the ability to differentiate water quality influences from confounding factors such as climate change, and the impact of severe storms and disease. (Australian and Queensland Governments 2019, p. 5).

Region (inshore)	Year	Coral index	Seagrass Index
Great Barrier Reef	2016-2017	43	36
	2017-2018	41	29
Cape York	2016-2017		34
	2017-2018		25
Wet Tropics	2016-2017	55	22
	2017-2018	57	36
Burdekin	2016-2017	46	54
	2017-2018	45	47
Mackay Whitsunday	2016-2017	52	33
	2017-2018	42	21
Fitzroy	2016-2017	23	24
	2017-2018	29	22
Burnett Mary	2016-2017		21
	2017-2018		19

Note: The Great Barrier Reef inshore score is the average of scores for six natural resource management regions. Grey shading indicates that there is no coral monitoring occurring in the Cape York or Burnett Mary. Values are indexed scores scaled from 0-100; ■ = very good (81-100), ■ = good (61-80), ■ = moderate (41-60), ■ = poor (21-40), ■ = very poor (0-20). NB: Scores are unitless. Data source: coral (Thompson et al. 2018, Thompson et al. 2019) and seagrass (McKenzie et al. 2018, McKenzie et al. 2019).

Figure 8. Inshore coral and seagrass scores for the Reef and natural resource management regions in 2016/17 and 2017/18. Scores summaries the health of coral and seagrass in these years. Source Australian and Queensland Governments 2019.

Improving water quality is important for increasing the GBR's resistance to the effects of climate change, such as the mass bleaching events in 2016 and 2017 (Thompson et al. 2019; Waterhouse et al. 2017b). However, certain stressors, such as sedimentation, are expected to increase in severity with more frequent extreme weather events (Gruber et al. 2019). This adds to the complexity of measuring anthropogenic based sources of water quality pollutants (Waterhouse et al. 2017a; Gruber et al. 2019) and the ability to meet water quality targets and objectives (Australian and Queensland Governments 2019). Further, while there has been an increasing recognition of these confounding issues in the recent 2050 Reef Plans, the Queensland Government lacked the relevant expertise and setup to properly action on climate change issues at the time of the 2014 Outlook Report, further delaying a response (GBRMPA 2019). This aligns with the Kroon et al. (2016) review that considered the effectiveness of the Reef Plans in addressing climate change issues was inadequate.

Conclusion

The health of the GBR ecosystems has continued to decline since 2003, largely due to poor quality water exiting adjacent catchments. Land-based pollutants reduce the resilience of the GBR to the effects of climate change, which are expected to become increasingly severe. The relationship between water quality and ecosystem health is well observed. For example, there is a correlation between rainfall, low river flows and coral recovery in the Burdekin region from 2013 to 2018 (Waterhouse et al. 2017b; Thompson et al. 2019).

The use of BMPPs as a primary mechanism for achieving water quality targets on the GBR has not been effective, largely due to slow uptake of practices and insufficient accountability for funding and reporting from farmers. Target 'goal-posts' have also been shifted in the Reef Plans, causing a lack of clear direction for farmers. These issues were highlighted in government audit reports and have resulted in more stringent regulatory measures in 2019. It is too early to comment on the effectiveness of these new measures.

3.5.3. Urban vehicle emission limits

The EU and its member states have developed a novel limits-based approach to reducing urban air pollution, a significant public health issue in cities across the EU. The approach combines product standards and city-specific spatial limits to meet EU environmental limits for air quality. Specifically, legally binding ambient air quality limits provide a driver for member states to reduce pollutant levels within their territories, while vehicle emission standards provide a mechanism for regulating the creation of emissions. In cities where ambient air quality levels breach limits, low emission zones have been established to ensure that only vehicles that meet recent emission standards can enter, thereby reducing polluting sources within the city. Research suggests that this combined approach has resulted in significant changes in the vehicle fleet and vehicle activity within low emission zones, with some indication that these changes have contributed to improvements in air quality in select cities. This section summarises the EU's limits-based approach to urban air quality management, its implementation and effectiveness.

Background

Air quality continues to be a significant environmental concern across Europe, particularly in urban areas, impacting public health and ecosystems alike. A European Commission (2017) public opinion survey found that air pollution is the second-most common environmental concern among the European public, second only to climate change. The European Environment Agency's (EEA) 2018 report describes widespread exceedances of the European air quality limits and WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide, benzene, and sulphur dioxide in 2016, while noting that some concentrations are decreasing. The report states that air pollution levels (especially particulate matter, ozone, and nitrogen dioxide) continue to have a significant impact on human health, particularly within

urban areas, resulting in premature deaths, increased medical costs, and lost productivity. In 2015, exposure to $PM_{2.5}$ alone was estimated to have been responsible for 422,000 premature deaths in Europe (EEA 2018). Air pollution also has detrimental effects on vegetation, fauna, water and soil quality, and wider ecosystem functioning.

Air quality issues are most common in urban areas in Europe, with pollutant emissions from transport being a main contributor to exceedances of air quality limits (Transport & Environment 2019). The EU has consequently developed a series of regulatory interventions to address air pollution—and specifically vehicle-related urban pollutants—as described below.

Ambient air quality limits

Since 1996, the EU has established a series of air quality directives that set ambient air quality standards to provide protection from specified pollutants across the EU. The most recent Ambient Air Quality Directive (2008/50/EC), adopted in 2008, consolidated previous directives and set objectives for fine particulate matter (PM2.5). It aims to control emissions from mobile sources, improve fuel quality, and integrate environmental protection requirements into the transport, industrial, and energy sectors. The Directive establishes health-based air quality standards and objectives for sulphur dioxide, nitrogen dioxide, PM_{10}, $PM_{2.5}$, lead, benzene, ozone and carbon monoxide. In most cases, the standards establish a limit value that must be achieved by a set date[12] while allowing for a limited number of exceedances. However, for $PM_{2.5}$ and ozone, authorities are required to take all necessary measures to attain the targets, but these are less strict than a limit value. Recognising that there is no 'safe' level for $PM_{2.5}$, the Directive also set objectives for average $PM_{2.5}$ exposure across the general population.

The Ambient Air Quality Directive is implemented by member states, who divide their territory into zones and then assess air pollution levels in the zones using measurements, modelling and other empirical techniques. Member states are required to report their air quality data to the European Commission. Where pollutant levels exceed limit or target values, member states are obliged to prepare an air quality plan or programme to address the pollutant sources and ensure compliance with the limits by the specified date. Member states can apply to the EC for 3- or 5-year extensions, dependent on local conditions.

The Directive has resulted in the development of further EU standards and directives, as well as member state plans and measures to reduce pollutants consistent with the air quality limits. The EEA (2018) states that most measures reported in the last 3 years address PM_{10} and NO_2 concentrations and focus on the road transport sector.

[12] Under EU law, a limit value is legally binding from the date it enters into force.

Two key approaches to reducing transport sector air pollutant emissions—at the EU and city scale, respectively—are described below.

Vehicle emission standards

Air pollutant emissions from transport are regulated in the EU through vehicle emission standards, which define the limits for emissions of specific pollutants for new vehicles sold in the European Union. Directive 2007/46/EC provides a harmonised legal framework for the approval of motor vehicles and their parts across the EU, under which regulations are developed to specify type approvals, vehicle maintenance, and emissions testing, among other matters. The 'Euro' standards set out in regulations define the emission limits for cars, vans trucks, buses and coaches for regulated pollutants, including emissions of particulate matter, nitrogen oxides (NOx), unburnt hydrocarbons and carbon monoxide. Successive regulations since the 1990s have introduced stricter limits for vehicle emissions, so that more recently produced cars are required to meet higher emissions standards. Over time, these regulations are expected to result in a lower-emission vehicle fleet, contributing to efforts to reduce transport related pollutants and meet EU air quality limits. The latest Euro standards, which came into force in 2014, are Euro 6 for light-duty vehicles and Euro VI for heavy-duty vehicles.

Low emission zones

Ongoing issues with exceeding the air quality standards has led many EU member states and/or cities to establish 'Low Emission Zones' (LEZs, also known as Green Zones or Environmental Zones) around their largest and most polluted cities or regions. They were developed to reduce vehicle related pollutants, specifically particulate emissions, nitrogen dioxide, and ozone (though indirectly). Vehicles entering such zones are required to acquire a permit (often a badge that goes on the car) that certifies that they meet a specific Euro vehicle emission standard. Only vehicles that meet the Euro standard are legally allowed to travel within the zone, and vehicles found without the right permits risk large fines. Some cities are now considering Zero Emission Zones, within which only zero emission electric cars and buses, bikes, and pedestrians would be allowed to travel.

According to Transport and Environment (2019) there are now more than 250 cities in the EU that restrict access for polluting vehicles, although cities' restrictions and implementation vary widely (see Urban Access Regulations in Europe 2007). In some cities, restrictions only apply to heavy duty vehicles, while in others they apply to all vehicles; similarly, some LEZs require vehicles that do not meet the standard to pay a fee, while other LEZs prohibit access by such vehicles. Transport and Environment (2019) emphasise that LEZ design—including the size of the zone, stringency of entry requirements, enforcement, and range of exemptions—significantly shapes the effectiveness of LEZs.

Germany provides a useful case study of the design and implementation of LEZs, as an early and widespread adopter of the approach. In Germany, cities and municipalities are responsible for the establishment of LEZs, which they set out in clean air plans. According to Holman et al. (2015) approximately 70 LEZs have been established in German cities or regions. To enter these zones, vehicles must bear a green environmental badge, certifying that they meet the Euro 4 vehicle emission standard or higher. The environmental badge is mandatory for all vehicles except light vehicles such as mopeds and motorcycles. Vehicles entering a LEZ without the correct environmental badge can be fined 100 Euros or more.

The green environment badge was primarily developed to reduce particulate matter pollution in German urban areas. However, increasing levels of nitrous oxides in cities—largely associated with diesel vehicles—has resulted in the extension of Germany's LEZ framework to target NOx emissions. Since 2018 Germany has begun to establish 'blue' LEZs in some cities, in addition to existing 'green' LEZs, to regulate the movement of diesel vehicles in areas where NOx emissions exceed EU air quality limits. Cities and municipalities may institute a general driving ban for diesel vehicles within the blue zone, or require vehicles to bear a blue badge certifying that they meet higher vehicle emission standards (Euro 5 or 6, see European Eco Service 2020a). At present, blue LEZs have been established in a handful of German cities, including Berlin in 2019 (see European Eco Service 2020b), but their implementation has been slowed by a series of court challenges.

Effectiveness of urban vehicle emission limits

Evidence of the effectiveness of LEZs in improving urban air quality varies significantly, with some studies claiming significant reductions in vehicle-related pollutants (see Holman et al. 2015), while others found small to negligible reductions (see Morfeld et al. 2015). Reviews highlight that it is difficult to disentangle any changes resulting from LEZs from the effects of other air quality initiatives in a region, while local environmental conditions, external pollutant sources, and weather variability can further complicate the detection of a LEZ effect signal in air quality data (see Holman et al. 2015; Transport & Environment 2019). In addition, variability in LEZ design and enforcement across member states and individual cities can make it difficult to detect any trend in air quality outcomes across LEZs.

The effectiveness of LEZs on nitrogen oxide emissions has been further complicated by the 2015 vehicle emissions testing controversy, in which significant differences were detected between the factory and real-world performance of diesel vehicles. Since then, new regulations have revised vehicle testing requirements to ensure that all new vehicles meet real-world emissions standards. Until highly polluting cars in the existing vehicle fleet can be removed or upgraded, they will continue to degrade air quality in cities.

Nevertheless, there is substantial evidence that LEZs are contributing to reductions in the concentration of particulate matter, NOx, and ozone in cities across Europe, although the scale of this contribution is debated. For example, a review by Holman et al. (2015) found that implementation of LEZs in German cities contributed to reductions in annual mean PM_{10} and NO_2 concentrations up to 7% and 4% respectively. They explain that 'a LEZ essentially introduces a step change in the normal fleet turnover, resulting in lower emissions than would have occurred without the LEZ. Over time the fleet emissions will become similar to those that would have occurred without the LEZ. For further benefits it is necessary to periodically tighten the scheme's criteria' (p.162). Transport & Environment (2019) similarly conclude that LEZs can be effective at reducing air pollution if well designed, but that 'the reductions observed so far are insufficient to reduce air pollution below legal limits all over the EU' (p. 7). They therefore argue that cities' LEZ policies must be strengthened, with a shift from low to zero emission zones that promote wider uptake of zero-emission forms of transport (including public transport, electric vehicles, and active transport).

3.5.4. European Union and Canadian biodiversity strategies

National biodiversity strategies and action plans are the primary instrument for implementing the global strategic plan for biodiversity 2011–2020 adopted at the 2010 Conference of Parties. The global plan was developed to combat biodiversity loss over the next decade and defined 20 concrete targets, known as the Aichi targets, in order to achieve this overall objective. Parties regularly report on progress towards the targets. This section summarises the structure and progress to date for two national biodiversity strategies—the EU biodiversity strategy (adopted in 2011) and Canada's 2020 biodiversity goals and targets (adopted in 2015). As an early adopter for the global strategic plan, the EU case study provides insight into the performance of national strategies over a longer period, while the Canadian case study provides insight into how Indigenous peoples' biodiversity objectives can be integrated into national goals and targets.

The EU adopted its national biodiversity strategy in 2011. The strategy set out 6 measurable targets and 20 actions (Table 6) to 'halt the loss of biodiversity and ecosystem services by 2020, to restore ecosystems in so far as is feasible, and to step up the EU contribution to averting global biodiversity loss' (European Commission 2011 p. 6). The targets focus on the main drivers of biodiversity loss:

- protect species and habitats
- maintain and restore ecosystems
- achieve more sustainable agriculture and forestry
- make fishing more sustainable and seas healthier
- combat invasive species
- help stop the loss of global biodiversity.

Notably, these targets seek to not only protect and improve areas of biodiversity value, but also integrate biodiversity imperatives into sectoral policies (e.g. forestry). The strategy also recognises the importance of retaining and improving ecosystem services for the benefit of society and the economy. Implementation of the EU Biodiversity Strategy was noted to require the growth and more efficient use of financial resources, building effective partnerships with business and societal organisations, and the development of a common implementation framework with Member States. The 2015 mid-term review of the EU Biodiversity Strategy provides an assessment of progress on the implementation of the strategy and its outcomes for biodiversity (European Commission 2015). While there is evidence of progress towards most targets, the level of progress to date is insufficient to meet the targets by 2020. Only efforts to combat invasive alien species were found to be on track to meet targets, while no significant progress was reported for agriculture and forestry's contribution to maintaining biodiversity. The 2015 assessment highlighted that the conservation status of a high proportion of species and habitats in the EU are unfavourable, and that the five key threats to biodiversity continue to exert pressure on biodiversity.

Canada adopted its 2020 biodiversity goals and targets in 2015, building on the earlier Canadian Biodiversity Strategy (Government of Canada 1995). The four goals and 19 targets (Table 7, Environment & Climate Change Canada 2016) were developed collaboratively by federal and provincial/territorial governments, with input from Indigenous organisations and governments and stakeholder groups. The implementation of the goals and targets is similarly expected to be collaborative across governance scales, and involve collective action by citizens, businesses, and community organisations. The four goals focus on:

- ecosystem-based approaches to land and water management
- reducing pressures on biodiversity
- sustainable biological resource use
- improving information on biodiversity and ecosystem services
- public education and engagement.

Targets range from the conservation of set percentages of different ecotypes, to the sustainable management of specific natural resource sectors, improved engagement and outcomes for Indigenous peoples, and enhanced scientific information and reporting. Each target is supported by one or more quantitative indicators that were developed to align with Canada's existing environmental indicators to ensure robust reporting of progress. In 2019, Canada reported on its progress on its national biodiversity targets, finding that it was on track to achieve its targets in over half of all cases, and making progress but at an insufficient rate in most others. The report states that 'while important steps have been taken by Canadian governments and their partners in recent years, progress has been somewhat slower with regard to the

recovery of species at risk, ecosystem-based management of fisheries, and reducing pollution levels in Canadian waters. These will continue to be areas of shared focus in Canada moving forward' (Environment & Climate Change Canada 2019, p. 3).

Two targets focus on improving biodiversity outcomes for Canada's Indigenous peoples through maintaining customary use of biological resources and promotion of traditional knowledge, including in biodiversity conservation and management. However, implementation strategies to meet these targets remain unclear, apart from supporting and learning from existing initiatives. One example of Indigenous-Crown co-management to promote the conservation and Indigenous use of a threatened species is the Beverly and Qamanirjuaq Caribou Management Board, which has been operating since 1982 (and is cited in the 1995 Biodiversity Strategy). The Board is intended to provide a means to address the multi-jurisdictional nature of caribou herds and the range of cultures who depend on them while including Indigenous peoples in decision-making processes. In 2014, the Board released its fourth caribou management plan, outlining principles and goals for caribou conservation through till 2022. Despite these sustained efforts, the Board's 2018-19 implementation report states that both the Beverly and Qamanirjuaq caribou herds continue to decline.

Table 6. Summary of targets and actions in the EU Biodiversity Strategy to 2020, with progress status from the 2015 mid-term review. Progress towards targets is colour coded: Green indicates that the government is on track to achieve targets; blue indicates progress towards targets but at an insufficient rate; and purple indicates no significant overall progress.

Goal	Targets	Actions	Progress (2015)
Fully implement the Birds and Habitats Directives	By 2020, compared with current assessments: (i) 100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status; and (ii) 50% more species assessments under the Birds Directive show a secure or improved status.	1. Complete the establishment of the Natura 2000 Network and ensure good management 2. Ensure adequate financing of Natura 2000 sites 3. Increase stakeholder awareness and involvement and improve enforcement 4. Improve and streamline monitoring and reporting	**Insufficient progress**
Maintain and restore ecosystems and their services	By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems.	1. Improve knowledge of ecosystems and their services in the EU 2. Set priorities to restore and promote the use of green infrastructure 3. Ensure no net loss of biodiversity and ecosystem services	**Insufficient progress**
Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity	**Agriculture:** By 2020, maximise areas under agriculture that are covered by biodiversity-related measures so as to ensure the conservation of biodiversity and to bring about a measurable improvement in the conservation status of species and habitats that depend on or are affected by agriculture and in the provision of ecosystem services as compared to the EU2010 Baseline. **Forests:** By 2020, Forest Management Plans or equivalent instruments are in place for all forests that are publicly owned or receive EU funding so as to bring about a measurable improvement in the conservation status of species and habitats that depend on or are affected by forestry and in the provision of related ecosystem services as compared to the EU2010 Baseline.	1. Enhance direct payments for environmental public goods in the EU Common Agricultural Policy 2. Better target Rural Development to biodiversity conservation 3. Conserve Europe's agricultural genetic diversity 4. Encourage forest holders to protect and enhance forest biodiversity 5. Integrate biodiversity measures in forest management plans	**No significant progress**
Ensure the sustainable use of fisheries resources	Achieve Maximum Sustainable Yield (MSY) by 2015. Achieve a population age and size distribution indicative of a healthy stock, through fisheries management with no significant adverse impacts on other stocks, species and	1. Improve the management of fished stocks 2. Eliminate adverse impacts on fish stocks, species, habitats and ecosystems	**Insufficient progress**

Goal	Targets	Actions	Progress (2015)
	ecosystems, in support of achieving Good Environmental Status by 2020.		
Combat Invasive Alien Species	By 2020, Invasive Alien Species (IAS) and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS.	1. Strengthen the EU Plant and Animal Health Regimes 2. Establish a dedicated legislative instrument on Invasive Alien Species	**On track**
Help avert global biodiversity loss	By 2020, the EU has stepped up its contribution to averting global biodiversity loss	1. Reduce indirect drivers of biodiversity loss 2. Mobilise additional resources for global biodiversity conservation 3. 'Biodiversity-proof' EU development cooperation 4. Regulate access to genetic resources and the fair and equitable sharing of benefits arising from their use	**Insufficient progress**

Table 7. 2020 Biodiversity Goals and Targets for Canada, with progress status from the 2018 review. Progress towards targets is colour coded: Green indicates that the government is on track to achieve targets; blue indicates progress towards targets but at an insufficient rate.

Goals: By 2020…	Targets: By 2020…	Progress (2018)
Canada's lands and waters are planned and managed using an ecosystem approach to support biodiversity conservation outcomes at local, regional and national scales.	At least 17 percent of terrestrial areas and inland water, and 10 percent of coastal and marine areas, are conserved through networks of protected areas and other effective area-based conservation measures.	Terrestrial: **Insufficient progress** Marine: **On track**
	Species that are secure remain secure, and populations of species at risk listed under federal law exhibit trends that are consistent with recovery strategies and management plans.	**Insufficient progress**
	Canada's wetlands are conserved or enhanced to sustain their ecosystem services through retention, restoration and management activities.	**On track**
	Biodiversity considerations are integrated into municipal planning and activities of major municipalities across Canada.	**On track**
	The ability of Canadian ecological systems to adapt to climate change is better understood, and priority adaptation measures are underway.	**On track**
Direct and indirect pressures as well as cumulative effects on biodiversity are reduced, and production and consumption of Canada's biological resources are more sustainable.	Continued progress is made on the sustainable management of Canada's forests.	**On track**
	Agricultural working landscapes provide a stable or improved level of biodiversity and habitat capacity.	**On track**
	all aquaculture in Canada is managed under a science-based regime that promotes the sustainable use of aquatic resources (including marine, freshwater and land based) in ways that conserve biodiversity.	**On track**
	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem-based approaches.	**Insufficient progress**
	Pollution levels in Canadian waters, including pollution from excess nutrients, are reduced or maintained at levels that support healthy aquatic ecosystems.	**Insufficient progress**
	Pathways of invasive alien species introductions are identified, and risk-based intervention or management plans are in place for priority pathways and species.	**On track**
	Customary use by Aboriginal peoples of biological resources is maintained, compatible with their conservation and sustainable use.	**Unknown**
	Innovative mechanisms for fostering the conservation and sustainable use of biodiversity are developed and applied.	**On track**
Canadians have adequate and relevant information about	The science base for biodiversity is enhanced and knowledge of biodiversity is better integrated and more accessible.	**Insufficient progress**

Goals: By 2020…	Targets: By 2020…	Progress (2018)
biodiversity and ecosystem services to support conservation planning and decision-making.	Aboriginal traditional knowledge is respected, promoted and, where made available by Aboriginal peoples, regularly, meaningfully and effectively informing biodiversity conservation and management decision-making.	**Insufficient progress**
	Canada has a comprehensive inventory of protected spaces that includes private conservation areas.	**Insufficient progress**
	Measures of natural capital related to biodiversity and ecosystem services are developed on a national scale, and progress is made in integrating them into Canada's national statistical system.	**On track**
Canadians are informed about the value of nature and more actively engaged in its stewardship.	Biodiversity is integrated into the elementary and secondary school curricula.	**On track**
	More Canadians get out into nature and participate in biodiversity conservation activities.	**On track**

3.5.5. Farmland protection in the United States

Soil conservation and land protection programmes in the United States have been motivated by concern for maintaining the productive capacity of land and by other objectives that have varied over time. Periodically, low commodity prices and farm incomes, alongside concerns about off-site effects of soil erosion, have motivated programmes that pay farmers to retire land from production for 10 to 15 years (McLeman et al. 2014; Coppess 2014). Somewhat paradoxically, periods of high prices and concerns about food security have also led to programmes aimed at keeping land in agricultural use.

By 2010, all 50 states had at least one farmland protection program. Programs included tax concessions, agricultural protection zoning (APZ), and the purchase of development rights (PDR). In some states, agricultural land is taxed based on its value for agriculture rather than on its value for development. This reduces the pressure on farmers to sell land in order to pay high taxes driven by development value. APZ protects farmland through zoning by discouraging other uses, which also reduces tax assessments. However, neither tax concessions nor zoning offer permanent protection (Oberholtzer et al. 2010).

PDR programmes have gained favour because they protect land through perpetual easements. As of January 2019, 28 states had active PDR programs. Some states purchase and hold easements directly, some acquire easements jointly with partners (e.g. county governments), and other states only provide grants to eligible entities, such as local governments and land trusts. Across the United States, approximately US$7.0 billion (NZ$12.7b) has been spent to protect 3 million acres (1.2 million hectares) through more than 16,000 easements (Farmland Information Center 2020). Many of these purchases have received matching funding from the US Department of Agriculture (Farmland Information Center 2020).

PDR programmes have also had mixed reviews. They are applauded for providing permanent protection but criticised because states have had inconsistent and incomplete monitoring of compliance with easement conditions (Bills 2007). The overall effectiveness of these programmes is therefore unknown.

The US federal government also funds several schemes for protection of environmentally sensitive land. By 2015, more than 30 million acres (~12% of US cropland) were receiving payments for at least one soil health practice (Bowman et al. 2019). Another 23 million acres are currently retired from production under 10- to 15-year contracts via the Conservation Reserve Program (CRP) (Claassen 2019), down from a peak of 36.8 million acres in 2007 (Hellerstein et al. 2019). Increasingly, the CRP funds retirement of high-priority areas such as filter strips and grass waterways, rather than whole-field or whole-farm enrolments (Claassen 2019). As a result of these various programmes, between 1982 and 2012, water and wind erosion on

cultivated cropland declined by 45 percent (Bowman et al. 2019). However, when commodity prices rise, land retirement schemes become less attractive and land in expiring CRP contracts often returns to production (Bigelow et al. 2020).

Discussion

US programmes have been successful at reducing soil erosion and, in some states, discouraging development of prime agricultural land. They have been motivated by several different concerns: the capacity for food production for domestic and export markets, water and air pollution from agriculture and, at times, by attempts to raise commodity prices and farm incomes.

These land protection programmes do not have targets based on global or national limits or requirements. One 1980 study that attempted to estimate how much cropland the US would need in 2000 got results that ranged widely depending on assumptions about productivity growth and price changes (Plaut 1980).

In recent years, concern about food security has become part of a wider discussion about the so-called food-water-energy nexus, e.g. ‘Greater policy coherence among the three sectors is critical for decoupling increased food production from water and energy intensity and moving to a sustainable and efficient use of resources’ (Rasul 2016, p. 1, though see also Wichelns 2017). This nexus makes any attempt to derive global or national targets for land protection even more challenging, because such targets would need to address water and energy requirements as well as food supply.

Even more fundamentally, some scholars have argued for many years that there is no world food problem per se, but rather a lack of access to food due to poverty, war and localised droughts and other natural disasters (e.g. see Griffin 1987). From this perspective, the world is able to produce more than enough food on the land available. Policy to reduce hunger would be better focussed on addressing social inequity and conflict than on protecting land for agricultural production in developed countries.

Conclusion

The United States has relied upon generous government funding to help farmers reduce soil erosion and protect agricultural land from development. While this has had clear environmental benefits, there have been no guiding targets or limits based on global or national food security. Given interactions with water and energy policy, and other drivers of food shortages in other countries, food security goals are unlikely to be a useful basis for deriving targets or limits for protection of agricultural land.

Like the United States, New Zealand has a large amount of productive agricultural land and exports billions of dollars of food products each year—the ability of the country to feed itself is not in doubt—and global food security has complex drivers, not just the amount of land available for food production. This suggests that New Zealand

government policies concerning land use and land use change would best be focussed on addressing biodiversity and carbon storage, off-site effects of sediment and nutrient loss from agricultural lands, and effects of land use change on local communities, rather than attempting to derive policy objectives for land from concepts of global limits or planetary boundaries.

3.5.6. Urban environment (Vancouver's Greenest City Action Plan)

Vancouver is one of several cities worldwide to develop urban sustainability goals and plans to become the greenest city in the world. Building on a history of sustainable policies and initiatives, Vancouver adopted its Greenest City 2020 Action Plan in 2011 and updated it in 2015. The action plan comprises ten goals, 15 targets, and 125 priority actions that together would make Vancouver the world's greenest city. While the plan is clearly aspirational in nature, it provides useful insights for how a limits and targets framework might be applied to urban areas. Many of the targets are underpinned by an awareness of the Earth's limited resources and assimilative capacity, the concentrated pressures that cities place on environmental systems, and the consequent need to reduce urban impacts in line with local and global environmental limits. At the same time, other targets are driven by the imperative to improve socio-ecological wellbeing, providing improved outcomes for urban citizens and ecosystems. The Vancouver case study therefore provides a useful (albeit imperfect) model for the incorporation of both social bottom lines and environmental limits in urban environmental targets, as advocated by the safe and just operating space framework.

Background

In 2009, the City of Vancouver commenced work on its Greenest City Action Plan (GCAP), bringing together a group of local experts (the 'Greenest City Action Team') to research best practices from cities around the world and identify the goals and targets that would make Vancouver the world's greenest city. The City of Vancouver (2012) argued that the new planning initiative was necessary to address the joint challenges of a 'growing population, climate uncertainty, rising fossil fuel prices, and shifting economic opportunities' in order 'to remain one of the best places in the world in which to live' (2012, p. 5). The GCAP notes that Vancouver's ecological footprint is three times larger than the Earth can sustain, with residents using more than their fair share of the Earth's resources. However, the overall tone of the Greenest City initiative is positive, emphasising the opportunities and benefits that sustainable urban living will generate:

> Fortunately, there are many solutions that address climate change and other environmental challenges while creating green jobs, strengthening our community, increasing the liveability of our city and improving the well-being of our citizens. In particular, the green economy is rapidly expanding and Vancouver is ready to take advantage of this opportunity. (City of Vancouver 2012, p. 5)

Academic commentators highlight that Vancouver's Greenest City initiative was an attempt to cultivate a sustainable brand that would attract people and investments to the city. Vanwhynsberg et al. (2012) and McCann (2013) note that the GCAP leveraged the sustainable business and innovation branding developed during the 2010 Winter Olympics (hosted in Vancouver) to promote Vancouver as a leader in sustainable urbanism. Such branding is aimed at presenting the city both as a green destination for investment in the neoliberalising global economy (Soron 2012), and as a green champion to local residents and policy makers elsewhere, encouraging buy-in to and replication of Vancouver's greenest city policies (McCann 2013; Affolderbach & Schulz 2017). Researchers argue that the Greenest City initiatives' competing economic and ecological objectives (Soron 2012) and external versus local audiences (Affolderbach & Schulz 2017) constitute challenges to the city's achievement of more radical transformations towards urban sustainability.

Greenest City Action Plan

The Greenest City initiative is notable for the city's sustained commitment to achieving its environmental targets over a period of more than 10 years, including widespread public consultation, regular reporting on progress, and a mid-way update to the GCAP. The plan's development itself was a significant undertaking, involving more than 60 city staff and 120 organisations, and generated ideas and feedback from over 9,500 people. The plan set out 10 goals with 15 measurable targets (see Table 8), and 125 priority actions to be implemented by the end of 2014. Many of the goals and targets focus on minimising urban impacts in recognition of environmental limits (e.g. zero waste), while others are geared towards improving socio-ecological wellbeing in cities (e.g. local food). The priority actions vary considerably, including the creation of new programs, policies, funds, and infrastructure by the city council, as well as the formation of partnerships with businesses, non-profits, and community organisations in Vancouver.

The GCAP has ten main sections, each focused on one goal. Each section includes a discussion of the targets, baseline numbers, priority actions, key strategies to 2020, and what it will take to achieve the targets for that goal. The city has also explicitly attempted to integrate the goals by acknowledging their interconnections through the creation of green jobs and contributions to reducing Vancouver's ecological footprint (see Part Two, 2015).

Table 8. Goals and targets in Vancouver's Greenest City 2020 Action Plan, with progress on targets reported in the City of Vancouver's 2018-19 implementation update.

Goal	Targets	Progress (2018)
Green economy: Secure Vancouver's international reputation as a mecca of green enterprise.	1. Double the number of green jobs over 2010 levels by 2020. 2. Double the number of companies that are actively engaged in greening their operations over 2011 levels by 2020.	**On track:** 1. Number of green jobs increased by 35% between 2010–2016. 2. The percentage of businesses engaged in greening their operations increased from 5% to 9% between 2011–2017.
Climate leadership: Eliminate Vancouver's dependence on fossil fuels	1. Reduce community-based greenhouse gas emissions by 33% from 2007 levels.	**Not met:** 1. Community CO_2 equivalent emissions declined by 12% between 2007–2018
Green buildings: Lead the world in green building design and construction	1. Require all buildings constructed from 2020 onward to be carbon neutral in operations. 2. Reduce energy use and greenhouse gas emissions in existing buildings by 20% over 2007 levels.	**Not met:** 1. CO_2 equivalent emissions per square metre of new floor area declined by 43% between 2007–2017. 2. CO_2 equivalent emissions from all community buildings declined by 11% between 2007–2018.
Green transportation: Make walking, cycling and public transit preferred transportation options	1. Make the majority (over 50%) of trips by foot, bicycle, and public transit. 2. Reduce average distance driven per resident by 20% from 2007 levels.	**Met:** 1. In 2018 53% of trips were made by foot, bike, or transit 2. Vehicle kilometres driven per person declined by 38% between 2007–2018.
Zero waste: Create zero waste	1. Reduce solid waste going to the landfill or incinerator by 50% from 2008 levels.	**Not met:** 1. Annual tonnes of solid waste sent to landfill or incinerator declined by 28% between 2007–2018.
Access to nature: Vancouver residents will enjoy incomparable access to green spaces, including the world's most spectacular urban forest	1. All Vancouver residents live within a five-minute walk of a park, greenway, or other green space by 2020. 2. Plant 150,000 new trees by 2020.	**Not met:** 1. City land within a 5-minute walk to a green space increased by only 0.1% between 2010–2018. This is despite the restoration or enhancement of 27 ha of natural area over 2010–2018 **On track:** 2. 122,000 new trees were planted by 2018.
Lighter footprint: Achieve a one-planet ecological footprint	1. Reduce Vancouver's ecological footprint by 33% over 2006 levels.	**On track:** 1. Total global hectares per capita decreased by 20% between 2006–2015*
Clean water: Vancouver will have the best drinking	1. Meet or beat the strongest of British Columbian, Canadian, and appropriate international	**Met:** 1. There were zero instances of not meeting drinking

Goal	Targets	Progress (2018)
water of any city in the world	drinking water quality standards and guidelines. 2. Reduce per capita water consumption by 33% from 2006 levels.	water quality standards in 2018 **Not met:** 2. Water consumption per capita decreased by 22% between 2006–2018.
Clean air: Breathe the cleanest air of any major city in the world	1. Always meet or beat the most stringent air quality guidelines from Metro Vancouver, British Columbia, Canada, and the World Health Organization	**Not met, worsening:** 1. There were 227 instances of not meeting of air quality standards for O_3, $PM_{2.5}$, NO_2 and SO_2 at the downtown monitoring station in 2018, up from 27 in 2008.
Local food: Vancouver will become a global leader in urban food systems	1. Increase city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels.	**On track:** 1. The number of neighbourhood food assets increased by 49% between 2010–2018.

* The city notes that measuring Vancouver's ecological footprint is complex and data-limited. They have consequently begun measuring the number of 'people empowered to take action' to reduce their environmental footprint in addition. The city reports that 28,500 additional people were empowered by a city-led or city-supported project to take personal action in support of a Greenest City goal and/or to reduce levels of consumption between 2011–2018.

By 2015, more than 80% of the priority actions had been implemented, while the remaining 20% had proven too costly or unnecessary. City staff therefore reviewed and revised the GCAP, drawing on the expertise of over 300 advisors to identify 50 priority actions for 2015–2020. The City again sought public feedback on the proposed actions, gathering input from over 850 people. The Greenest City 2020 Action Plan Part Two: 2015–2020 had several key differences from the original plan.

First, it added several new Greenest City targets (Table 9), building on the experience and knowledge gained over the last four years. In particular, Part Two proposed more ambitious 2050 climate change targets in line with the City's commitment (in March 2015) to move the city towards deriving 100% of its energy from renewable sources by 2050. Second, it introduced an 11th goal—to green the City of Vancouver's operations, in recognition that the City must 'walk the talk' in reducing its environmental impact. The 11th goal is supported by three corresponding targets and priority actions. Third, Part Two goes beyond identifying priority actions to also specify advocacy items, wherein the City of Vancouver commits to petitioning other levels of government to develop policies, create funds, or implement actions that will help to achieve the greenest city goals. These advocacy agendas recognise that achieving the goals and targets will require coordinated effort across multiple government agencies and other organisations.

Table 9. New goal and targets introduced in the Greenest City Action Plan update—Part Two: 2015–2020.

Goal	Additional targets
Climate leadership	2050 targets: 1. Derive 100% of the energy used in Vancouver from renewable sources. 2. Reduce greenhouse gas emissions by 80% below 2007 levels.
Green transportation	2040 target: 1. Make at least two thirds of all trips by foot, bike and public transit.
Access to nature	2050 target: 1. Increase canopy cover to 22%.
Green operations	2020 targets: 1. Zero carbon: 50% reduction in greenhouse gas emissions from city operations over 2007 levels. 2. Zero waste: 70% waste diversion in public-facing city facilities, and 90% waste diversion in all other city-owned facilities. 3. Healthy ecosystems: reduce water use in city operations by 33% over 2006 levels.

The City of Vancouver produces annual implementation update reports and annual progress updates to council. These reports describe the priority actions completed to date, measures of progress towards targets, and contextual information for the interpretation of trends.

Discussion

Overall, implementation reports and progress updates suggest that the GCAP has been partly successful, although progress on targets varies considerably across the 11 goals. The 2015 'Part Two' update stated that 80 percent of the 2012–2014 priority actions were complete, including:

- passing a green building code
- expanding the City's walking and cycling network
- creating a fund for community-led projects
- restoring beaches, shorelines and waterfronts
- opposing several proposed fossil fuel projects
- banning future coal facilities
- creating complementary strategies and plans to support achievement of specific goals (e.g. Urban Forest Strategy).

The 2018–19 implementation report provides a clear indication of progress against the targets and are shown in graphical form on the city's website. As summarised in Table 8, recent measurements suggest that Vancouver is unlikely to meet approximately half its Greenest City targets, has met three targets, and was on track to meet the remainder of its targets in 2018. In one instance—clean air—the current

measurements are worse than baseline conditions, due in large part to exceptional fire seasons in recent years.

The mixed success of Vancouver's GCAP approach in implementing priority actions, meeting urban sustainability targets, and thus keeping within environmental and social bottom lines suggests that action planning can be a useful though not sufficient approach to achieving urban environmental objectives. The city itself noted that it had limited jurisdiction to achieve many of its goals, because success depended on actions by other levels of government, residents, and businesses (City of Vancouver 2015). The repeated air quality exceedances due to wildfires outside Vancouver provide a clear example of where the drivers of and ability to mitigate environmental change exceed the jurisdiction of the city government. Similarly, the introduction of 'advocacy' items in Part Two reflects the need for higher level changes in rules and funding for the city to implement its Greenest City agenda. These challenges highlight the importance of coordinating policy and planning across multiple levels of government, so that higher levels of government create an enabling environment for the implementation of local and agency action plans.

The Vancouver case study further suggests that target-based action planning can provide an effective way of prioritising sustainable urban investments and policy making, but that the scope of changes in environmental outcomes is limited by local government capability. It is notable that the targets on which the city has made the most progress are those under the city and regional governments' jurisdiction, and where Vancouver already had a history of green initiatives and investments.

Vancouver's achievement of its green transportation targets built on existing investments in walking, cycling, and transit infrastructure, following the city's adoption of a comprehensive transport plan in 1997. Similarly, the City regularly reports zero instances of exceeding the drinking water quality standards due to the early protection of the watersheds feeding the city's reservoirs. Conversely, while Vancouver has made significant investments into renewable forms of energy (such as the Southeast False Creek energy utility) and waste diversion, meeting these targets relies on the overhaul of supply chains and infrastructure, and/or widespread changes in consumer behaviour. The City of Vancouver also encountered resident opposition to the conversion of suburban land to green spaces and the installation of water meters to reduce water consumption (City of Vancouver 2015). As noted earlier, Soron (2012) and Affolderbach and Schulz (2017) further suggest that city governments' achievement of socio-ecological targets may also be limited by their competing political and economic priorities. Local target setting is therefore most likely to be effective where targets align with existing social and political priorities, investments, and government capacity.

The City of Vancouver's approach to target setting provides several additional lessons for environmental limit and target frameworks more generally. First, the Greenest City

targets provide a model for SMART urban environment targets. All of the targets use easily understood quantitative measures of progress over a set time period and are closely aligned with indicators that use (in most cases) existing data sources. For example, the 2020 target 'all Vancouver residents live within a five-minute walk of a park, greenway or other green space" is measured using the indicator "percent of city's land base within a five minute walk to a green space', analysed using the City's GIS database. The target and indicator framework therefore provides for annual public reporting on progress towards targets, an important accountability mechanism.

Second, the GCAP provides a model for combining local priorities and global issues within a target-setting framework. The plan responds to global environmental issues and responsibilities through the inclusion of climate leadership and ecological footprint goals, as well as locally relevant green economy, green transportation, and green building goals that all contribute towards reducing the city's greenhouse gas emissions and footprint.

Finally, the Greenest City targets provide a model for integrating social and environmental wellbeing indicators within a single framework. Targets such as those for access to nature, clean water, green buildings, and clean air not only seek to reduce human impacts on environmental systems, but also provide for human health and social equity (e.g. through reducing home heating bills). The Vancouver GCAP therefore provides inspiration for developing goals, targets, and actions that simultaneously advance social wellbeing while reducing impacts within environmental limits.

However, the original targets did not adequately address existing socio-economic inequality in the city, including Indigenous peoples' ongoing experiences of colonialism, the growing homeless population, and gentrification of low-income suburbs. By not explicitly addressing these societal issues through the GCAP, the City missed significant opportunities to improve the city's liveability for low income and Indigenous peoples and may have contributed to further inequality (e.g. by contributing to gentrification). For example, the City of Vancouver's 2018–19 implementation update acknowledges that the access to nature target was not the right one, as it does not measure how many people can access green zones, or how easy it is for them to get there. They propose to focus on Equity Initiative Zones in the future to prioritise investments for communities with low green space and recreational access.

3.6. Lessons learned from international approaches

Our review of international case studies indicates that usage of environmental limits in legislation and policy differs significantly between countries and subject areas. The EU is notable for employing environmental limits and targets approaches across a

wide range of subject areas, including freshwater, air, biodiversity, and land use. The EU is also notable for integrating the notion of limits into its 7th Environment Action Programme. However, we found that the limits and targets incorporated in EU policy were generally high level, lacked specificity, and relied on further legislation and member state uptake for implementation. In contrast, the Canadian case studies that we reviewed emphasised setting specific, time-bound, measurable targets and action plans to meet those targets. While both Canada and the EU have issues with implementation due to their fragmented governance arrangements, the Canadian targets provided a stronger framework for measuring progress on environmental issues and holding government accountable.

Several case studies involved environmental limits in the form of standards, including both environmental quality standards and activity standards. Standards provide a specific and measurable form of environmental limits, are legally enforceable, and have been widely used to manage discharges to air, water, and land to protect human and ecosystem health. However, the effectiveness of standards in preventing environmental degradation varies depending on implementation pathways and authorities' ability to monitor and enforce compliance with standards. In the US Clean Water Act and EU vehicle emission limit examples, implementation of standards was pursued through allocation of maximum nutrient loads and spatial limits on high-emitting vehicles, respectively. These approaches directly addressed the spatiality of anthropogenic discharges, focused enforcement on areas that regularly exceeded quality limits, and linked biome-scale environmental quality to individual discharges.

Other jurisdictions in our case studies involved economic and industry-focused approaches to keeping human impacts within environmental limits. In the United States, tax instruments and government purchasing were used alongside traditional planning tools (zoning, easements) to prevent the development of valued agricultural land. Whereas taxes and zoning disincentivised farmland conversion in some areas, the government's purchase of development rights provided a more permanent form of protection for agricultural land use. Notably, while these policies may be effective at spatially fixing specific land uses, they do little to limit degradation of valuable agricultural soils or ecosystems. In Australia, a more flexible and collaborative approach to landscape-scale management was implemented, in the form of water quality protection and improvement plans. These plans set objectives and targets for the Great Barrier Reef. Guidelines and best management practice programmes encouraged landowners to reduce their impacts in line with targets. This voluntary approach has proven insufficient to keep sediment and pollutant discharges within limits and prevent the reef's degradation. Rather than strengthen the interventions, the programme's objectives have been changed from 'reef protection' to 'improvement planning'.

Our final three case studies concern the efforts of the EU, Sweden and the United Kingdom to create holistic frameworks for limit- and target-setting, rather than

specifying limits/targets to address a specific environmental issue. The EU has attempted this through its multiyear Environment Action Programmes (EAP), the latest of which sets nine priority objectives for environmental action that ranged from protection of natural capital, to better implementation of legislation, to addressing international environmental and climate challenges. While the 7th EAP's vision statement—'In 2050, we live well, within the planet's ecological limits'—emphasises a limits-based approach to sustainable development, the policy itself does not specify clear limits or targets, instead relying on broad, qualitative and non-specific objectives and actions. Strategies to achieve these priority objectives generally rely on EU directives and other policy mechanisms. Indeed, EAP7 has been strongly criticised for being 'an action plan without actions' (Krämer 2020). Thus, while the EAP7 is a sweeping document that encompasses virtually all aspects of EU environmental policy, it identifies no concrete limits or actions other than those already adopted in other EU policy.

In contrast, Sweden's Environmental Code and the UK's post-Brexit Environment Plan and Bill set specific, legally binding environmental goals, targets, and standards for a range of environmental domains. The Swedish Environmental Code is a framework law that contains provisions on the management of land, water, biodiversity, hazards, chemicals, biotechnology, and waste, among other subjects. Its generational objectives guide environmental action at all levels of society, including the shorter-term environmental quality objectives; milestone targets in turn define the changes required to achieve the generational and environmental quality objectives. In addition, the government issues environmental quality standards to address specific environmental issues. Quality standards are set at levels that humans or ecosystems may be exposed to without risk of significant detriment; permits cannot be granted for activities that are deemed non-compliant with the quality standards.

The United Kingdom has recently taken steps to develop a similar framework law with the development of an Environment Plan in 2018 and Environment Bill in 2019. As in Sweden and the EU, the Environment Plan establishes a set of long-term environmental goals and targets to guide 'government action to help the natural world regain and retain good health'. The Environment Bill (currently due for its second reading) seeks to achieve these goals by providing an overarching legal framework for environmental governance, including a new statutory cycle of target setting, monitoring, planning and reporting and a new oversight body—the Office for Environmental Protection—to help deliver long term environmental improvement and improve accountability. Specifically, the Bill requires the creation of regulations that set long-term legally binding targets for air quality, waste and resource efficiency, water, and biodiversity, as well as a target for the annual mean level of $PM_{2.5}$ in ambient air. All targets must specify the environmental standard to be achieved, which must be able to be objectively measured, a date by which that standard is to be achieved, and a reporting date for the target.

These three framework approaches provide examples of how subject area-specific limits and targets may be brought together within a holistic statutory framework that specifies the objectives, standards, and governance of national-scale environmental management. The subject-specific case studies in turn provide guidance on what tools and approaches may be effective (or not) at reducing anthropogenic impacts or driving environmental improvement in particular domains.

4. ENVIRONMENTAL LIMITS AND TARGETS IN NEW ZEALAND

4.1. Introduction

A wide range of New Zealand legislation, regulations, policies, plans and non-statutory tools have been used to set environmental limits and/or targets for specific subject areas. This section identifies where limits and targets are being used (and where they are not), the types of instruments used to implement them, what agencies administer them, and the nature of Māori involvement, if any. Table 10 presents a collation of information about limits and targets across numerous environmental subject areas under New Zealand legislation and policy.

The purpose is not to provide a comprehensive summary of all environmental limits and targets in New Zealand—we almost certainly have missed some. Rather, we seek to gain a wider perspective on where and how limits and targets are being used, to shed light on how practice differs across various environmental subject areas and to identify gaps in coverage.

Legally binding limits and targets are reviewed in Section 4.2, followed by examples and discussion of non-statutory (i.e. non-binding) instruments in Section 4.3.

4.2. Legally binding environmental limits and targets

Legally-binding environmental **limits** include prohibitions or controls on certain activities; environmental quality standards or bottom lines; caps on the amount of certain activities (e.g. fish harvest) or emission/discharges (e.g. nitrogen allowances); protection of specified areas or features (e.g. national parks); or requirements to maintain, improve, or prevent the loss of specified environmental qualities (e.g. no loss of indigenous vegetation). In some instances, limits also are specified in non-statutory policies (e.g. agency strategies).

Targets for environmental action and improvement are also common in New Zealand. Specific, measurable targets most commonly occur in government policies, strategies, plans and other non-statutory instruments (but see the Zero Carbon Act for an example of statutory targets). Targets are set to guide environmental action and investment towards specific outcomes and to enable measurement of progress towards wider objectives. In some cases, policies employ both limits and targets (e.g. the NPS for Freshwater Management), while in others, targets are framed in language that evokes limits without necessarily being legally binding (e.g. the Biodiversity Strategy and Action Plan have a target of ‘no net loss’ of certain habitats, but this is not legally binding).

Most of the targets and limits documented in Table 10 are established and applied nationally. The table contains a few examples of regional freshwater limits established under the RMA (e.g. limit on nitrogen discharges to Lake Taupo) as well as references to the scope for regional limits in other areas, e.g. air quality. There are many more examples of limits and targets in regional and district plans that have not been documented in the table.

In New Zealand, the use of limits and targets is more common in some fields of environmental management than others. Marine fisheries have been managed using a limits-based approach since the mid-1980s, and air quality since 2004. More recently, the Climate Change Response (Zero Carbon) Amendment Act 2019 legislated new greenhouse gas emissions targets for New Zealand, adding to existing targets in energy strategies and international agreements. The subject area with New Zealand's most comprehensive attempt to establish environmental limits is fresh water.

4.2.1. Lessons from limit-setting for freshwater environments

The National Policy Statement (NPS) for Freshwater Management and associated national environmental standards represent a nested series of objectives, limits, and targets to guide freshwater management nationwide, in addition to waterbody-specific limits and targets instituted by water conservation orders and regional plans; detail is provided in Table 10. The experience with establishing and implementing limits for freshwater environments is instructive for several reasons.

Freshwater environments are ecologically and socially complex—there is no universal determinant or indicator of acceptable status. To manage for diverse uses and values, numerous indicators (attributes) are required, many of which are proxies for ecosystem features that cannot be quantified or managed directly. Because of this complexity and its spatial variability, the freshwater policy has been implemented using a mix of national direction and devolution to regional councils, which are required to identify objectives, limits and measures to achieve them. Implementation by regional councils has generated variable results, as councils with different capacities operate at different speeds, with different approaches to involvement of Māori and others and different degrees of effectiveness.

For many water bodies, limits have already been exceeded, in terms of abstraction leaving insufficient flow for aquatic life or discharges (both direct and diffuse) making water bodies inhospitable for taonga species and other life forms. In such cases, councils are faced with the need to constrain existing water and land use practices and limit access for new users. This creates political resistance from both existing and prospective users, including Māori who might find themselves unable to develop ancestral land when intensification is more strictly controlled.

Table 10. Examples of the use of limits and targets in New Zealand's environmental management. Glossary of terms is at end of table.

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
Freshwater • Quantity • Quality • Nitrogen and phosphorus • Emerging contaminants	National Policy Statement for Freshwater Management (Freshwater NPS) 2017	• National bottom lines for ecosystem and human health attributes. • Water quality and quantity objectives. • Water quality limits - Freshwater NPS requires regional councils to set, for all water bodies, discharge limits for some contaminants by 2030 (many do now). • Environmental flows/levels - Freshwater NPS requires councils to set an allocation limit and minimum flow or water level (or other flows/levels) for all water bodies. • Targets where current state does not meet objectives. • Regional and national targets.	Regional plans and rules. Consent conditions: Limits on individual takes, discharge standards and volumes. Rules re levels at which permitholders must reduce or cease water takes.	**Spatial:** National-scale bottom lines; objectives, limits and targets set for freshwater management units (individual water bodies or groups of water bodies). **Temporal:** Objectives and limits set by 2025, with possible extension to 2030. Minimum flows often weekly average; Take limits are variable; Discharge limits usually annual; quality targets often annual average or exceedances per year.	New Zealand government sets bottom lines; regional councils set objectives, limits & targets, and rules to govern use. Regional councils enforce limits and targets via consent conditions.	Te Mana o Te Wai gives priority to health of water. Freshwater NPS specifies tangata whenua roles and interests.
	Proposed Essential Freshwater package (2020)	• More detail on targets (attributes) • No further drainage or development of wetlands • Proposed new minimum standards for wastewater discharges and overflows • Require stock exclusion from most waterways, impose minimum setback area	Regional plans; Consent conditions; regulations; national environmental standards.	**Spatial:** National-scale bottom lines; objectives, limits and targets set for freshwater management units; nitrogen and stock exclusion limits at property scale.	New Zealand government sets bottom lines and regulations; Regional councils set objectives, limits and targets; Regional councils to enforce limits,	Clarifies and strengthens Te Mana o Te Wai, which requires that the health of freshwater bodies have priority over human uses. Mahinga kai added as a

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
		• Caps on nitrogen loss at property scale - limit nitrogen application to 190 kg/ha/year • Controls on new intensification – must demonstrate will not increase pollution		**Temporal:** Implementation timeline varies for different rules, e.g. fertiliser caps and stock exclusion. Councils have until 2025 to establish plans with limits.	targets, and regulations	mandatory value that must be provided for.
	NES for Sources of Drinking Water (2008)	Authorities may not authorise activities if they are likely to introduce or increase the concentration of determinands in drinking water such that: • it exceeds the maximum acceptable values for health determinands or guideline values for aesthetic determinands in the DWSfNZ (where drinking water previously complied) • it increases the concentration of determinands by more than a minor amount (where drinking water is not monitored or did not comply)	Resource consents, regional plans	National scale standards	Regional councils	
	Waikato Regional Council: Regional Plan	• Maintain the current (2001) water quality of Lake Taupō, as indicated by key water quality characteristics • Cap nitrogen outputs from land in the catchment by placing limits on the annual average amount of nitrogen leached • Cap nitrogen outputs from wastewater systems • Permanent removal of 20% of total annual manageable load of nitrogen leached from land use activities and wastewater in the Lake Taupo catchment	Regional plan policies; consents contain nitrogen discharge allowances for individual properties; property-scale nitrogen management plans; public fund for reducing nitrogen leaching; covenants on retired land	**Spatial –** Lake Taupo catchment; property scale **Temporal –** aims to restore the water quality of Lake Taupo to its 2001 levels by 2080; nitrogen removal target to be reviewed after 10 years; resource consents expire in	Regional council, district council, government, Lake Taupo Protection Trust	Ngāti Tūwharetoa are a partner with local and central government regarding Lake management – joint committee overseeing the Trust, 2020 Taupo-nui-a-Tia Action Plan, and memorandum of understanding

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
				2036; nitrogen loss measured annually		
	Bay of Plenty Regional Council: Lake Rotorua Nutrient Management	• Lake water quality is maintained or improved to meet the Trophic Level Index of 4.2 for Lake Rotorua • Total nitrogen entering Lake Rotorua shall not exceed 435 tonnes/annum • Reduce nitrogen losses from farming activity to achieve the 435 tonnes/annum nitrogen load for Lake Rotorua by 2032	Regional plan rules; consents contain nitrogen discharge allocations to individual properties; managed reduction targets and offsets; property-scale nutrient management plans N allocations by property	Lake Rotorua groundwater catchment; property scale **Temporal –** 5 yearly nutrient management plans and managed reduction targets; nitrogen loss measured annually	Regional council, district council	Partnership through the Rotorua Te Arawa Lakes Programme; includes specific policies and rules for Māori land
	Water Conservation Orders	Permanently limit modifications to specified water bodies or parts thereof, to: • preserve the water body's natural state • protect certain characteristics that a water body has or contributes to. Limits to modification are variously defined through natural variability, environmental flow regimes, water body levels, water quality, water body character (e.g. braided river profile), and features (e.g. fish passage). Modifications/activities limited include damming, diversion, discharges, abstraction of water, and opening outlets.	Prohibits or restricts regional councils from granting resource consents or including rules in plans authorising specified activities or modifications	**Spatial** – from the water body (and connected waters) to the reach scale **Temporal** – highly variable, depending on the attributes protected	WCOs are made by government by order in council. Regional councils and territorial authorities are prohibited from issuing resource consents or making rules in plans that are inconsistent with the WCO	WCOs can be granted to protect water body characteristics considered to be of outstanding significance in accordance with tikanga Māori
	RC regional plans-various	Most rivers have 'minimum flows'; some rivers and aquifers have abstraction limits; hydro lakes have operating limits	Consent conditions; mandatory farm plans; rules re farming/forestry practice	**Spatial** – Individual water bodies and groups of water bodies **Temporal** – variable, can be continuous, monthly, annual etc.	Regional councils	Varies widely. Some councils have equal Māori and councillor membership on key RMA committees

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
Chemicals	Hazardous Substances and New Organisms Act 1996	No limits or targets identified	Controls on use of approved substances; codes of practice.	National	Environmental Protection Agency	Consultation
Air • Air quality • Ozone-depleting emissions	RMA 1991	• Regional air quality targets • regional/local activity limits (e.g. domestic fireplaces)	Regional plans	Consents and associated conditions for individual sites	Regional councils	Varies. Some councils have equal Māori and councillor membership on key RMA committees
	NES for Air Quality 2004	• Ambient air quality standards for PM_{10}, NO_2, CO, SO_2 and O_3; proposals to add $PM_{2.5}$ • Sets design and efficiency standards for fuel burners • Prohibits or restricts specific polluting activities	National standards; Resource consents; design and thermal efficiency standards for woodburners (proposals to extend to all solid fuel burners)	National standards; implemented at airshed scale. Standards are for 1-24 hour means, with a maximum number of annual exceedances	New Zealand government sets standards; regional councils responsible for implementation & compliance	
	Ozone Layer Protection Act 1996 (and regulations)	Phase out ozone depleting substances as soon as possible except for essential uses; phase down of hydrofluorocarbons	Prohibition on import, export and manufacture of listed controlled substances	National regulation	MfE, EPA	
Land • Land-use change • Soils • Forests	RMA 1991	Rural urban limit for Auckland Zoning – density and land use limits	Regional and district plans, e.g. rural zones typically have controls on subdivision for residential use.		Regional councils	
	Erosion Control Funding Programme (MPI)	No targets or limits evident	Some highly erodible land eligible for subsidies for land treatment (now ended); Subsidies for community initiatives	NA	MPI Gisborne DC provides some additional funding, and has some rules requiring some treatment of highly erodible land.	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
	Proposed National Policy Statement for Highly Productive Land	No limits or targets proposed	Policy statements and plans must maintain the availability and productive capacity of highly productive land for primary production, by: prioritising use for primary production; increasing protection to areas of highly productive land; and protecting highly productive land from inappropriate subdivision, use and development	Sub-regional	Regional councils, territorial authorities	
	National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2012	Contaminated soil standards: activity status depends on whether soil contamination at site exceeds standards	Consents; Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (MfE)	Contaminated soil standards are national scale; implementation at site scale	Regional councils must identify and monitor contaminated land; territorial authorities to observe and enforce standards	
	Forests Act 1949 (and other forestry legislation)	Strict controls on harvest of indigenous forests (mostly not allowed) – mainly for biodiversity objectives See also Permanent Forest Sinks Regulations	Regulations	National, permanent	MPI	
	National Environmental Standards for Plantation Forestry	No fixed limits	Resource consents	-	-	
	One Billion Trees	Plant one billion trees by 2028	Funding for landowners and organisations, incl direct grants for planting	National	Te Uru Rākau (Forestry New Zealand)	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
Biodiversity • Indigenous species • Ecosystems and habitats • Invasive species	Conservation Act 1987	Population targets for vulnerable species	Conservation strategies; Action plans with voluntary and regulatory measures;	Regional strategies, decadal	Department of Conservation (DOC)	
	National Parks Act 1980 Reserves Act 1977	None	Protected areas (national parks and reserves); Limits on visitor numbers; Activity restrictions and concessions	NA	Department of Conservation	
	Wildlife Act 1953	None	Bans or controls on killing of wildlife Provides for creation of wildlife reserves	NA	Department of Conservation	
	Biosecurity Act 1993	None	National and regional plans and rules, funding	NA	MPI and regional councils	
	Biosecurity 2025 Direction Statement (2016)	Targets for 2025: • 90% of relevant businesses actively managing pest and disease risks. • Public and private investment of at least $80 million in science for biosecurity, of which at least 50% focused on critical biosecurity areas. • Identifying 150,000 skilled people to support responses to biosecurity incursions	Research, education, outreach etc (more details on MPI website[13])	Various	MPI and regional councils	
	New Zealand Biodiversity Strategy 2000-2020 New Zealand Biodiversity Action Plan 2016–2020	Both the strategy and action plan contain a range of goals and targets/desired outcomes. However, they are largely qualitative, high level statements, and difficult to measure. The proposed update 'Te Koiroa o te Koiora' (2019) sets goals for 2025, 2030	National Policy Statement, regional biodiversity strategies, iwi management plans, partnerships	Goals and targets are framed at national scale; implementation at national and regional scales	DOC, MfE, MPI, LINZ and local authorities	Te ao Māori, principles of kaitiakitanga, and Treaty partnership have been integrated throughout

[13] https://www.mpi.govt.nz/protection-and-response/biosecurity/biosecurity-2025/biosecurity-2025/

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
		and 2050, some of which could be developed into measurable limits or targets (e.g. no net loss of extent of rare and naturally uncommon terrestrial indigenous habitat)				(especially in Te Koiroa o Te Koiroa)
	Proposed National Policy Statement for Indigenous Biodiversity 2019	Seeks to maintain indigenous biodiversity at current levels - requiring at least no reduction in: a) the size of populations of indigenous species: b) indigenous species occupancy across their natural range: c) the properties and function of ecosystems and habitats: d) the full range and extent of ecosystems and habitats: e) connectivity between and buffering around, ecosystems: f) the resilience and adaptability of ecosystems. The maintenance of indigenous biodiversity may also require the restoration or enhancement of ecosystems and habitats	Mapping significant natural areas in regional/district plans Rules in policy statements and plans Regional biodiversity strategies Monitoring plans	Regional/local scale	Regional councils, territorial authorities	Māori concepts integral to policy; centres Treaty and role of tangata whenua throughout (see Policy 1)
	Statement of National Priorities for Protecting Rare and Threatened Biodiversity on Private Land (2007)	The statement aims to limit further loss of indigenous vegetation, rare ecosystems, and habitats of threatened indigenous species by identifying them as national priorities. The priorities are defined according to ecological thresholds of loss, rarity, and threat status	National maps, regional plans, resource consents	National scale priorities, regional and local implementation	Local authorities	
	Queen Elisabeth II National Trust Act 1977	No targets	Payments to purchase permanent covenants on private land	National programme that protects individual properties, perpetual	QE II Trust	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
Climate Change • GHG emissions • Energy	ZCAA 2019	Emission targets: • net zero emissions of all greenhouse gases other than biogenic methane by 2050 • 24–47% reduction below 2017 biogenic methane emissions by 2050, including 10% reduction below 2017 biogenic methane emissions by 2030. Emission limits to be set	Emissions Trading Scheme		MfE, EPA	
	Permanent Forest Sink Regulations 2007	Payments for reforestation	Emissions Trading Scheme		MfE, EPA	
	National Policy Statement for Renewable Electricity Generation (2011)	Aims to meet or exceed New Zealand's national target for renewable electricity generation (90% of electricity to be generated from renewable energy sources by 2025)	Regional policy statements and plans, district plans	National scale target, regional/district implementation	Government sets national target, implemented by territorial authorities	
	New Zealand Energy Strategy 2011–2021	Three targets for reducing greenhouse gas emissions from energy, though two are conditional*: • 90% of electricity to be generated from renewable energy sources by 2025* • 50% reduction in greenhouse gas emissions from 1990 levels by 2050 • 10-20% reduction in greenhouse gas emissions from 1990 levels by 2020*	-	National scale targets Decadal scale targets	New Zealand government agencies – EECA, MOT, MBIE, MfE and others	
	New Zealand Energy Efficiency and Conservation Strategy 2017–2022	Two greenhouse gas emission reduction targets: • 30% reduction in greenhouse gas emissions from 2005 levels by 2030 • 50% reduction in greenhouse gas emissions from 1990 levels by 2050 Three energy/emissions targets: • >1% annual average decrease in industrial emissions intensity (kg	-	National scale targets Annual and decadal scale targets	Primarily EECA, also MoT, MBIE, MfE etc	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
		CO_2-e/$ Real GDP) between 2017 and 2022 • Electric vehicles make up 2% of vehicle fleet by the end of 2021 • 90% per cent of electricity to be generated from renewable sources by 2025				
Oceans/marine • Acidification • Eutrophication • Sediment • Plastics	RMA 1991 Conservation Act 1987 Waste Minimisation Act 2008 EEZ Act 2012	No limit or target for: • Acidification • Plastics in environment • Coastal nutrients or sedimentation	New Zealand Coastal Policy Statement and regional plans, rules etc Action plans **Water quality:** Discharge rules; plastic bag ban (see also fresh water)		DOC, MPI EPA	
	Resource Management (Marine Pollution) Regulations 1998	No limits	Controls on discharges into marine environment	National	Regional councils	
	New Zealand Coastal Policy Statement 2010	Two policies seek to prevent activities exceeding environmental limits in the coastal environment: • Enables local authorities to set thresholds or acceptable limits to change to assist in determining when activities causing adverse cumulative effects are to be avoided • Requires subdivision, use or development to not result in a significant increase in sedimentation in the coastal environment	Regional policy statements and plans, district plans	Regional/local scale	Regional councils, territorial authorities	Objective 3 and Policy 2 set out how the policy statement gives effect to the Treaty of Waitangi and provides for tangata whenua involvement
• Fisheries (and bycatch species including seabirds)	Fisheries Act 1996	• Biomass targets and limits for fish stocks • Adoption of bycatch mitigation practices (e.g. seabirds) (for other non-fish species, see above re biodiversity)	• Catch limits • Transferable quota/ catch entitlements • Fishing regs to limit bycatch, e.g. gear requirements	Fisheries Management Area for fish stocks, annual catch limits. Population area for seabirds and other	MPI	Māori entities own over 50% of fisheries quota shares. Customary fishing has a

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
			• Closed or restricted areas • National Plan of Action – Seabirds 2020	non-fish species, indefinite measures		priority share of total catch. Act enables Māori management of customary fishing areas (mātaitai and taiāpure)
• Marine mammals	Marine Mammal Protection Act 1978 Fisheries Act 1996	Maximum allowable fishing mortality (via population or threat management plans for given species)	• Sanctuaries • Regulations (e.g. whale watching) • Population management plans • Codes of Conduct (e.g. Acoustic Disturbance)	National, with some regional and local measures	DOC	
• Marine biodiversity	Marine Reserves Act 1971	10% of New Zealand marine environment in network of representative protected areas by 2010 (NZ Biodiversity Strategy 2000)	Regulations banning fishing and other activities in designated areas	National, permanent protection	DOC	Variable, contested by some iwi/hapū
Built environment • Waste	Waste Minimisation Act 2008	Regulation-making powers to control or prohibit the manufacture, sale, or disposal of specific products: • Ban on the sale and manufacture of wash-off products containing plastic microbeads; • Ban on the sale of plastic shopping bags for the purpose of distributing goods sold by the retailer. Requires waste management and minimisation plans for all districts, which may include limits and targets for waste (e.g. Auckland Council)	Regulations Waste management and minimisation plans	National scale District; reviewed every 6 years	MfE Territorial authorities	
	Proposed National Environmental Standard for the Outdoor Storage of Tyres	Volume thresholds for outdoor storage of tyres – stockpiles exceeding thresholds require a discretionary resource consent	Permitted activity rule requirements; resource consent conditions	National scale	Regional councils	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
• Housing	National Policy Statement on Urban Development Capacity 2016	• Requires local authorities with high growth urban areas to set minimum targets for development capacity for housing	Regional policy statement, district plan	Regional scale. Medium- and long-term targets, reviewed every 3 years	Regional councils, territorial authorities	
	Building Act 2004 and Code (regulations)	• Sets performance-based standards for building construction, alteration, demolition, and maintenance, across a range of building classes. • Minimum standards relate to structural stability, durability, fire safety, moisture control, and energy efficiency.	Building consents for some types of building work; all building work must meet performance standards	National scale	MBIE, building consent authorities (usually councils)	
• Noise	RMA 1991	• Regulation-making powers to prescribe national environmental standards for noise (none made) • All persons have a duty to avoid unreasonable noise • Prohibits 'excessive noise', meaning "any noise that is under human control and of such a nature as to unreasonably interfere with the peace, comfort, and convenience of any person (other than a person in or at the place from which the noise is being emitted)" excepting noise emitted by airplanes, vehicles, and trains	National environmental standard Abatement notice Excessive noise direction	National scale	Territorial authorities	
• Exposure to high frequencies	National Environmental Standards for Telecommunication Facilities 2016	• Noise limits for roadside cabinets. Different limits for cabinets located in residential zones and elsewhere • Maximum exposure levels for radiofrequency fields	Resource consents	National scale limits. Noise limits differ for daytime and night-time hours, and include 5-minute averages and maximum volume	Local authorities	

Subject area / issue	Legislation or Policy	Description of limits/targets	Instruments (implementation)	Scale (temporal and spatial)	Agency(ies) responsible	Māori involvement
	National Environmental Standards for Electricity Transmission Activities	Electricity transmission must either: • not exceed reference levels for public exposure for electric field strength and magnetic flux density; or • not exceed restriction level for density of electric current induced in the body Restrictions on transmission line tower size and proximity to occupied buildings. Limits on noise and vibrations for construction activities.	Resource consents	National scale limits	Local authorities	
• Wastewater • Green space • Light pollution • Impermeable surface area	RMA 1991 Local Government Act 2002Health Act 1956	No nation-wide limits or targets for these issues. Territorial authorities may set limits, targets or standards for these issues for specified areas through a range of policy instruments	Regional policy statements, regional plans, district plans, bylaws, and consent conditions	Regional or local scale	Territorial authorities	Territorial authorities are required to consult with iwi in planning and policy making

Glossary for Table 10:

DOC	Department of Conservation
EECA	Energy Efficiency and Conservation Authority
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
HSNO	Hazardous Substances and New Organisms Act 1996
LINZ	Land Information New Zealand
MALF (7 day)	Mean Annual Low Flow, calculated by finding the lowest running 7-day average for each year of the record and then averaging all annual low flows.
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
MMPA	Marine Mammals Protection Act
MARPOL	Resource Management (Marine Pollution) Regulations 1998, implementing the International Convention for the Prevention of Pollution from Ships
MOT	Ministry of Transport
MPI	Ministry for Primary Industries

NES	National Environmental Standard
NPS	National Policy Statement under the Resource Management Act
OLPA	Ozone Layer Protection Act 1996
RC	Regional council
RMA	Resource Management Act 1991
WCO	Water Conservation Order
ZCAA	Climate Change Response (Zero Carbon) Amendment Act 2019

To address these diverse challenges and incorporate new scientific findings, the Freshwater NPS has required ongoing revision and refinement. The initial NPS was issued in 2011 after more than a decade of policy work, and major revisions were made in 2014 and 2017. The government has announced more changes to be made in 2020 and further work on attributes for nitrogen and phosphorus, to be implemented at a later date. While probably unavoidable, these ongoing changes generate uncertainty for councils, Māori, water users and wider communities, including the possibility of having to re-do regional plans to incorporate national policy changes. All of this involves considerable time and expense—it is over twenty years since it was recognised that New Zealand needed more effective limits on the use of freshwater, and it is likely to be at least 2025 before most water bodes are protected by effective limits.

Collaborative governance approaches have been used nationally (through the Land and Water Forum) and in some regions to resolve both ecological and social aspects of freshwater management. While collaborative approaches have helped to achieve consensus on some issues and to narrow differences on others, collaboration is not a panacea. Many disagreements remain and there is no indication that collaboration has increased public confidence in freshwater management (Tadaki et al. 2020).

Similarly, references in the Freshwater NPS to Māori values and Te Mana o Te Wai have not yet led to satisfaction amongst Māori that their values, rights and interests have been properly addressed.[14] Further elaboration of provisions concerning Te Mana o Te Wai has been proposed for the latest set of Freshwater NPS changes—it will take some time to implement these and even longer to assess their effectiveness.

New Zealand's experience with establishing limits for freshwater environments demonstrates the magnitude of the challenge when dealing with ecologically and socially complex systems. This does not detract from the importance of establishing such limits; rather, it highlights the commitment and awareness necessary to complete the task.

4.2.2. Biodiversity, land, marine and built environments

In contrast to freshwater, marine and coastal ecosystems, land, biodiversity, and the built environment are subject to few binding environmental limits or targets. Policies governing these subjects contain some issue-specific limits (e.g. controls on tyre storage) or targets (e.g. population targets for vulnerable species) and are part of an array of approaches implemented via different policy instruments, often by different agencies. New Zealand uses limits to manage fish stocks and a few bycatch species (e.g. NZ sea lions) but not other aspects of coastal and marine environments.

[14] RNZ, 2020, "Water rights: Māori Council seeks precedent-setting court judgment", 5 March https://www.rnz.co.nz/news/te-manu-korihi/411002/water-rights-maori-council-seeks-precedent-setting-court-judgment

Existing limits and targets in these areas are often not well coordinated and hence do not address the wider scope of environmental management for these subject areas. For example, national-scale environmental limits and targets for the built environment focus on housing capacity; exposure to noise, radio frequency fields, and electric fields; and environmental impacts of waste tyres and specific plastics. Land policies contain a similarly diverse set of limits and targets, including controls on harvesting indigenous forests, standards for contaminated soil and a target of planting one billion trees. Neither the built environment nor land use change has an overarching framework that identifies the wider policy goals or the components of environmental use or protection that require limits or targets.

Outside of fisheries management, marine and coastal areas are subject to even fewer environmental limits or targets than land or the built environment, despite widespread problems of water quality, sedimentation, and novel contaminants (e.g. plastics). While the New Zealand Coastal Policy Statement 2010 gives local authorities the ability to set limits or thresholds to address cumulative effects in coastal areas, a 2017 review 'found little evidence of limit setting and allocation in the coastal marine area' (Department of Conservation 2017, p. 30).

In biodiversity management, there are a plethora of targets and limits, but most targets are in non-binding strategies and plans, and limits generally take the form of spatially specific activity controls (e.g. activity restrictions in wildlife reserves). Many of the targets also lack the specificity required to monitor and report on progress. The proposed National Policy Statement for Indigenous Biodiversity represents an opportunity to further specify, strengthen, and coordinate targets to guide biodiversity management.

Many limits and targets have been set nationally—e.g. for air quality, freshwater bottom lines, noise, and biodiversity—to protect shared human health and ecosystem values. Others are devolved to the regional or local level (e.g. land use zoning) and/or apply to specific environmental systems (e.g. limits for freshwater management units) in recognition of variability in ecosystems, values, and anthropogenic pressures. In a minority of cases, national limits and targets have been set in line with global priorities as established by international agreements (e.g. Montreal Protocol on Substances that Deplete the Ozone Layer).

We do not consider that all subject areas should be governed by comprehensive environmental limits and targets, but that currently limits and targets are set in an uncoordinated way, adding to pressures on decision makers and not necessarily reflecting the highest priority issues for environmental management. A more explicit framework for the use of targets and limits could improve the overall coherence and effectiveness of environmental management in New Zealand, by enabling better management of cumulative effects.

4.2.3. Observations about the use of legally binding limits and targets

New Zealand examples of limits and targets include measures to control human activities or outputs and measures that define limits in terms of change to an environmental system; both have been widely used in resource management under the RMA. However, cumulative activity limits are becoming more common only recently as it has become apparent that cumulative limits on extraction or discharge are often necessary to prevent exceedance of an environmental quality limit.

The most prominent recent example of limits on changes in environmental systems is the national objectives framework of the National Policy Statement on Freshwater Management. The Freshwater (NPS) lists a number of freshwater attributes that effectively serve as bottom line standards that councils must achieve over time, and it encourages councils to identify cumulative limits on extraction and discharges to achieve the attributes. Earlier examples include biomass targets, catch limits and quota for fish stocks under the Fisheries Act, environmental flow regimes for rivers and related allocation limits on water permits, and national standards for air quality and the associated air quality rules implemented by regional councils.

Also, while some limits apply equally to all parties (e.g. bans on activities or standards that are the same for everyone), other policies set overall limits on resource use or impacts and then allocate these limits to particular parties (e.g. farm nutrient discharge allowances and emissions trading). As has been seen recently with freshwater policy, allocation decisions can be contentious because they have important implications for the social and cultural impacts of environmental limits.

Another theme that emerged from our review of existing environmental limits and targets in New Zealand is the limited involvement of Māori in limit and target setting and implementation. Many of the policies reviewed make no mention of te ao Māori, requirements for engagement, or partnership with tangata whenua in environmental management. In particular, older statutes and policies (e.g. NPS renewable energy) make very limited mention of te ao Māori in setting limits and targets that will affect the development of Māori land and resources, as well as affecting te taiao. These policies appear to fall short of Treaty principles of active protection, participation and partnership and may be a barrier to iwi and hapū exercising their kaitiaki roles.

Two sets of policies appear to better incorporate Māori values, tikanga, and roles in the setting and implementation of limits and targets—the Department of Conservation's policies on biodiversity and coastal management (the New Zealand Biodiversity Strategy, the proposed NPS on indigenous biodiversity and New Zealand Coastal Policy Statement, respectively), and the fisheries management system, administered by Fisheries New Zealand (see Table 10 for more information). More recently, in freshwater policy, the government has moved to strengthen the role of Māori values and communities in decision making, through its centring of 'Te Mana o

Te Wai'. These policies provide examples of how environmental limits and targets can be set in ways that promote the wellbeing of both communities and their environment, and recognise the rights and responsibilities of tangata whenua. Further, tikanga such as rahui and mātaitai reserves, and objectives in iwi management plans, provide strong examples of Māori-led approaches to environmental limit and target setting. Collectively, these examples highlight opportunities to strengthen limit and target setting in line with tangata whenua interests and aspirations.

New Zealand's experience with establishing and implementing limits for freshwater environments is instructive:

- complex – has required several iterations of policy (4th NPS is pending)
- involves balance of national direction and devolution to regions
- time-consuming and expensive
- collaborative approaches have helped but are not a panacea
- Māori involvement has often not met their expectations or aspirations – work in progress with Te Mana O Te Wai
- need for clawback generates difficult allocation decisions – better if legal limits can be established before limit is exceeded.

4.3. Examples of non-statutory environmental limits and targets

4.3.1. International agreements

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC was adopted by over 185 countries (including New Zealand) at the Rio Earth Summit in 1992 and entered into force in New Zealand in 1994. The UNFCCC's main objective is 'to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. Signatory countries are required to reduce greenhouse gas (GHG) emissions and enhance greenhouse gas absorbing sinks, thereby stabilising emissions at 1990 levels by 2000, but the agreement contained no enforcement mechanisms.

In 1997, the Kyoto Protocol to the UNFCCC established legally binding obligations for developed countries to reduce their GHG emissions in the period 2008–2012. New Zealand's target was to stabilise net emissions at 1990 levels by 2000 (Taylor 2004). In 2010, parties agreed that future global warming should be limited to 2 °C relative to pre-industrial levels. The Kyoto Protocol was amended in 2012 to cover the period 2013–2020. In 2015, the Paris Agreement was adopted, through which countries are to achieve emission reductions from 2020, with a view of lowering the target to 1.5 °C.

New Zealand's target under its Nationally Determined Contribution for the Paris Agreement is to reduce greenhouse gas emissions for the period 2021-2030 by 30% relative to 2005 (equivalent to 11% below 1990 levels). In 2019, the Zero Carbon Amendment Act established a new 2050 target with two components: (1) net zero emissions of all greenhouse gases other than biogenic methane by 2050; and (2) biogenic methane emissions reduced by 24 to 47% below 2017 levels by 2050, including 10% below 2017 biogenic methane emissions by 2030.

New Zealand's climate change policy has been formulated via Climate Change Policy Option Statements and implemented through the Climate Change Response Act 2002, the Energy Efficiency and Conservation Act 2000 (Taylor 2004), Permanent Forest Sink Regulations 2007 and, most recently, the Zero Carbon Amendment Act 2019, which amended the Climate Change Response Act 2002.

Minamata Convention on Mercury

The Minamata Convention aims to control the harmful effects of mercury pollution on the environment and human health. To achieve this objective, the Convention sets out control measures for anthropogenic mercury releases, including direct mining of mercury, export and import of the metal, mercury emissions from some industrial activities, artisanal gold mining that uses mercury, significant releases to land and water, safe storage, and contaminated sites and waste mercury.

Under the Convention, New Zealand is required to institute a wide range of measures, including controlling mining for mercury (and phasing it out within 15 years), ensuring environmentally sound disposal of mercury, and discouraging the use of mercury in new products without environmental and health benefits. In its National Interest Analysis, MfE (2013) considered that the Convention 'could be implemented into NZ law simply and without needing to create extensive new regimes or specialised agencies.' Relevant permitting systems are managed by the Environmental Protection Authority and enforcement is carried out by the New Zealand Customs Service.

United Nations Convention on Biological Diversity

The Convention on Biological Diversity entered into force in 1993 and has three primary objectives (United Nations 1992):

- the conservation of biological diversity[15]
- the sustainable use of the components of biological diversity
- the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies.

[15] In the context of the Convention, 'biological diversity' is defined as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.'

There are two supplementary agreements within the framework of the Convention. The Cartagena Protocol on Biosafety aims to ensure the safe handling, transport and use of living modified organisms resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health (Secretariat of the Convention on Biological Diversity 2000). The second is the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (United Nations 2011).

Implementation of the Convention and associated protocols in New Zealand is largely via the RMA, the Biosecurity Act 1993, the Hazardous Substances and New Organisms Act 1996 and the Hazardous Substances and Other Organisms Act 2003. In 2000, government adopted a National Strategy on Biological Diversity to meet New Zealand's commitments under the Convention (Department of Conservation 2000). The Strategy sets out a strategic framework for action containing a vision, goals and principles to conserve and sustainably use and manage New Zealand's biodiversity. The goals are to:

- enhance community and individual understanding about biodiversity, and inform, motivate and support widespread and coordinated community action to conserve and sustainably use biodiversity
- enable communities and individuals to equitably share responsibility for, and benefits from, conserving and sustainably using New Zealand's biodiversity, including the benefits from the use of indigenous genetic resources
- actively protect iwi and hapū interests in indigenous biodiversity, and build and strengthen partnerships between government agencies and iwi and hapū in conserving and sustainably using indigenous biodiversity
- maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified ecosystems in production and urban environments
- maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity.

Vienna Convention for the Protection of the Ozone Layer and Montreal Protocol on Substances that Deplete the Ozone Layer

The Vienna Convention for the Protection of the Ozone Layer, adopted in 1985, aimed to protect human health and the environment against the adverse effects resulting from modifications of the ozone layer. It was followed shortly afterwards by the adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, which specifies control measures for various ozone-depleting substances. The Protocol, along with the Vienna Convention, achieved universal ratification with 197 countries in 2009; the first treaties of any kind in the history of the UN system to achieve that aspiration (United Nations 2020).

New Zealand has phased out virtually all ozone-depleting substances governed by these agreements. For example, the import of halons was phased out by 1994; chlorofluorocarbons (CFCs), other fully halogenated CFCs, carbon tetrachloride, methyl chloroform and hydrobromofluorocarbons were phased out by 1996; the import of methyl bromide for non-quarantine and pre-shipment purposes ended in 2007; and imports of hydrochlorofluorocarbons ended in 2015 (MfE 2020). New Zealand's obligations under the Convention and the Protocol are mainly implemented through the Ozone Layer Protection Act 1996.

Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or the environment. This Convention entered into force in 2004 (United Nations 2018). It requires parties to, among other things, prohibit and/or eliminate the production, use, import and export of certain intentionally produced POPs and reduce or eliminate releases from certain unintentionally produced POPs. When New Zealand ratified the Convention in 2004, 12 chemicals were listed as POPs; a further 16 chemicals have since been added.

New Zealand has a national implementation plan to address its obligations under the Convention, including plans to reduce dioxin releases, complete phase-out approaches for polychlorinated biphenyls, manage POP wastes and undertake environmental monitoring in relation to these substances. Obligations under this Convention are met through the Hazardous Substances and New Organisms Act 1996, the Imports and Exports (Restrictions) Prohibition Order (No 2) 2004, and the Hazardous Substances (Storage and Disposal of POPs) Notice 2004.

New Zealand also complies with the requirements for the environmentally sound management of POP wastes set out in the Basel Convention, the Waigani Convention and the Organisation for Economic Co-operation and Development Hazardous Waste Decision (MfE 2019b). The management of POPs and implementation of the Convention's requirements in New Zealand requires a cross-government approach. The legal and administrative framework relating to the Convention's implementation are described in detail in the National Implementation Plan (MfE 2018).

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. The scope of this convention covers a wide range of wastes defined as 'hazardous wastes' based on their origin and/or composition and their characteristics, as well as two types of

wastes defined as “other wastes” (household waste and incinerator ash) (United Nations 2018). The provisions of the Convention focus on:

- the reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes
- the restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management;
- a regulatory system applying to cases where transboundary movements are permissible.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention)

The London Convention contributes to the international control and prevention of marine pollution by prohibiting the dumping[16] of certain hazardous materials. Under this convention, a special permit is required prior to dumping of a number of other identified materials and a general permit for other wastes or matter (International Maritime Organization 2020a). In 1996, signatories adopted a Protocol to the Convention (London Protocol) which entered into force in 2006. This protocol requires that “appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects” (International Maritime Organization 2020a) and is based on the polluter pays principle. The London Protocol restricts all dumping into the marine environment, except for a few permitted substances (e.g. sewage sludge, dredged material, fish waste, inert and inorganic geological materials, etc.). In New Zealand, these and other obligations on ocean dumping activities and oils spills are regulated primarily through the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 and Maritime Transport Act 1994.

International Convention for the Prevention of Pollution from Ships (MARPOL)

The MARPOL is the main international convention covering pollution of the marine environment by ships from operational or accidental causes. Adopted in 1973, the convention has been amended on several occasions (International Maritime Organization 2020b). Currently, MARPOL contains six technical annexes:

- regulations for the prevention of pollution by oil
- regulations for the control of pollution by noxious liquid substances in bulk
- prevention of pollution by harmful substances carried by sea in packaged form
- prevention of pollution by sewage from ships
- prevention of pollution by garbage from ships

[16] Dumping is defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves.

- prevention of air pollution from ships.

In New Zealand, the Convention has been implemented through measures under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, the Maritime Transport Act 1994, and the RMA and its associated Marine Pollution Regulations (MfE 2014).

Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar)

The Ramsar Convention recognises that wetlands are among the most diverse and productive ecosystems and represent many important economic, cultural, scientific and recreational values. Under the Convention, which entered into force in New Zealand in 1976, signatories commit to:

- work towards the wise use of all their wetlands
- designate suitable wetlands for the list of Wetlands of International Importance (the 'Ramsar List') and ensure their effective management
- cooperate internationally on transboundary wetlands, shared wetland systems and shared species.

Suitable wetlands are designated based on their international significance in terms of ecology, botany, zoology, limnology or hydrology (Ramsar 2014). Currently, New Zealand has 6 sites designated as Wetlands of International Importance (Awarua Wetland, Farewell Spit, Firth of Thames, Kopuatai Peat Dome, Manawatu river mouth and estuary), covering a total area of 56,639 ha (Ramsar 2020).

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES, which entered into force in 1975, aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Trade in endangered species is monitored and regulated through a system of permits and certificates, which a person must have to cross internatioal borders with any CITES species or any product containing CITES species. Endangered species are listed in three categories, depending on their conservation status and how much they are traded:

- species that are the most endangered, for which trade is more restricted
- species that can withstand more trade
- species that individual countries have requested assistance with protection.

In New Zealand, CITES is implemented through the Trade in Endangered Species Act 1989.

Fisheries and related agreements

The United Nations Fish Stocks Agreement[17] enables the establishment of regional fisheries management organisations that can regulate the fishing of highly migratory and straddling (i.e. transboundary) fish stocks in their region. It aims to ensure alignment between management measures for fish stocks in areas under national jurisdiction and in the adjacent high seas, and to ensure that there are effective mechanisms for compliance and enforcement. Regional fisheries management organisations established under the umbrella of the Fish Stocks Agreement negotiate and agree measures to conserve fish stocks in those regions, which are binding on countries that have ratified the Agreement (United Nations 1995).

New Zealand is also a member of three such regional fisheries management agreements: the Convention for the Conservation of Southern Bluefin Tuna, the South Pacific Regional Fisheries Management Organisation, and the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (Fisheries New Zealand 2020a). Through the commissions that govern these agreements, New Zealand participates in decision-making about management measures, which in some cases include decisions about catch limits and how these should be apportioned amongst member states. New Zealand's share of any such catch limit is then implemented via domestic legislation to ensure that New Zealand fishing companies do not collectively exceed New Zealand's allocation.

The Agreement on the Conservation of Albatrosses and Petrels (ACAP), to which New Zealand is one of 13 parties, strives to conserve albatrosses and petrels by coordinating international activities to mitigate threats to their populations. In 2019, ACAP's Advisory Committee declared that its 31 listed species continue to face a conservation crisis, with thousands of albatrosses, petrels and shearwaters dying every year as a result of fisheries operations[18]. More generally, New Zealand has obligations to protect seabirds under the International Plan of Action for reducing the incidental catch of seabirds in longline fisheries developed by the Food and Agriculture Organisation in 1999. New Zealand addresses its obligations for seabird management through its National Plan of Action—Seabirds 2020 (Fisheries New Zealand and Department of Conservation 2020), the third iteration of this plan.

New Zealand is also a member of Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). The Convention applies conservation principles that are based on the maintenance of ecological relationships between harvested, dependent and associated species, and the prevention or minimisation of irreversible changes to the marine environment (FAO 2020).

[17] Formally known as the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.
[18] https://acap.aq/

4.3.2. Limits and targets in Māori environmental management

Iwi management plans and related documents

An Iwi Management Plan (IMP) is a document prepared by an iwi, iwi authority, rūnanga or hapū [19] to address resource management and planning matters as well as broader areas of interest. Some plans, such as the Mahaanui IMP[20], are intentionally designed to be used by planners, while others have a more general audience. Section 66(2A) of the RMA directs councils to take into account 'planning documents recognised by an iwi authority' though does not further specify the content of these documents, which can also include environmental management plans, hapū management plans, cultural values frameworks or statements of cultural values or interest (e.g. declarations and statements). Box 2 shows how one IMP approaches the issues of stream flow and pesticides.

Of the IMPs that we sighted for this report, most had wording that supported the use of environmental limits but typically did not specify quantitative limits. Rather, the IMP wording tends to be aspirational and describe actions for achieving iwi goals, sometimes including actions by government agencies and councils. The IMPs take a holistic approach and often incorporate, for example, wellbeing of people.

According to a review in 2004, iwi organisations generally consider their IMPs as a very useful tool within the organisation to clarify and prioritise their environmental issues (KCSM 2004). However, most respondents felt that IMPs were still not being adequately utilised by councils and consultants:

> Even in situations where there was high recognition of the IMP in council plans, and high awareness of the IMP amongst resource consent applicants, iwi respondents stated that it was still too easy for councils and applicants to ignore the views of iwi (KCSM 2004, p. v).

The reasons for this almost certainly vary but may include a preference by council officers and decision-makers for a style and structure that conforms to their worldview and aligns with existing council plans, even though this may be inconsistent with iwi and hapū aspirations and management approaches. Other reasons could include a lack of guidance, capacity and capability (including funding) for both councils and iwi in how to prepare and use IMPs. The situation may have changed since the 2004 review, as the IMPs we sighted were written more recently.

Taiāpure: Customary fisheries management

Under Section 185 of the Fisheries Act 1996, a local fishery management committee can recommend regulations for the conservation and management of:

> areas of New Zealand fisheries waters (being estuarine of littoral coastal waters) that have customarily been of special significance to any iwi or

[19] https://www.qualityplanning.org.nz/node/1006
[20] https://mahaanuikurataiao.co.nz/wp-content/uploads/2019/08/Full-Plan.pdf

> hapū either- (a) as a source of food; or (b) for spiritual or cultural reasons.

Taiāpure regulations, which must be approved by the Minister of Fisheries, can relate to:

- species fished
- fishing seasons
- sizes and amounts of fish
- fishing areas
- fishing methods.[21]

Taiāpure provide Māori with some control over local areas important for customary fishing and provide for the use of limits if deemed appropriate. However, the process of establishing taiāpure has been described as a “cumbersome procedure” requiring a relatively complex and lengthy consultation process over which the Minister of Fisheries has ultimate control at every step, thereby limiting the expression of rangatiratanga (Jackson 2013, p. 71). Box 3 describes how the Minister of Fisheries accepted one recommendation from the Maketu Taiāpure Management Committee and declined their other two recommendations.

[21] https://www.mpi.govt.nz/law-and-policy/maori-customary-fishing/managing-customary-fisheries/#Taiapure

Box 2. Te Poha o Tohu Raumati

Te Poha o Tohu Raumati is an Environmental Management Plan prepared by Te Rūnanga o Kaikōura to carry out its role as kaitiaki and rangatira over ancestral lands and taonga (Te Rūnanga o Kaikōura 2007). The plan presents priority issues, aspirations and acceptable outcomes for the hapū Ngāti Kuri, so that decision makers and planners can understand and apply the values of the hapū Ngāti Kuri in resource and environmental management systems. The plan takes a holistic approach to management. For example, the health of wetlands is assessed not by water quality measurements, but by the condition of plants such as watercress, which is a food source for tangata whenua:

> when we look at a river, we sometimes use watercress as an indicator of waterway health. We look at how much watercress is there, and where it is growing, and how lush it may be. Naturally, watercress should be growing along the sides of the river, not in the middle. If it is in the middle it indicates that there are problems with the river. There may not be enough flow, or there may be too much nutrient run off into the river. This makes the watercress grow too thick, and it chokes the river. (p. 129)

Based on the above example, planners could align limits and targets with iwi values, e.g. by limiting abstractions to achieve a target flow, as expressed in this iwi policy:

> To promote the setting of limits that identify the maximum amount of water that can be taken from a given area to be used for irrigation or other specific activities (p. 58*).*

The EMP also promotes the use of other limits to protect these and other values, for example opposing the use of herbicides near streams, avoiding harvest of live seaweed, and promoting limits on coastal camping, on coastal structures in culturally sensitive areas, and on recreational harvest of kaimoana and beach-cast seaweed, in addition to limits on water abstraction.

Box 3. Maketu Taiāpure

Section 61 of the Recreational (Amateur) Fishing Regulations limits the harvest of green-lipped mussels in the Maketu Taiāpure to 25 per day. This is a reduction from 50 following recommendations from the Maketu Taiāpure Management Committee. The Committee had first attempted non-statutory and other customary measures to sustainably manage the fishery, but these were ineffective. The regulation is as follows:

61 Daily limit for green-lipped mussels in Maketu taiapure

(1) A person must not, on any day,—

(a) take more than 25 green-lipped mussels (the **daily limit for green-lipped mussels**) from the Maketu taiapure; or

(b) possess more than the daily limit for green-lipped mussels in the Maketu taiapure; or

(c) possess more than the daily limit for green-lipped mussels taken from within the Maketu taiapure.

(2) A person contravenes this subclause if the person, on any day, takes or possesses more than the daily limit for green-lipped mussels from or in the Maketu taiapure, but not more than 3 times that daily limit.

(3) A person contravenes this subclause if the person, on any day, takes or possesses more than 3 times the daily limit for green-lipped mussels from or in the Maketu taiapure.

(4) A person who contravenes—

(a) subclause (2) commits an offence and is liable on conviction to a fine not exceeding $10,000:

(b) subclause (3) commits a serious non-commercial offence and is liable on conviction to a fine not exceeding $20,000.

Compare: SR 1986/222 r 3AC

The Committee also recommended (1) introducing a minimum size of 90 mm for the amateur harvest of green-lipped mussel and (2) a period each year when the taiapure would be closed to the amateur harvest of green-lipped mussels and pāua. These recommendations were declined by the Minister of Fisheries following advice from the Ministry for Primary Industries that reducing the daily harvest limit would be the most effective of the three measures recommended by the Committee and that the additional measures would result in unreasonable implementation costs and impacts on recreational fishers (MPI 2013).

4.3.3. Industry limits and targets

In addition to formal limits and targets expressed through government legislation and strategies, limits and targets also feature in environmental management by businesses and industry sectors, and sometimes in agreements between business and government. Prominent examples include the New Zealand Forest Accord of 1991, the Sustainable Dairying Water Accord of 2013 (which replaced the Dairying and Clean Streams Accord of 2003), and Toitu Envirocare.

The New Zealand Forest Accord, also known as the West Coast Accord, was an agreement between the New Zealand forestry industry and environmental groups. In the Accord, the forestry industry agreed to refrain from clear-felling indigenous forest, and the environment groups agreed to allow sustainable harvesting that does not exceed the rate of replenishment. The Sustainable Dairying Water Accord was developed by the dairy industry with representatives from farmers, dairy companies, central and regional government, and the Federation of Māori Authorities. The dairy accord commits the industry to targets relating to riparian planting, effluent

management, dairy farm conversions, and the efficiency of water and nutrient use. Each target has actions to be achieved by specific dates, with interim targets in some cases.

A somewhat different example is provided by the Toitu Envirocare programme. Toitu Envirocare, a subsidiary of Manaaki Whenua Landcare Research, provides carbon-neutral and other certifications to organisations that meet specified standards, and organisations can use this certification in their marketing. Other organisations provide similar services of carbon measurement, offset and certification. The ability to gain certification for reducing carbon emissions provides an incentive for a business or other organisation to exceed regulatory standards and be a leader in its sector.

Other businesses use environmental management frameworks such as IS0 14000. ISO standards provide a structured and comprehensive framework for an organisation to document its responsibilities, targets and actions, and also provide a basis for external audit and certification. Company policies adopted using the ISO 14000 framework may incorporate voluntary targets as well as legal requirements and may also incorporate the principle of continuous improvement.

4.4. Summary of environmental limits and targets in New Zealand

In New Zealand, the use of limits and targets is more common in some fields of environmental management than others. For freshwater environments, New Zealand has a nested series of objectives, limits, and targets to guide freshwater management nationwide; regional councils are responsible for local implementation. Marine fisheries have been managed using a limits-based approach since the mid-1980s, and air quality since 2004. More recently, the government has legislated greenhouse gas emissions targets for New Zealand.

By contrast, marine and coastal ecosystems, land, biodiversity, and the built environment are subject to few binding environmental limits or targets. Existing limits and targets are not necessarily well coordinated and do not address the wider scope of environmental management for these subject areas. The New Zealand Coastal Policy Statement lacks sufficiently clear and measurable environmental standards and limits, whereas biodiversity policies have clear goals to prevent species decline but lack effective limits on activities that contribute to such decline. Neither the built environment nor land use change has an overarching framework that identifies the wider policy goals or the components of environmental use or protection that require limits or targets.

Effective management of cumulative effects, i.e. to avoid transgressing environmental limits, requires both environmental quality standards (reflecting an environmental boundary or the desired state of the environment) and measures to control resource

use, whether in the form of abstraction, discharge or converting a resource to another use. Such approaches can be seen in management of freshwater environments, air quality and marine fisheries.

However, imposing limits on, for example, nitrogen discharges to water does not ensure that aquatic environments impacted by nitrogen will be healthy. Similarly, catch limits for individual fish stocks may protect the abundance of target fish species but do not, in themselves, ensure the health of marine ecosystems. Both freshwater and marine environments are ecologically complex systems; their status is the result of multiple factors interacting in complex ways. Other complementary measures are therefore needed to protect environmental integrity and to avoid transgressing ecological, social and cultural boundaries. This is an important learning: unless an environmental limit can be clearly specified and directly managed, the limit will need to be implemented via proxy variables and complementary measures are likely to be required.

Tikanga Māori supports the use of limits for environmental management, yet there has been limited involvement of Māori in limit setting and implementation in New Zealand. Many of the policies we reviewed make no mention of te ao Māori, requirements for engagement, or partnership with tangata whenua in environmental management, thus falling short of Treaty principles of active protection, participation and partnership. Two exceptions are biodiversity policies and the fisheries management system. More recently, in freshwater policy, the government has moved to strengthen the role of Māori values and communities in decision making, through its centring of ‘Te Mana o Te Wai’. While there remain areas to be addressed, especially concerning allocation, these freshwater policies provide examples of how environmental limits and targets can be set in ways that recognise the rights and responsibilities of tangata whenua. Further, tikanga such as rahui and mātaitai reserves, and objectives in iwi management plans, provide strong examples of Māori-led approaches to environmental limit and target setting. Collectively, these examples highlight opportunities to strengthen limit and target setting in line with tangata whenua interests and aspirations.

Voluntary accords with industry can be an effective method for establishing and implementing environmental limits and targets if most members of the industry adopt and comply with the accord. Such accords can also facilitate eventual regulatory limits that address any remaining non-compliance and provide long-term protection. Actions by individual businesses, such as achieving carbon-neutral or ISO certification, are not by themselves an effective means for ensuring adherence to global, national or local limits, but they can provide industry leadership and thereby facilitate the adoption of regulatory limits or industry-wide accords.

5. A LIMITS AND TARGETS FRAMEWORK FOR NEW ZEALAND

5.1. Section overview

This section summarises our recommendations for the use of limits and targets in New Zealand environmental management. Our recommendations focus on describing the *types* of environmental limits and targets, legislation, and governance arrangements needed to improve environmental outcomes, but stop short of identifying specific laws or governance entities. Given current and ongoing resource management reforms in New Zealand, we have sought to provide recommendations that will remain relevant and applicable whatever shape reforms may take. Policy and legal advice will therefore be required to translate these recommendations into a workable legal architecture.

Section 5.2 describes the analysis and information that informed our proposed approach. In Section 5.3 we provide an overview of our recommendations for a coordinated framework for environmental limits and targets in New Zealand, summarising the case for overarching legislation that would deliver this framework. The details of this proposed legislation are then outlined in Section 5.4, including suggested goals, principles, and topics, and governance requirements for environmental limits and targets. Subsection 5.4.3 also presents criteria and a decision tool for prioritising environmental topics for limit and target setting. Our proposed approach is then applied to four environmental subject areas in Section 5.5, providing greater detail on topics that our review and workshop identified as needing stronger outcomes-based management. Finally, Section 5.6 identifies further considerations for the implementation of our proposed approach, including recommendations on indicator selection and processes for limit and target setting, and reflections on capability.

5.2. Background to our proposed framework

Our proposed framework for environmental limit and target setting in New Zealand is based on insights from the reviews of the literature, international case studies, and applications in New Zealand. This included the theory and implementation of environmental limits and targets in the international literature, together with examples of limits-based frameworks from the literature (e.g. Häyhä et al. 2016), other countries (e.g. the Swedish Environmental Code 1999), and New Zealand grey literature (e.g. Severinsen 2019). These insights and examples were then interpreted through New Zealand's environmental management context, including co-governance commitments in the Treaty of Waitangi, existing governance and regulatory institutions, and New Zealand's unique environments and management issues. By analysing existing limits and targets in statutory and non-statutory instruments and the agencies responsible

for implementing them, we assessed existing capability for limits-based environmental management in New Zealand and areas for further development.

The international literature highlights the importance of a comprehensive, integrated framework for limit and target setting to improve environmental outcomes (Haines-Young et al. 2006; Steffen et al. 2015b). The requirement for integration is typically multi-faceted, highlighting the need for coordination across multiple subject areas and spatial and governance scales to address both social and environmental outcomes (Cole et al. 2014; Raworth 2017a). To be effective, such a framework must be supported by robust processes for democratic limit setting, oversight, reporting, and enforcement (see Häyhä et al. 2016; Pickering & Persson 2019), and therefore requires substantial institutional, scientific, and financial resourcing (see Nykvist et al. 2013).

In practice, such comprehensive frameworks have been implemented through overarching legislation that sets out requirements for limit or target setting, reporting, enforcement, and governance responsibilities (see section 3). Other regulatory instruments, policies, or plans are then used to implement limits and targets for specific environmental subject areas. In New Zealand, the Resource Management Act 1991 (RMA) provides an integrative basis for articulating and protecting environmental bottom lines through decision making, though its potential has not been realised in practice (Severinsen 2019). Instead, New Zealand environmental management is subject to a series of limits and targets set using different statutory instruments to manage specific resources or issues (see Section 4). Notwithstanding the gaps and lack of integration, the current and increasing use of limits and targets demonstrate New Zealand's capacity for their greater use and integration.

We tested and refined our analysis of the need for an improved environmental limits and targets framework for New Zealand at a half-day workshop with environmental experts. The workshop is described above in section 1.5 and participants are listed in Appendix 1.

5.3. A coordinated framework for limit and target setting

Our analyses of the academic literature, international case studies, and New Zealand grey literature on environmental limits have consistently highlighted the need for a holistic, integrative approach to limits and targets that provides a minimum level of protection across environmental systems. While environmental limit and target setting will always respond to the particularities of each domain of environmental management, a holistic view is crucial for recognising interconnections between domains and promoting improvements in overall environmental outcomes. Further, our analyses of international and New Zealand case studies demonstrate the value of

legally binding limits and targets in driving long-term action for environmental improvement, in a way that is resilient to political changes.

We therefore recommend that New Zealand's environmental management system be strengthened through a legislative requirement to set legally binding limits and targets for key environmental issues in New Zealand. As noted earlier, New Zealand already has a range of statutory environmental limits and targets in place, created through legislation and regulations, national policy direction, and local policies and plans. In many cases, these limits and targets have proven effective at articulating and protecting minimum levels of environmental quality or driving environmental improvement. Our proposed framework consequently focuses less on creating a new system of environmental limits and targets, and more on ensuring that limits and targets are sufficiently comprehensive, coordinated, robust, and at the forefront of policy and decision-making.

Further, our framework focuses on setting legally binding limits and targets for some, but not all, areas of environmental management in New Zealand. Limits and targets are effective tools where they set clear boundaries and goals for environmental management, and in doing so articulate priority considerations for decision making. A proliferation of environmental limits and targets across all aspects of environmental management would consequently make it more difficult to integrate these bottom lines into decision making, rendering them less effective. Equally, limits and targets will not always be the most appropriate or useful tool to drive environmental management. The management of invasive species, natural hazards, and emerging contaminants, for example, are all complex interjurisdictional issues that may defy our ability to set and enforce limits. We therefore propose legally binding limits and targets for only a subset of environmental subject areas and topics.

Based on our reviews and expert input, we conclude that priority should be given to environmental limits that protect a minimum level of environmental quality necessary to sustain human wellbeing and ecosystem functioning. In particular, defining a minimum environmental state is likely to be important to prevent the ongoing deterioration of environmental systems, to identify the minimum requirements for rehabilitating already degraded systems, to uphold environmental justice by securing minimum environmental standards for all, and to uphold the Treaty of Waitangi by ensuring protection of taonga and culturally significant environments. In addition, environmental limits may be necessary elements in the sustainable allocation of finite resources (as in fisheries). Environmental limits are seen as particularly important in New Zealand to complement and strengthen the effects-based approach instituted in the RMA, under which the failure to adequately manage cumulative effects has allowed the degradation of many environments (see Resource Management Review Panel 2019; Severinsen & Peart 2018).

Our recommendations also emphasise the use of environmental targets to complement mandatory environmental limit setting. Environmental limits identify the minimum acceptable state for an environmental system; in many cases, communities desire higher levels of environmental protection and enhancement to uphold key socio-ecological values.[22] We therefore recommend that specific, measurable, and timebound targets should be set where current environmental outcomes are less than those articulated in policy, plan, or strategic objectives. Targets provide a focus for action planning, a metric to measure progress, and a basis for holding government to account (European Environment Agency 2013; Dao et al. 2015).

Briefly, we recommend the enactment of clear requirements for environmental limit and target setting in a new or amended overarching statute that would govern all other statutory environmental instruments. This overarching legislation would set out the subject areas and topics for which limits and targets *must be set* by statutory instruments; the goals and principles for limits and target setting; the procedural requirements for reporting and review; and the governance requirements for oversight and enforcement of limits. The required limits and targets should be binding, stated in statutory instruments with clear duties for policy and decision makers to actively secure them and not undertake actions that are likely to result in the transgression of limits. The legislation would allow for limits and targets to be set at national or sub-national scales (e.g. regional, local, city, ecosystem), in line with the scale of the environmental system and issue the limit/target addresses. National scale limits and targets should also deliver on New Zealand's international environmental commitments.

We recommend the articulation of clear goals, narrative objectives, and principles to guide environmental limit and target setting in the overarching legislation. While the goals will identify the high-level rationale for setting environmental limits and targets, the narrative objectives will specify the environmental bottom lines that must be secured through the development of limits and targets for each subject area. The principles will provide guidance on when, at what scale, and how limits and targets should be set for each subject area. In addition, the overarching legislation would set out requirements for:

- regular public reporting on environmental conditions vis a vis the limits and targets
- regular review of the limits and targets set in statutory instruments, to determine their influence on decision making and government action, and whether they give effect to the narrative objective

[22] Socio-ecological values refer to people's material and symbolic relationships to their biophysical environment, and as such are neither purely 'social' nor 'natural'. Examples include wild food gathering/mahinga kai, access to nature, and tapu.

- an independent authority to oversee the reporting and review processes, and call to account government agencies that do not meet limit setting requirements or demonstrate sufficient progress towards targets.

Given that the proposed overarching legislation would institute requirements for other statutory environmental instruments in New Zealand, and would be consequently quasi-constitutional in nature, the development of this legislation would require a robust process governed by Treaty principles, with ample avenues for public participation. Specifically, iwi/hapū representatives should be involved in identifying the goals, topics, narrative objectives, and principles for limit and target setting, followed by wider consultation on the proposed statute.

This recommended approach bears strong similarity to the overarching environmental legislation operating in Sweden and proposed for the United Kingdom, both of which require environmental limits and/or targets to be set for key environmental issues. This approach was echoed in the Environmental Defence Society's recommendations for overarching legislation to govern environmental management (a 'Future Generations Act') and for the clear articulation of comprehensive environmental bottom lines in Part 2 of a revised RMA 1991 (see Severinsen 2019).

While the development of overarching legislation to institute mandatory limit and target setting is central to our recommendations, we recognise that legislation alone is not sufficient to achieve the level of environmental protection and improvement required in New Zealand, for two main reasons. First, non-statutory instruments and non-governmental organisations play an important role in New Zealand's environmental management. As noted in Section 4.3, a range of Māori authorities, industry groups, international organisations, and NGOs use limits and targets to guide their management activities and set expectations for other entities. We intend the legislative requirements to set limits and targets to support rather than supersede these broader environmental management initiatives. By giving greater prominence to the role of environmental limits in New Zealand more generally, the legislation can guide and support communities in articulating their own minimum environmental standards, which can in turn inform limits set through statutory instruments.

Second, recent reviews of New Zealand's resource management system highlight widespread issues with resourcing, compliance, and enforcement (MfE 2016; New Zealand Productivity Commission 2013; Severinsen & Peart 2018), as well as insufficient adherence to the obligations and principles of the Treaty of Waitangi (Waitangi Tribunal 2011, 2019). Therefore, while overarching legislation is needed to establish minimum environmental outcomes (i.e. limits and targets) to inform environmental planning and decision making, these outcomes are unlikely to be achieved without parallel reforms to existing funding, compliance, and enforcement frameworks. Compliance monitoring and reporting in particular are crucial to ensure

that resource users and governments are accountable for their environmental effects (Severinsen 2019). Widespread reforms to laws and governance arrangements are also required to realise the Treaty partnership between Māori and the Crown, and deliver promised rights and protections to natural taonga.

5.4. Overarching legislation

We recommend the development of overarching legislation that requires environmental limits and targets to be established for specified subject areas and sub-topics in statutory (i.e. legally binding) instruments, and in accordance with principles stated in the legislation. This overarching legislation should set out:

- for each topic, a narrative objective that limits and targets set through statutory instruments must give effect to (this section, below)
- goals for limit and target setting (Section 5.4.1)
- principles for limit and target setting and implementation (Section 5.4.2)
- the subject areas and topics for which limits and targets are required (Section 5.4.3)
- procedural requirements for reporting and review of limits and targets (Section 5.4.4)
- governance requirements for oversight and enforcement (Section 5.4.4).

The overarching legislation would act as a coordinating framework for limits and targets set under a range of statutory instruments by differing governance entities operating at various scales. Available instruments include national policy statements and national environmental standards under the RMA; total allowable catch limits, gear controls, area exclusions and bycatch management measures under the Fisheries Act; population management plans under the Marine Mammals Protection Act; forest harvesting controls under the Forests Act; controls on greenhouse gas emissions under the Emissions Trading System; building controls under the Building Act; and many more (see Table 10). With some of these instruments, particularly those that rely upon implementation via regional planning processes, it can take many years to establish a full set of limits and targets. While there is no simple solution to this, interim precautionary limits can be established through national instruments while sub-national limits are developed. Such an approach would provide interim protection against overshooting boundaries and a stronger incentive for communities to reach agreement on locally appropriate limits.

For some of the identified subject areas, limits and targets that give effect to the narrative objective will have already been set in statutory instruments. These limits and targets would be retained but be subject to the procedural and governance requirements identified in the overarching legislation. Other subject areas may have

existing limits and targets that are outdated or otherwise insufficient to give effect to the narrative objective; the overarching legislation would require the review of these instruments to set improved limits and targets that provide adequate protection of environmental systems and related values.

The legislation would identify subject areas and topics for which limits and targets have not been set in statutory instruments. The legislation would therefore direct the enactment of limits and targets for these topics within a specified timeframe. Our proposed list of environmental subject areas and topics is indicative only, reflecting current knowledge of environmental systems and issues in New Zealand. We expect this list to be refined through engagement with iwi/hapū, scientists, and the public, and added to over time as new issues arise. Therefore, in section 5.4.3 we have proposed a decision-making tool to help guide the identification of priority environmental issues for limit and target setting. This tool could also be used to assist government in identifying those limits and targets that should be revised or developed first, given scarce resources and capacity.

Figure 9 illustrates the relationship between the overarching legislation and the limits, targets, and related indicators that would be set by statutory instruments. As in Section 4, **subject areas** refer to general realms of environmental management in New Zealand (e.g. freshwater or biodiversity), while **topics** are narrower subsets of those subject areas (e.g. freshwater quantity or quality). For each topic, a **narrative objective** for limit and target setting would be stated in the legislation—a high level statement of what the limits and targets are intended to achieve (e.g. to safeguard the life-supporting capacity of fresh water, its associated species and ecosystems, and protect the ability of freshwater bodies to provide for human needs). Policy makers will be required to give effect to the narrative objective when developing new limits and targets in statutory instruments, and these objectives will also be used to evaluate the efficacy of existing limits and targets. The narrative objectives are intended to provide an enduring statement of New Zealand's minimum expectations and aspirations for improvement of its environmental systems. While the detailed limits and targets set in statutory instruments may be revised over time in line with changing knowledge and improved metrics and data, the narrative objectives will provide a consistent set of expectations for limit and target setting, review and revision.

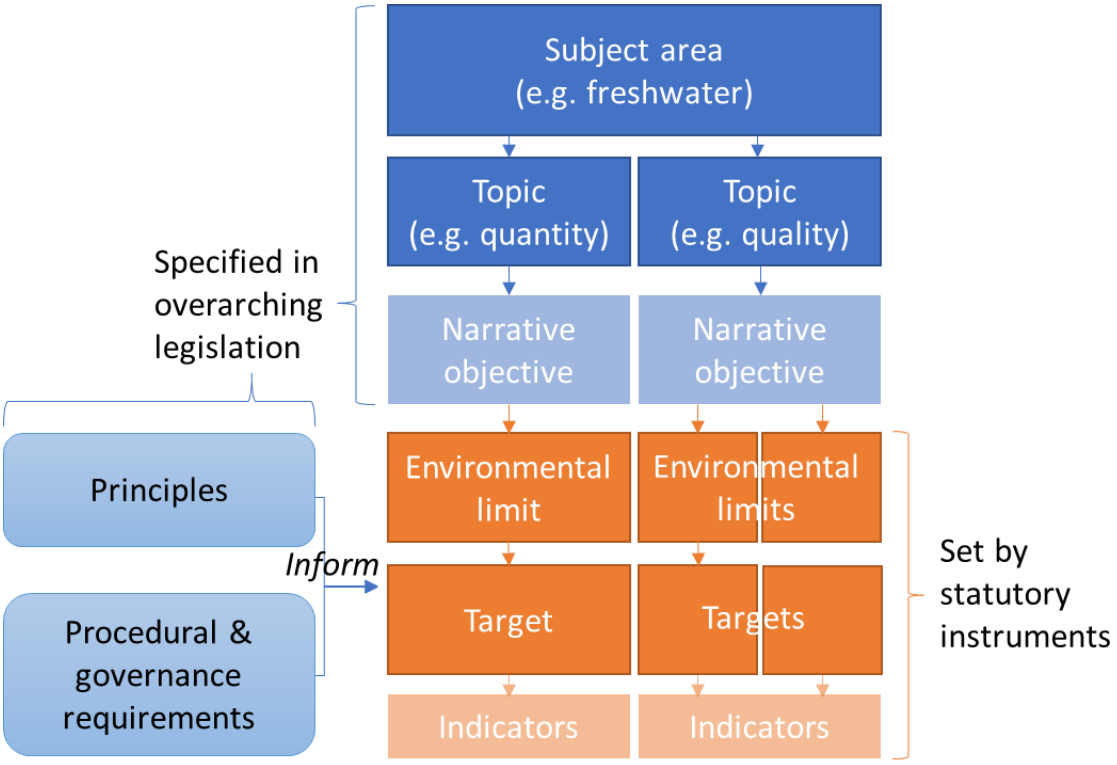

Figure 9. Diagram of the relationship between overarching legislation and the limits, targets, and related indicators that would be set by statutory instruments. The overarching legislation specifies subject areas, topics and objectives for limit and target setting, which are then implemented using other statutory instruments.

As noted earlier, we use the term **environmental limits** to mean 'the level of some environmental pressure, indicator of environmental state or benefit derived from the natural resource system, beyond which conditions which are deemed to be unacceptable in some way' (Haines-Young et al. 2006, p. 8). When set in policy, legally-binding environmental limits may include: prohibitions or strict controls on certain activities; environmental quality standards or bottom lines; caps on the amount of certain activities (e.g. fish harvest) or emission/discharges (e.g. nitrogen allowances); protection of specified areas or features (e.g. national parks); or requirements to maintain, improve, or prevent the loss of specified environmental qualities (e.g. no loss of indigenous vegetation). We envision that multiple policy limits may be needed for any one topic to give effect to the narrative objective. For example, water quality standards would need to be set for a range of physical, chemical, and biological attributes to give effect to an objective on maintaining the life supporting capacity of water.

Environmental **targets** are specific, measurable statements about the desired state of an environmental system and its outcomes for people (Dao et al. 2018). In environmental policy, targets are set to guide environmental action and investment towards specific outcomes and to enable measurement of progress towards wider

objectives. We recommend that targets be required when current environmental outcomes do not meet the minimum level set by the environmental limit, or when the public desires a higher level of protection (as reflected in policy and planning objectives or goals). To be effective tools for driving long term change, policy makers may decide to set both long-term targets that specify policy objectives and short-term targets that act as markers of progress towards long-term goals.

The key components of the overarching legislation (goals, principles, mandatory limits and targets, and procedural and governance requirements) are detailed in the following subsections.

5.4.1. Goals for limit and target setting

We recommend that the legislation include a clear set of goals that articulate the rationale for instituting environmental limits and targets and the socio-ecological outcomes sought. These goals would summarise the purpose of the overarching legislation and should be reflected in the narrative objectives for each topic, as well as inform the development of limits and targets in statutory instruments. While high level, the goals should be written precisely enough that it is possible to evaluate statutory limits and targets according to how well they give effect to the goals. In this way, the goals should have similar stature to the Purpose in the RMA 1991 (Part 2, Section 5).

We recommend that the goals of the overarching legislation be developed in partnership with iwi/hapū and with opportunities for public input and feedback. As noted earlier, environmental limit and target setting are not simply scientific exercises—they reflect societal assessments of acceptable levels of environmental change and/or risk (see Steffen et al. 2015b). As such, it is important that tangata whenua and the public are centrally involved in identifying the purpose, scope, and principles for limit and target setting.

Nevertheless, to illustrate the nature of the goals we envisage and their role in guiding limit and target setting and implementation, we have proposed a set of indicative goals below. In developing these goals, we have sought to include both substantive (i.e. the outcomes desired) and procedural (i.e. how limits are instituted) dimensions of environmental limit and target setting.

Proposed goals:

- To protect and enhance the life supporting capacities of New Zealand’s natural environment
- To reduce New Zealand’s environmental footprint such that it is not contributing to the exceedance of global environmental limits
- To ensure that resource use does not exceed environmental thresholds, causing the loss or significant degradation of ecosystems

- To ensure a minimum level of environmental quality necessary to protect human health and wellbeing
- Environmental limits and targets improve protections and enhancement of Māori land, resources, and taonga, in line with iwi/hapū aspirations
- New Zealanders are directly involved in identifying environmental bottom lines and aspirations to guide limit and target setting
- Environmental limits and targets are effective in informing decision making
- Operating within environmental limits underpins resource management by all relevant agencies and statutory instruments.

5.4.2. Principles for environmental limits and targets

We recommend that the overarching legislation outline a set of principles for setting and implementing environmental limits and targets. Given that we are recommending that mandatory limits and targets be set via a range of statutory instruments, by varying government entities, using different processes, it is important to establish principles to promote consistency in approaches. Our use of principles is thus similar to that in the Swedish Environmental Code and UK Environment Bill, which outline environmental principles to guide implementation by a range of decision makers. In line with these examples, the principles set out in Part 2 of the RMA 1991, and the legal principles outlined by the Environmental Defence Society (Severinsen 2019, p. 47-48), we recommend that the principles included in the legislation include both ethical (e.g. intergenerational equity) and best practice (e.g. adaptive management) guidance. In addition, principles should provide specific guidance on the attributes of effective environmental limits and targets (e.g. specific and measurable).

We further recommend that the overarching legislation require policy makers to give effect to these principles when developing or revising statutory instruments that include environmental limits and targets. This requirement would extend to policy makers that set limits and targets (or requirements for limits and targets) in national statutory instruments and, where limit and target setting is devolved to other entities, subnational policies, plans, and strategies. Thus, in the case of the Freshwater NPS, both the Ministry for the Environment and regional councils would be required to give effect to the principles in developing the Freshwater NPS and setting limits in regional plans, respectively. We intend these principles to have broad relevance for limit and target setting in New Zealand, including by providing guidance to governance entities developing limits and/or targets outside of statutory instruments.

Where limits and targets are set in statutory instruments authorised by other environmental legislation (e.g. the Fisheries Act or RMA), any limits and targets set would need to be consistent with that legislation. Legal advice will be required on how to minimise the likelihood of the overarching legislation conflicting with requirements in

other statutes used to establish limits, and how to resolve any conflicts should they arise.

As with the goals for limit and target setting, we recommend that the principles in the overarching legislation be developed in collaboration with iwi/hapū leaders and public input. Again, we have proposed some indicative principles to illustrate the range of principles that might be included.

Ethical-substantive principles

- Limits and targets should recognise and respond to New Zealand's role in **global environmental systems**, including its contribution to global environmental issues and international contributions to changes occurring in New Zealand.
- Limits and targets should support both **human and environmental** wellbeing, including consideration of human health, needs, and acceptable levels of risk.
- Limits and targets should advance **inter- and intra-generational equity** in environmental outcomes and in the costs and risks of implementation.
- Maintenance of current environmental outcomes is not sufficient for many systems that are already in a degraded state – **environmental enhancement** is required.
- Resource limits should promote the **sustainable and equitable** allocation and use of finite resources, recognising the obligations and principles of the Treaty of Waitangi/Te Tiriti o Waitangi.

Best practice principles

- Limits and targets should be **science-based** and **democratic**, informed by both scientific data and expertise (including mātauranga Māori) and public and tangata whenua input on acceptable levels of environmental quality, impacts, and risk.
- The setting of environmental limits and targets should give effect to the **Treaty of Waitangi/Te Tiriti o Waitangi** principles of partnership, participation, and protection.
- Where significant scientific uncertainty exists, limit setting should exercise **precaution** in proportion to the risk posed to human and environmental systems.
- Limit and target setting should be **adaptive**, allowing for regular review and revision to improve environmental protections.
- Limits and targets should be set in statutory instruments that **directly influence** decisions that will give effect to or contribute to exceeding the limits/targets.
- Statutory instruments should clearly set out the **duties, responsibilities, and requirements** for implementing limits and targets.

Principles for setting effective limits and targets

- Limits and targets should be **specific and measurable**, with clear indicators and available environmental data to measure progress over time. Measurable

indicators may be quantitative or qualitative as long as there is a clear indicator by which to measure change.

- Targets should be **realistic**, taking into account constraints on enhancement actions and their effectiveness while still seeking meaningful change.
- Targets should be **timebound**, identifying a date by which the target is to be achieved.
- Limit and targets should be set with a view to **future generations**, recognising the often slow, non-linear, and multi-scale nature of environmental change.
- Long-term environmental improvement targets should be complemented by **intermediary targets** that enable assessment of progress and promote democratic accountability.
- Limits and targets should be set at the **scale** at which environmental outcomes occur, while ensuring that human health and wellbeing receive the same protection nation-wide.

5.4.3. Mandatory limits and targets

As stated earlier in Section 5.3, we recommend that the overarching legislation include a list of subject areas and topics for which the government is required to set environmental limits and targets. We recommend that this list be included as a schedule to the legislation, to enable the list to be added to over time as environmental issues arise or become a priority for limit and target setting. For each topic, the schedule would also state a narrative objective for limit and target setting and a date by which limits and targets must be set in statutory instrument(s).

Narrative objectives are intended to provide high level guidance on what the limits and targets for a topic are intended to achieve. This approach mirrors the environmental statements that accompany Sweden's 16 environmental quality objectives. For example, for their clean air objective they state: 'the air must be clean enough not to represent a risk to human health or to animals, plants or cultural assets'. Similarly, the Environmental Defence Society (Severinsen 2019) propose the inclusion of a list of narrative environmental bottom lines in Part 2 of the RMA.

In this section we set out the criteria and process by which we identified topics for mandatory limit and target setting under the proposed overarching legislation and include a list of proposed subject areas and topics. This list is indicative only, based largely on our knowledge and judgement, with input from other subject matter experts through the workshop. This list should be further refined in conversation with subject matter experts, environmental practitioners, iwi/hapū leaders, and policy makers, with opportunities for public input. We have provided our decision-making criteria and prioritisation tool in the hope that they may be useful in guiding such a conversation.

We have not provided narrative objectives and dates for our list of priority topics—these should be developed in conjunction with the final selection of topics, through a participatory process. However, in Section 5.4 we apply our assessment of priorities for limit and target setting to four subject areas: land use change, biodiversity, the built environment, and marine and coastal environment. For each subject area we provide a more detailed assessment of the need and rationale for environmental limits and describe the impetus to set limits for specific topics, with some suggestions on possible statutory instruments.

The following decision criteria were developed based on our review of the academic literature, along with responses from workshop participants to the question 'when (under what circumstances) are environmental limits useful and appropriate?' We identify criteria for identifying whether environmental limits should be mandatory first, and then pose additional criteria for target setting. That is, environmental targets would act as a supplementary tool to limits.

To determine whether environmental limits should be mandatory for a topic, we applied four main criteria:

- strength of evidence of environmental deterioration
- degree of (likely) impact on environmental system
- socio-ecological values at stake
- ability of government to influence environmental outcomes.

Provided that there is moderate to strong evidence of decline, and at least a moderate ability for the government to influence outcomes, limits should be mandatory for a topic when any of the following conditions apply:

- Environmental decline poses an unacceptable risk to human health and wellbeing, or socio-ecological values that are of widespread importance and/or are significant to tangata whenua.
- An affected environmental system is likely to cross a threshold, change state, or become degraded such that it no longer performs key functions at significant scales.
- There is a substantial risk of loss of a population, species, ecologically-significant habitat, ecosystem, or significant natural feature.
- New Zealand's resource use is contributing to the degradation of an Earth system process or resource such that the global system has transgressed, or is at risk of transgressing, a global environmental limit/boundary.

In addition, precautionary interim limits should be set for a topic when information about environmental changes and/or impacts is limited, but the change poses an unacceptable risk to humans or environmental systems. Such interim limits should remain in place until sufficient information on the system change and its outcomes is

gathered, such that a determination can be made as to whether a permanent limit is needed.
Setting environmental targets should be mandatory for a topic when:

- environmental limits are mandatory; and
- either:
    - The environmental system has already exceeded the set environmental limits; or
    - The current environmental state is degraded relative to agreed environmental aspirations or objectives.

We developed these criteria into a decision tool, illustrated in Figure 10 as a flow diagram. If at topic scores ‘low’ on any of the criteria, it is a low priority for limit setting. For topics that pass this test, scoring ‘moderate’ on two or more criteria makes it a moderate priority, whereas ‘moderate’ on only one (and thus ‘high’ on the other criteria) makes a topic a high priority for limit setting. Finally, if limits have already been exceeded, targets must be set as well. Appendix 2 presents this tool as a decision tree, with greater detail on our prioritisation of topics.

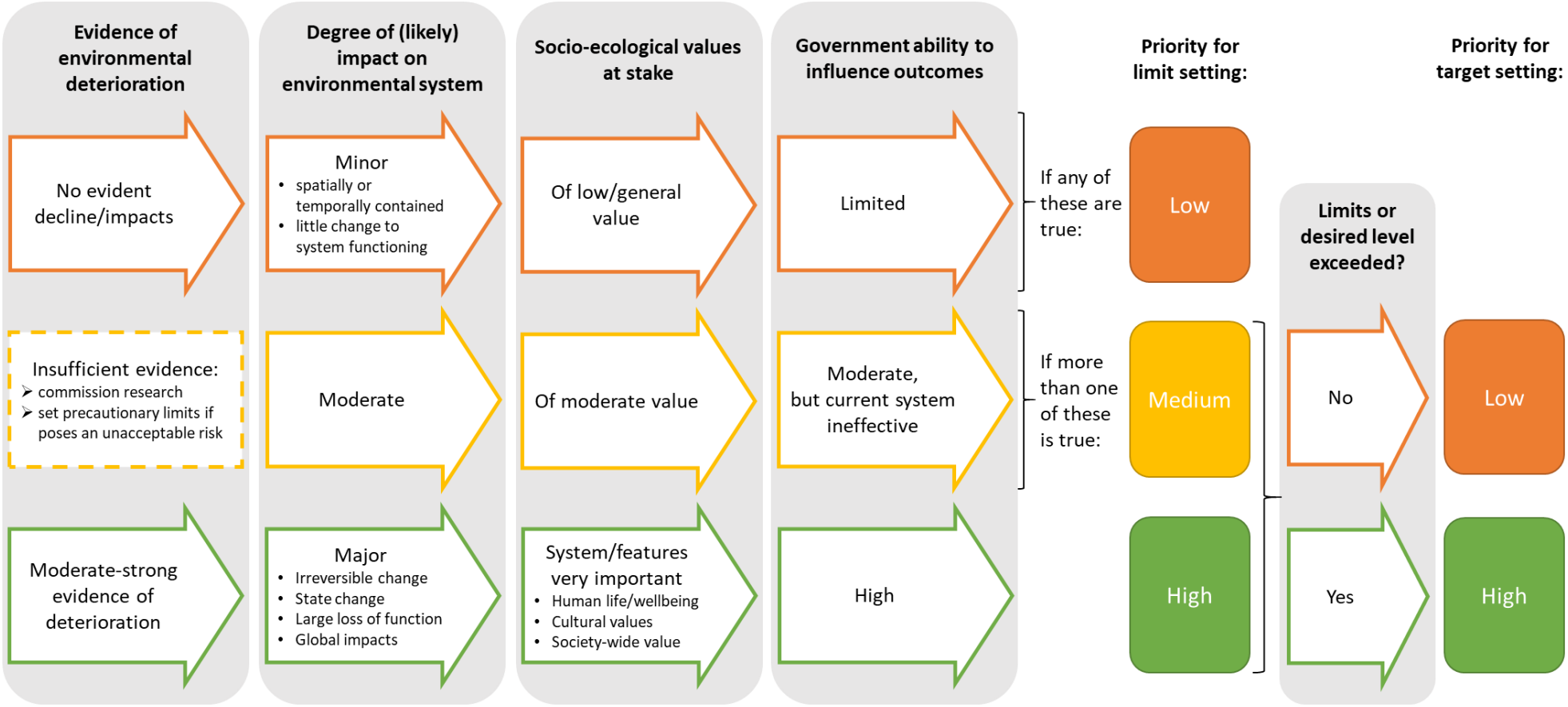

Figure 10. Decision tool for prioritising topics for environmental limit and target setting.

We applied this decision tool to a list of environmental topics to identify priorities for limit and target setting. The list was first populated with the topics identified in our stocktake of New Zealand statutory instruments (see Table 10 above), and then refined through comparison with the planetary boundaries framework and international case studies, together with expert knowledge. Table 11 lists the subject areas and topics that we have identified as candidates for mandatory limit and target setting in the overarching legislation

Table 11. Priority subject areas and topics for mandatory limit and target setting.

Subject area	Topic	Status of limits & targets*
Freshwater	Quantity	National limits & targets set
	Ecosystem health	National limits & targets set
	Contact recreation	National limits & targets set
	Drinking water	National limits set
Air	Air quality	National limits set
	Ozone-depleting emissions	National limits set
Land	Soil contamination	National limits set
	Forests/indigenous forest cover	National limits set
Biodiversity	Ecological integrity	**No limits exist**
	Ecosystem status	Some limits proposed
	Threatened species	**Few limits exist**
	Taonga species	**Few limits exist**
	Invasive species	Some targets exist
Climate Change	GHG emissions produced by New Zealand	National limits set
	Embodied emissions in consumption goods	**No limits exist**
Coastal & marine	Estuary health & eutrophication	**No limits exist**
Environments	Fisheries	Stock limits set
	Fisheries bycatch eg seabirds	Some limits & targets set
	Marine mammals	Some limits set
	Aquaculture	**Few limits exist**
	Marine biodiversity & habitat	**Few limits exist**
Built environment	Solid waste	Some limits and targets set
	Wastewater	Some limits set
	Healthy housing	Some limits set
	Carbon footprint of new buildings	**No limits exist**
	Noise	National limits set
	Exposure to electromagnetic fields	National limits set
	Green space	**No limits exist**

* Some of the limits referred to in this column, especially those for freshwater, require regional specification and implementation.

5.4.4. Reporting and oversight arrangements

Reviews of the academic literature and international case studies highlight the importance of reporting and oversight arrangements in environmental limit and target setting. Regular public reporting on indicator data for limits and targets is essential to promote transparent communication of proximity to limits and targets, as well as trends in environmental outcomes. Such information provides a basis with which to hold governments accountable for environmental enhancement or degradation. The UK Environment Bill, for example, requires government to set and adhere to reporting dates for each long-term target, and to report annually on progress towards improving the natural environment and meeting interim targets. The City of Vancouver provides another strong example of public reporting on environmental targets. Its Greenest City Action Plan uses indicators that are closely aligned with quantitative targets and supported (in most cases) by existing data sources, allowing it to report trend data and assess whether it is on track to meet targets. This information is presented in easily understood graphs and statistics in annual reports and on the City's website.

In New Zealand, state of the environment reporting provides information on current environmental quality and (where data are available) trends in attributes, but these data are not always tracked against limits or targets (Petrie 2018). Further, a recent report by the Parliamentary Commissioner for the Environment (2019) revealed significant inconsistencies in how and for what purpose environmental data are collected. As such, it can be difficult for members of the public to interpret the meaning or significance of trends in environmental data. As Severinsen (2019, p.282) states:

> environmental reporting is for the most part reduced to general statements about positive and negative trends rather than "achievement" or "failure" of a system within which those trends are occurring. This clouds a sense of accountability for the very real problems we are seeing.

Some statutory instruments (e.g. the Fisheries Act) require additional environmental data collection and reporting, including against limits or targets, but this information is typically domain or industry specific and can be difficult for the public to find and interpret (Severinsen 2019). The current fragmentation in limit and target setting and reporting thus makes it difficult to gain a holistic overview of how New Zealand's environment is changing with respect to bottom lines or aspirations.

Regional councils are primary contributors to public environmental reporting in New Zealand, due to their monitoring networks and state of the environment reporting requirements. However, such reporting has not necessarily promoted local government accountability for environmental outcomes, with few mechanisms to hold governments legally answerable for continued environmental degradation. While the Parliamentary Commissioner for the Environment can investigate and report on the

effectiveness of environmental management by public authorities and advise on remedial action, the Office of the Parliamentary Commissioner for the Environment cannot force a response from government nor initiate legal action. Indeed, New Zealand has few environmental organisations that have the resources to take government agencies to court (Severinsen 2019). Lack of alignment between environmental reporting timelines and electoral cycles also weakens democratic accountability for governments' environmental performance (Petrie 2018).

We therefore recommend that the overarching legislation (1) contains clear environmental reporting requirements, (2) empowers an independent agency to oversee limit and target setting and reporting, and (3) requires the independent agency to undertake regular reviews of mandatory limits and targets. These steps, detailed further below, would promote transparency, democratic accountability, and independent oversight and accountability for performance against environmental limits and targets in New Zealand.

First, we recommend that the overarching legislation require all statutory instruments that set environmental limits or targets to have a reporting term of no more than three years. Government agencies responsible for administering the statutory instruments would be obliged to collect data on the limit and target indicators (discussed further in Section 5.3) and produce a publicly accessible report by the end of each reporting term. A maximum reporting term of three years corresponds with electoral cycles, which promotes democratic accountability for environmental performance. Where government agencies already prepare regular reports on environmental data, they should be allowed to integrate environmental limit and target reporting into their existing reporting as long as progress against limits and targets is clearly communicated. Where data indicate that limits have been or are close to being exceeded, or that system trends are not on track to achieve targets, the reports should also identify actions the agency plans to undertake to improve environmental outcomes.

Second, we recommend the overarching legislation creates or empowers an independent agency to oversee its implementation, including limit and target setting, reporting, and review. As with other independent crown entities in New Zealand, the oversight agency would be charged with providing advice to government on implementing the law and investigating and reporting on environmental performance. We also recommend that this oversight role include a requirement for government (or specific government entities) to publicly respond to findings in its reports, and powers to recommend investigations of, or legal proceedings against, government agencies that fail to fulfil their duties. These recommendations are similar to the proposed oversight arrangements and powers for the UK Environment Bill (see Section 3.3.2).

Specifically, the independent agency would be responsible for:

- overseeing government agencies' setting of limits and targets in statutory instruments by the specified date, including through provision of guidance
- overseeing government agencies' reporting on environmental limit and target indicator data
- undertaking a regular review of the environmental limits and targets set in statutory instruments, and preparing regular public reports on the findings
- reporting to Parliament on any agencies that do not fulfil the limit and target setting requirements specified by the overarching legislation, including failure to set or report on limits and targets by specified dates, or failure to give effect to limits and targets in decision making under the relevant statutory instrument
- recommending investigations or legal proceedings against government agencies that repeatedly fail to fulfil their duties under the legislation.

As Severinsen (2019) observes, New Zealand already has several independent environmental oversight agencies, including the Parliamentary Commissioner for the Environment and Climate Change Commission. With further oversight agencies proposed for specific domains (including for infrastructure and freshwater), we do not wish the overarching legislation to contribute to the duplication or fragmentation of oversight responsibilities. Such an outcome would be contrary to our focus on improving the coordination of outcomes-based environmental management in New Zealand. It may therefore be preferable that an existing entity be empowered to oversee implementation of the new legislation, or that a new oversight agency take on both oversight of the legislation and the duties and responsibilities of existing agencies.

Third, and as already indicated, we recommend that the overarching legislation require the regular review of environmental limits and targets in statutory instruments. Specifically, the review should include:

- review of information collected for any precautionary limits, to evaluate whether the precautionary limit should be removed, revised, or made permanent
- evaluation of limits and targets set in statutory instruments according to the goals, principles, and narrative objectives in the overarching legislation, to determine whether they are sufficient to give effect to the legislation's goals
- review of limits and targets set in statutory instruments based on the latest data and scientific understanding (including mātauranga Māori), to determine whether any revisions to limit and target levels or indicators are needed
- future scanning to identify emerging topics for which environmental limits and targets should be set.

Any revisions to environmental limits or targets in statutory instruments would need to give effect to the narrative objective for the topic, as stated in the legislation. New

topics that warrant environmental limit and target setting could be added to the schedule by the government of the day.

Such a review should be led by the independent oversight agency and summarised (alongside environmental data) in a report to Parliament every six years, within six months of triennial national elections.[23] The review and report would draw together indicator data for all statutory environmental limits and targets, providing a single comprehensive assessment of New Zealand's environmental outcomes. The report should clearly identify the topics and locations that are currently or close to exceeding environmental limits and evaluate the extent of progress towards targets. The government of the day would be required to respond to the findings and recommendations within a set timeframe, identifying what actions the government will undertake. The clear presentation of such information will help to support an informed environmental citizenry that can hold agencies accountable for outcomes.

5.5. Applying environmental limits and targets to four subject areas

In this section we apply our assessment of priorities for limit and target setting to four subject areas: land use change, biodiversity, the built environment, and marine and coastal environments. There is overlap between these areas, for instance biodiversity is an issue under land use change and marine and coastal environments and is a subject area in its own right. For completeness, we have included it in each of these. For each subject area we provide a more detailed assessment of the need and rationale for setting environmental limits and targets and identify any limits/targets already in use. We describe the impetus to set or refine limits for specific topics in the subject area, with some suggestions on possible statutory instruments. At the end of each subsection, a table summarises our assessment of each topic's priority for limit and target setting.

5.5.1. Applying limits and targets to land use change

Questions about whether to control land use and land use change in New Zealand encompass issues of biodiversity loss, availability of land for food production, soil contamination, carbon storage, effects of land use practices on freshwater and coastal environments, and the effects of land use change on small communities.

At a global scale, the Planetary Boundaries proponents have recommended a global limit of retaining at least 75% of original forest cover and at least 50% of temperate forests, in order to retain sequestered carbon and to protect biodiversity and the integrity of ecological systems (Steffen et al. 2015b). In New Zealand, we have

[23] We recognise that the preparation of a report every three years would be more democratically accountable, but argue that a review of all data, limits, and targets every six years is both more practicable and more likely to detect longer term trends in environmental outcomes.

retained less than 30% of our original forest cover (Ewers et al. 2006). The conversion of land to urban, agricultural and exotic forestry uses has resulted in a loss of significant stores of carbon as well as deleterious effects on terrestrial, freshwater and coastal ecosystems, raising the question of whether we should adopt a target for restoring native forest cover. In addition, the government has proposed a national policy statement on highly productive land to protect New Zealand's vegetable production and associated communities (MFE 2019c).

Global food security

Globally, conversion of land from natural systems has been driven primarily by human demand for food, fibre and other agricultural and forestry products and, to a lesser degree, by urbanisation. New Zealand has a large amount of productive agricultural land and exports billions of dollars of food products each year—the ability of the country to feed itself is not in doubt. To some extent, highly productive land retained in agricultural use in New Zealand will reduce the pressure for conversion of less productive land elsewhere in the world, so a case for limits on land use change could be made on this basis. However, as explained in Section 3.5.5 above, poverty—the lack of income to buy sufficient food—is a more significant issue than food supply. Beyond this, post-harvest loss and food wastage would likely be more effective at ensuring global food security than trying to prevent conversion of agricultural land to other uses.

The ability of the New Zealand government to influence global food security through controls on land use change is low. Land use change can have negative effects on communities, though attempts to prevent change can stifle innovation and preclude positive effects. We are not convinced that the negative effects on communities are significant enough to warrant national limits or controls on the conversion of highly productive land, or that the government is able to exercise much influence on such conversions short of prescriptive legislation that would stifle innovation.

As for other concerns about land use change, there is clear evidence of a loss of forest cover and that the effects are both widespread and significant for biodiversity, carbon storage and other ecosystems, e.g. freshwater and coastal environments. Also, the government is able to influence actions and outcomes in these areas. New Zealand policy regarding potential limits and targets for land use change should therefore be focused on issues of soil contamination, carbon storage, biodiversity and ecosystem function. Using the framework presented above in Figure 9, our analysis of the need for limits on land use change are summarised in Table 12 and explained below.

Table 12. Criteria for limits and targets on land use to address five possible topics. Responses are colour coded to illustrate the rationale for the priority assigned to a topic (in line with Figure 10): mostly green criteria suggests a high priority topic, many yellow indicate medium priority, and any orange criteria indicate a low priority topic.

Topic	Evidence of environmental deterioration	Degree of impact on environmental system	Socio-ecological values at stake	Government ability to influence outcomes	**Priority for limit-setting**	Exceeded the desired level for New Zealand	**Mandatory targets?**
Global food security	Clear evidence	Moderate: localised	High	Low	**Low**	No	**No**
Soil contamination	Clear evidence	Moderate: localised	High	High	**High**	Yes, but difficult to reverse	**Maybe**
Carbon storage	Clear evidence	High	High	High	**High**	Yes	**Yes**
Biodiversity	Clear evidence	High	High	Low-moderate	**High**	Yes	**Yes**
Ecosystem function	Clear evidence	High	High	Moderate	**High**	Yes	**Yes**

Soil contamination

New Zealand has implemented limits to address soil contamination through national environmental standards that establish controls on activities on contaminated land. While soil contamination is highly localised, there is the potential for serious negative effects on people and the environment if contaminated land is used inappropriately, e.g. for food production or residential dwellings. Governments can manage this risk through land use controls, and limits are therefore warranted. Although the desired level of contamination (in principle, none) has been exceeded, reversing contamination is typically difficult if not impossible, so setting targets for remediation may or may not be helpful.

Carbon storage

Existing legislation requires accounting for carbon emissions due to forest clearance and rewards the establishment or restoration of forest, the rules for which are governed by international agreements. Carbon is also stored in large areas of forest that are in national parks or public lands, and most of these are protected. Increasing the amount of carbon stored in agricultural and horticultural soils should also be encouraged and rewarded, and loss of soil carbon discouraged. This could be done by incorporating soil carbon changes into the emissions trading scheme for greenhouse gases, once the science is sufficiently robust. As for forest carbon, however, the rules for accounting for changes in soil carbon are governed by international agreements. We consider that issues of carbon storage in soils are best

addressed through climate policy mechanisms, and that additional limits or targets on land use change for that purpose are not needed.

Biodiversity

New Zealand has large areas of natural forest protected in national parks and other forms of public reserves, providing a haven for many indigenous species. Significant remnant pieces of vegetation are protected by purchase or easement e.g. via the QEII Trust and private entities. The condition of forests and the presence of invasive species probably pose a greater threat to biodiversity loss than does the potential for clearance of natural forest.

However, Other biomes are less well preserved. Over 80% of New Zealand's original wetlands have been lost, for example. Limits should be established on further conversion of rare or significantly reduced ecotypes, complemented by targets for their restoration where appropriate. In the case of wetlands, for example, drainage is restricted via RMA and regional and district plans, and the government's 2020 reforms will strengthen these protections. The government could go further by establishing a target of restoring a specified number of hectares of wetlands by 2030 and an additional area by 2040. These targets could be further apportioned regionally or even more locally, based at least in part on the pre-European extent of wetlands in a given area.

Past attempts to establish limits on the conversion of natural vegetation have encountered strong political opposition at both local and national scales, e.g. a national policy statement on indigenous biodiversity was proposed in 2011 but later withdrawn.[24] A new proposed national policy statement (NPS) on indigenous biodiversity was released in November 2019 and submissions closed on 14 March 2020. This NPS would require the mapping and protection, via regional plans, of significant natural areas and thus could provide an appropriate platform for establishing restoration targets as well.

The imposition of limits on land use change can have significant equity implications and Treaty implications. The Forests Act prohibitions on harvest of natural forest, for example, fell heavily on Māori owners of the SILNA25 forests in Southland. After extended discussions between the owners and the government, some allowance was made for harvest from these forests.

Ecosystem function

The third area for which land use change has major implications for a 'safe operating space for humans' is the integrity of ecosystem function. In New Zealand, the

[24] https://www.mfe.govt.nz/more/biodiversity/upcoming-government-biodiversity-initiatives/developing-national-policy-statement

[25] South Island Landless Natives Act 1906 – see https://www.mpi.govt.nz/growing-and-harvesting/forestry/indigenous-forestry/forests-under-the-south-island-landless-natives-act-1906/.

declining health of freshwater ecosystems is the most prominent example of land use impacts on ecosystems. This is being addressed through the Freshwater NPS, which provides some useful pointers for other areas, such as estuaries, that may require a similar approach. The Freshwater NPS directs regional councils to establish limits and standards for every freshwater body in New Zealand and specifies a number of attributes and minimum standards that must be met over time.

While there is considerable work to be done on implementation by regional councils, we consider that the structure of the Freshwater NPS is an appropriate way to address land use change as it affects ecosystem function. As noted above, there are significant Treaty and equity implications arising from limits and policies for their implementation, and in many cases there will be a need for a transition over time, with support for those expected to make major changes to existing patterns of use.

5.5.2. Applying limits for biodiversity

Biological diversity is defined by hierarchical and spatial scales—genetic, species and ecosystems, and (sub)nationally, regionally, and globally. At the global scale, the Planetary Boundaries proponents have recommended a limit on the rate of extinctions (< 10 per million species years[26]) in order to protect genetic diversity, but this was estimated to be exceeded 100-fold at the global scale in 2009 (Steffen et al. 2015b). New Zealand has a high rate of extinction; 75 known animal and plant species have become extinct since human habitation including 50% of bird species (MfE, Stats NZ 2019). Marine, freshwater, and land ecosystems all have species at risk of extinction: 90% of seabirds, 76% of freshwater fish, 84% of reptiles, and 46% of vascular plants (MfE, Stats NZ 2019).

New Zealand has a relatively high proportion of area in protected status—30% of total marine area and 32% of land and inland waters (OECD 2017). However, many ecosystem types are not well represented, e.g. only 10% of wetlands remain (Ausseil et al. 2008). Despite being a global leader in recovering species and controlling pests, the separation of management of species and ecosystems in New Zealand threatens further biodiversity loss. Biodiversity protection and land-use planning are fragmented and the state of indigenous biodiversity on private lands appears to be declining (OECD 2017).

The 2019 Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) report outlines five key drivers of biodiversity loss: (1) changes in land and sea use, (2) direct exploitation of organisms (e.g. overfishing), (3) climate change, (4) pollution, and (5) invasive species. Limits and targets to govern biodiversity can help to protect indigenous species and their habitats through a focus

[26] Background extinction rate is about 1 per million species year. For example, if there are a million species on planet earth, one would go extinct every year, or if there was only one species it would go extinct in one million years.

on either species' risk of extinction (i.e. vulnerability), ecosystem level resilience, or the eradication of invasive exotic species. Biodiversity goals encompass land, freshwater and marine domains and can also be impacted by air quality and global climate effects. As such, limits and targets developed to address these domains often address biodiversity outcomes, i.e. biodiversity imperatives are part of other sectorial policies.

This section briefly summarises a range of biodiversity **outcomes** that could be improved through the application of environmental limits and targets. Of prominence is a set of goals outlined in Te koiroa o te koiora (2019) which focus on the need for holistic tools that incorporate te ao Māori perspectives and Treaty partnership, and 'system shifts' that clarify and enable roles at local, regional and national levels.

Ecological integrity

Ecological integrity (EI) is an integrating biodiversity concept that is defined as 'the full potential of indigenous biotic and abiotic features and natural processes' (Lee et al. 2005). It includes aspects of habitat, ecosystem function and connectivity, as well as biophysical components of an ecosystem. It has been suggested that EI aligns closely to the Māori concept of mauri in that humanity is seen as an integral part of the system, but mauri also encompasses elements of wairua and whakapapa (McGlone et al. 2020). Ecological integrity assessment frameworks have been developed for marine (Thrush et al. 2011), freshwater (Clapcott et al. 2018), and the terrestrial conservation estate (McGlone et al. 2020). Limits and targets for EI could provide a high-level assessment of whether biodiversity objectives are being met. Specific targets could sit within sectorial policies, e.g. National Policy for Freshwater Management. Limits would need be informed by expert evidence given the integrative nature of the objective.

Ecosystem threat status

Protecting biodiversity requires maintaining a full range and extent of ecosystems and habitats and connectivity between them. Ecosystem status classification can help inform conservation prioritisation and direct restoration investment as well informing limits on resource use. The significance of a habitat or ecosystem informs the threat classification, which is assessed by representativeness, rarity, diversity/patterns, and ecological context. In New Zealand, 71 different types of naturally uncommon ecosystems have been described, of which 18 are classified as critically endangered (the highest level of threat), 17 as endangered, and 10 as vulnerable (Holdaway et al. 2012). Four ecosystems (volcanic dunes, young tephra plains and hillslopes, coastal turfs, shell barrier beaches) have less than 20% of their total area under public conservation land and hence require other mechanisms to protect them. The proposed National Policy Statement for Biodiversity includes provisions to manage adverse effects from new activities that impact on 'Significant Natural Areas'. Subsequent boundaries or limits will most likely require expert judgement, although

scientific evidence has been used to recommend specific habitat thresholds e.g. 60% area remaining of specific wetland types in New Zealand (Clarkson et al. 2015).

Threatened species

The conservation status of indigenous taxa is one of the few systematically, comprehensively, and regularly assessed factors of biodiversity in New Zealand and globally (McGlone et al. 2020). Like ecosystems, the classification for species relies on expert opinion. However, once classified, threatened species are not supported by comprehensive legislation in New Zealand, such as the US Endangered Species Act 1973 or the Australian Environment Protection and Biodiversity Act 1999, which would enable an integrated and legally accountable approach to the management and recovery of threatened species (Seabrook-Davidson & Brunton 2010). A systematic and transparent approach to species planning, better integration with resource development, and a measure of accountability is required (Wallace & Fluker 2016), applicable to limit and target setting.

Invasive species

Introduced species are ideally primarily managed to maintain or enhance indigenous biodiversity, and secondarily for other values they provide. However, sometimes introduced species threaten indigenous species and become invasive. The Biosecurity 2025 Direction Statement (2016) outlines targets to minimise the impacts of invasive species on biodiversity, including, (1) the active management of pests and disease risks by 90% of relevant businesses, (2) public and private investment of at least $80 million in science for biosecurity, of which at least 50% focused on critical biosecurity areas, and (3) identifying 150,000 skilled people to support responses to biosecurity incursions.

Taonga species

Closely aligned to the outcome of protecting threatened species is protecting taonga species—flora and fauna which are central to the identity and well-being of Māori. Similar to targets in the Canadian 2020 biodiversity goals, a focus here is on improving biodiversity outcomes for indigenous peoples through maintaining customary use of biological resources and promotion of traditional knowledge. Key to developing limits and targets will be a place-based relationship with iwi/hapū and systems to incorporate mātauranga into decision making.

Table 13. Criteria for limits and targets for biodiversity topics. Responses are colour coded to illustrate the rationale for the priority assigned to a topic (in line with Figure 10): mostly green criteria suggests a high priority topic, many yellow indicate medium priority, and any orange criteria indicate a low priority topic.

Topic	Evidence of environmental deterioration	Degree of impact on environmental system	Socio-ecological values at stake	Government ability to influence outcomes	**Priority for limit-setting**	Exceeded the desired level for New Zealand	**Mandatory targets?**
Ecological integrity	Clear evidence	Key high-level objective	High	Moderate-High	**High**	Unknown	**Yes**
Ecosystem status	Clear evidence	Important for prioritisation and protection	High	Moderate-High	**High**	Probably	**Yes**
Threatened species	Clear evidence	High especially when key taxa	High	High	**High**	Yes	**Yes**
Taonga species	Clear evidence	Moderate-High*	High	Moderate-High	**High**	Unknown	**Yes**
Invasive species	Clear evidence	High	High	High	**High**	Yes	**Yes**

* Species dependent

5.5.3. Applying limits and targets in the built environment

A range of environmental limits and targets are applied to the built environment, including limits and targets that govern freshwater, land, air, and biodiversity domains, as well as those developed to address issues specific to urban environments (Hoornweg et al. 2016). Home to approximately 85 percent of New Zealand's population, urban areas are a key site of environmental impacts on human health, the consumption of resources and production of wastes, and public interactions with nature. The design and location of infrastructure, buildings, and public space all influence human and ecological wellbeing within the built environment (e.g. urban food security, urban stream syndrome, see Vardoulakis et al. 2016) and contribute to pressures on wider regional and global environmental systems (e.g. through energy demand, see Viglia et al. 2018). Greenfield development generates more intensive effects on freshwater, soils, and greenhouse gas emissions, while re-development can (but does not always) improve sustainability and health outcomes in the built environment (Preval et al. 2016). Environmental limits and targets are typically used in the built environment to secure a minimum level of human health, constrain adverse environmental effects of development, and promote the retention or inclusion of socio-ecological values in urban design.

This section briefly summarises the range of built environment outcomes that could be improved through the application of environmental limits and targets, identified through our review of the international literature and case studies, stocktake of New Zealand statutory instruments, and expert input during the May workshop. We identify four broad classes of limits and targets to improve built environment outcomes: waste disposal, urban design, human exposure to harmful activities, and minimum levels of environmental quality. We conclude that while environmental limits and targets could be useful tools to improve socio-ecological outcomes across a range of issues, nationally mandated limits and targets are only appropriate for some of these issues. Other issues may be addressed through context-specific limits and targets in local policies and planning processes.

Limits on the disposal of wastes

Limits on waste seek to contain waste flows to prevent adverse effects on human health and the surrounding environment, through strict controls on the disposal of hazardous wastes (e.g. tyres), policies to reduce the amount or specific types of waste produced (e.g. microbead ban) and minimum standards for waste infrastructure (e.g. wastewater treatment systems). Many of these limits are already in place, with local governments developing waste reduction targets[27] to reduce the amount of waste being sent to landfill, and central government increasingly using its regulatory powers under the Waste Minimisation Act 2008 to ban unsustainable products. Wastewater represents an area of ongoing water policy development[28] to improve infrastructure management and limit the effects of discharges on receiving environments and human health. Thus, these issues are likely to be addressed as part of larger reforms to water management in New Zealand, rather than through policies to improve built environment outcomes.

Urban design

Urban design limits and targets focus on reducing the impacts of urban development on environmental processes—from local to global—and improving outcomes for human wellbeing. Built areas significantly alter local environmental systems, including the hydrological cycle (e.g. reduced infiltration), temperature profiles (e.g. urban heat islands), air, water, and soil chemistry (e.g. tropospheric ozone), and ecosystem structure and processes (e.g. scavenger species). Urban design limits can improve outcomes by setting minimum standards for housing and other buildings, infrastructure, and development (e.g. insulation standards, water sensitive urban design requirements), controlling the use or release of hazardous substances (e.g. asbestos), and setting spatial limits for new development (e.g. urban boundaries,

[27] For example, in 2018 Auckland Council set a target to be zero-waste by 2040 https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/Pages/waste-management-minimisation-plan.aspx

[28] Reforms to the National Policy Statement for Freshwater Management are expected to strengthen environmental limits for receiving environments, while the ongoing ‘Three Waters Review’ will address regulation of wastewater and stormwater infrastructure

maximum impermeable surface ratios). In the following paragraphs, we focus on buildings as an example of an urban design issue where limits are needed.

The Building Code is the primary instrument for New Zealand-wide building limits, while development organisations and local authorities set additional sector- or place-specific limits and targets (e.g. Healthy Homes Standards for rental housing). While the Building Code was recognised as world-leading at the time of its creation, participants at our workshop argued that its minimum performance standards require significant revision to establish stronger sustainability requirements and protect human and ecosystem health. The Building Code has already been revised several times to improve minimum standards for housing, as evidence of the impacts of cold, damp housing on human health highlighted the need to improve thermal insulation and ventilation requirements. Cold and damp housing has been linked to higher rates of respiratory and cardiovascular illness, and contributes to energy poverty, where low income residents are forced to choose between being cold and paying more than average to heat their homes (Howden-Chapman et al. 2012). Poorly insulated and ventilated houses also contribute to a higher than average carbon footprint for housing due to the additional energy required for heating, and can contribute to poor air quality where residents use low-cost wood burners to heat their homes.

Workshop participants argued that current standards for housing and other buildings remained significantly behind standards in other parts of the world. In particular, they identified the embodied and operational energy demand of new buildings and sustainability of construction materials as key work areas for limit and target setting to address energy poverty and to reduce the built environment's contribution to global environmental issues (see also Vickers & Fisher 2018). The City of Vancouver, for example, has attempted to reduce the environmental footprint of urban re-development by setting minimum material reuse and recycling requirements for demolition.[29] Such limit and target setting in New Zealand would likely require revisions to the Building Act 2004 and Building Code, trade policies, and planning requirements in the Resource Management Act 1991.

The existing building stock poses a significant but not insurmountable challenge for implementing urban design limits. Retroactively applying higher standards to existing buildings places a significant burden on financially vulnerable building owners. Over the last 10–20 years, more stringent requirements for domestic fuel burners and rental housing have been applied to the existing housing stock, albeit slowly and with significant financial assistance through subsidies and incentives. Improved earthquake, asbestos, and health and safety standards have also been applied to much of the commercial building stock. These examples demonstrate that it is possible to improve minimum urban design standards for existing buildings, using a

[29] https://vancouver.ca/home-property-development/demolition-permit-with-recycling-requirements.aspx

range of statutory instruments, but that great care must be taken to avoid contributing to existing housing poverty and urban gentrification.

Human exposure limits

Third, a range of built environment limits are set to protect human health and wellbeing by minimising exposure to hazards and nuisances. The built environment generates a range of emissions that are potentially harmful to human health, including chemical contaminants, electromagnetic fields, and noise from industrial and residential activities. Limits are set to ensure a safe level of human exposure to these hazards, including maximum emission levels (e.g. for radiofrequency radiation by telecommunication facilities), temporal controls (e.g. for construction noise), and spatial rules on the proximity of residential or commercial areas to hazards (e.g. location controls for electricity transmission infrastructure). There are already a range of limits set to minimise human exposure to such hazards in the RMA 1991, national environmental standards, and related legislation, with no evidence that these nation-wide limits require revision or expansion. Local governments also use district plans and bylaws to provide additional protections and manage locally significant hazards in the built environment.

Environmental quality: green space

Finally, limits and targets can be used to secure a minimum level of environmental quality for residents. Built environment quality ranges from urban amenity in the form of recreational opportunities, to building types and aesthetics to provision of green space and associated natural features. While the quality of the built form and associated recreational opportunities are typically regulated through local plans, provision of and access to green space has received less attention. Green space can range from local parks and reserves, to green infrastructure (e.g. swales and wetlands), to biodiversity corridors, urban agriculture, community gardens, and trees in public spaces. Accordingly, green spaces provide a diversity of social and ecological functions, regulating urban temperature profiles, water cycles, biodiversity, and air quality. A lack of access to quality green space is noted to impact residents' mental and physical health, connections to nature, and access to locally grown food.

The government can limit the further loss of green space and institute the creation and enhancement of green space through controls on development, local planning processes, public land policies, and investments in tree planting and other forms of natural amenity. Policies and strategies help to guide protection of and investments in green space so that they promote ecosystem functioning (e.g. stormwater filtering and biodiversity corridors) and environmental justice. Minimum levels might therefore include both a quality level and a spatial minimum to promote equality. Incorporation of green space in the environment is currently managed through local policies and plans without national direction in the RMA 1991.

The above issues for the built environment were reviewed using the decision-making framework proposed in section 5.4.3 to identify those issues that are a priority for mandatory limit and target setting (shown in Table 14). The analysis is based on the reviews conducted for this report and the authors' and workshop participants' knowledge of the issues. Further research and expert input are needed to refine this analysis.

Table 14. Criteria for limits and targets in the built environment to address six possible topics. Responses are colour coded to illustrate the rationale for the priority assigned to a topic (in line with Figure 10): mostly green criteria suggests a high priority topic, many yellow indicate medium priority, and any orange criteria indicate a low priority topic.

Topic	Evidence of environmental deterioration	Degree of impact on environmental system	Socio-ecological values at stake	Government ability to influence outcomes	**Priority for limit-setting**	Exceeded the desired level for New Zealand	**Mandatory targets?**
Solid waste	Evidence of capacity limitations	Significant chemical & ecological impacts	Land area, human & ecosystem health	Moderate: regulations & planning	**High**	Yes	**Yes**
Wastewater	Evidence of untreated discharges	Large impacts on receiving environment	Human health, mahinga kai, tapu	Moderate: varies across systems	**High**	Yes	**Yes**
Healthy housing	Evidence of poor-quality existing housing	Moderate: energy use, mould, asbestos	Human health & wellbeing	High for new builds, moderate for existing stock	**Medium**	Yes	**Yes**
Carbon footprint of new buildings	Evidence of large carbon footprint	Local energy demand, global emissions	Wide-ranging (climate change)	Moderate: requires multiple policy changes	**Medium**	Yes	**Yes**
Noise	Evidence of nuisance noise	Widespread but irregular over time	Mental & physical health	High for regulated activities, otherwise moderate	**High**	Site specific	**No**
Exposure to electro-magnetic fields	Evidence of potential issue	Moderate: localised	Human health	High: infrastructure rules	**High**	No	**No**
Green space	Evidence of limited, poor quality green space	Impacts water, air, ecological systems	Human health, nature interaction	High: local government planning & investment	**Medium**	Yes	**Yes**

The analysis suggests that solid waste, wastewater, noise, and exposure to electromagnetic fields are all priorities for mandatory limit and target setting. However as noted earlier, most of these issues are already subject to limits and targets set by legislation, regulations, and regional and district plans. Wastewater management represents one area where policy revision to improve environmental outcomes is ongoing, as part of wider water reforms.

The analysis also indicates two new areas for mandatory limit and target setting—the carbon footprint of new buildings and greenspace in the urban environment. In the former case, limits have the potential to substantially reduce new buildings' contribution to global greenhouse gas emissions, while in the latter, limits and targets could promote improved human and ecosystem health within built environments. The appropriate scale, objectives, and policy instruments for limit and target setting correspondingly differ across the two issues. Reducing the carbon footprint of new buildings would likely require limit setting at the national scale, to limit the carbon emissions of locally produced and imported materials, set minimum efficiency standards for new buildings, and require greater reuse and recycling of materials. The Building Act 2004 and Code, Waste Minimisation Act 2008, Resource Management Act 1991, and trade policies would likely all have a role in setting and implementing such limits. In addition, limits and targets in local government policy statements and plans would be instrumental in promoting low carbon development in urban areas.

Conversely, limits and targets to promote access to nature, multi-functional green space, and use of green infrastructure are likely to be most effective if set at subnational scales based on an understanding of local ecosystems and community needs. Limits could be used to set minimum provision of green space and socio-ecological amenity across neighbourhoods, while targets could be used to prioritise recovery or enhancement of locally significant ecosystem functioning and values. Local and regional planning under the RMA 1991 provide potential processes for setting place-based limits and targets for green space, although such considerations are currently not required. To ensure that green space provision advances the environmental equity and cultural significance of an area, mana whenua should be centrally involved in identifying local goals and criteria for green space limits and targets. Ongoing resource management reforms provide an opportunity to highlight urban green space requirements as a key consideration in collaborative urban planning.

5.5.4. Applying limits and targets to coastal and marine environments

Pressures associated with climate change and human activities on land are causing many effects on New Zealand's coastal and marine environments, and there is a corresponding need to identify environmental limits and targets to address these effects. These will provide greater certainty about the environmental quality required

to ensure sustainable development of communities and industries that rely on coastal and marine resources.

Estuary health and eutrophication

Estuaries are defined as coastal waters in the RMA and covered by the New Zealand Coastal Policy Statement (NZCPS). The NZCPS contains an objective for maintaining coastal water quality and improving it where it has deteriorated to the point of causing significant adverse effects, but has no framework for setting objectives and quantitative limits. Nor does it specify national bottom lines for estuaries (Parliamentary Commissioner for the Environment 2015). However, under the Freshwater NPS, regional councils are required to 'improve integrated management of fresh water and the use and development of land in whole catchments, including the interactions between fresh water, land, associated ecosystems and the coastal environment'. To strengthen this direction, the Parliamentary Commissioner for the Environment has recommended amending the Freshwater NPS to include the management of estuaries under the National Objectives Framework (Parliamentary Commissioner for the Environment 2015).

A framework for assessing estuary eutrophication has been developed by the Coastal Special Interest Group. This framework, the New Zealand Estuary Trophic Index (ETI) toolbox, assists regional councils to determine the susceptibility of an estuary to eutrophication, to assess its trophic state, and to assess how changes to nutrient load limits may modify its current state. The framework does this by providing tools for determining an estuary's eco-morphological type and its position along the ecological gradient from minimal to high eutrophication, and by providing stressor-response tools (e.g. empirical relationships, nutrient models) that link the ecological expressions of eutrophication (measured using appropriate indicators) with nutrient loads (e.g. macroalgal biomass/nutrient load relationships) (Robertson et al. 2016). The ETI toolbox provides guidance for underpinning the ecological health component of regional plans by identifying relevant estuary attributes and outcomes, defining methods and indicators to measure ecosystem health attributes, and providing guidelines to assess whether or not the outcomes are being met (Robertson et al. 2016).

State of the environment monitoring programmes have been implemented by some regional councils. These programmes have considered guidelines and limits for specific environmental stressors, indicators of ecosystem health and models to relate changes in health of intertidal sandflats with storm water contamination and sedimentation. Some councils have also considered the use of ecosystem goods and services in both spatial planning and monitoring, to bring human values into planning decisions and to highlight the importance of any changes revealed by monitoring. There have also been attempts to develop reporting techniques to explain and help the public better understand the meaning and causes of any changes in environmental state observed.

Fisheries

In New Zealand, fish stocks are managed under a quota management system (QMS) where a stock is defined as a species of fish, shellfish, or seaweed in a particular area (MfE & Stats NZ 2019). The allocation of fisheries rights is split between tradeable rights for commercial fishers, restricted open access for recreational fishers and collective management for customary fishers (Peart 2008). The main mechanisms used to manage fisheries are the total allowable catch (TAC) and the total allowable commercial catch (TACC) (Peart 2008). Almost all the main fish stocks within New Zealand's Exclusive Economic Zone have a TACC, established separately for each fish stock to ensure future harvests. It includes adjustments for recreational and customary fishing and other fish-related mortality (MfE & Stats NZ 2016).

Information on the status of the main commercial species has improved in recent years. In 2019, 82% of routinely assessed stocks were considered to be within safe limits, an improvement from 81% in 2009 (Fisheries New Zealand, 2020b; MPI 2016). Of the 16% that were considered overfished, 9 stocks were deemed to have collapsed, meaning that closure should be considered to rebuild the stock (MfE & Stats NZ 2019).

The main fisheries management objective, which is to keep fish stocks at levels of biomass that can support their maximum sustainable yield, has been a source of considerable conflict (Peart 2008). In theory, fishing a stock down to a small proportion of its original size benefits commercial fishers by maximising the amount of harvestable fish over time. However, it can have negative effects for both recreational fishers and the environment. Recreational fishers find it harder to catch fish and fish are generally smaller. For the environment, the removal of up to 80% of a dominant species can result in profound changes to the coastal and marine ecosystem (Peart 2008). In the longer term, implementation of more ecosystem-based approaches that account for interactions between different stocks and interactions with the broader marine environment would help achieve fisheries targets and wider environmental objectives.

Marine mammals

Fifty-eight taxa of marine mammals are resident or migrant in New Zealand waters (Baker et al. 2019). All of these species are protected under the Marine Mammals Protection Act (MMPA). Additional protection is conferred under the Fisheries Act 1996, which requires the government to "avoid, remedy, or mitigate any adverse effects of fishing on the aquatic environment, including protected species". This involves management strategies to assess and mitigate incidental captures of protected species in commercial fisheries, including the systematic collection of incidental capture data (Thompson et al. 2016). Each year, a number of species such as Hector's dolphin, common dolphin, New Zealand fur seal, and New Zealand sea lion are incidentally captured in commercial trawl fisheries through capture inside trawl nets, entangled in gillnet meshes and longlines, captured on longline hooks, etc.

(Thompson et al. 2016). Marine pollution and habitat loss and degradation also threaten marine mammals.

It is estimated that 22% of marine mammals are currently threatened with, or at risk of, extinction (MfE & Stats NZ 2019). New Zealand's management of interactions between marine mammals and commercial fishing activities is based on the status of marine mammals, risks to individuals and populations, and the intent of minimising mortalities (Open Seas 2019). Non-statutory initiatives in fisheries include vessel-based risk management plans and liaison activities, education, research and monitoring, and assessing conformance with on-vessel practices (e.g. industry-led Codes of Practice) intended to reduce capture risks (Open Seas 2019).

The MMPA provides for the development of population management plans, which are intended to limit the fisheries-related mortality of protected species. However, to date, a Population Management Plan has not been completed for any marine mammal (Open Seas 2019). Instead, Threat Management Plans have been developed for NZ sea lions[30] and for Hector's and Maui dolphins[31] using measures under section 15 of the Fisheries Act 1996, including gear and area restrictions and limits on fishing-related mortality. The MMPA also provides for the spatial management of interactions between marine mammals and fishing activities. Marine mammal sanctuaries are created to protect marine mammals from harmful human impacts, particularly in vulnerable areas such as breeding grounds and on migratory routes. This has been done in various ways such as restricting commercial fishing and certain methods of recreational fishing. The Department of Conservation is responsible for the implementation, management and monitoring of all marine mammal sanctuaries (DOC 2020a). In 2019, Government determined that measures to mitigate fishing-related threats to dolphins would be achieved under the Fisheries Act 1996, to achieve a balance between reducing fishing-related mortality and providing for use of the fisheries (Fisheries NZ 2019). More recently, the Government has proposed extensions to marine mammal sanctuaries to address threats to dolphins. The proposed measures result from a review of the Hector's and Māui Dolphin Threat Management Plan. The Government also proposed to prohibit seismic surveying and seabed mining in the sanctuaries to protect dolphins from the impacts of noise and sedimentation, as well as seabed mining within Te Rohe o Te Whānau Puha Whale Sanctuary off Kaikōura (DOC 2020b).

Most marine mammals rely on sound for a range of important interrelated behaviours, including foraging/feeding, sensing predators and other dangers, social interactions, breeding, and general communication. Therefore, marine noise can affect these animals in many ways, from behavioural changes and displacement to permanent

[30] https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/marine-mammals/nz-sea-lion-tmp/nz-sea-lion-threat-management-plan.pdf
[31] https://www.doc.govt.nz/news/media-releases/2020-media-releases/new-protection-for-dolphins-and-support-for-changes-to-fishing-methods/

hearing loss. Currently, there are no standards for managing noise impacts on marine mammals in New Zealand, apart from the Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. This Code of Conduct applies to seismic surveying but not to other anthropogenic activities at sea. Limits on marine noise from seismic surveying and seabed mining could be set to mitigate their effects on marine mammals. Other limits and targets identified for coastal development and pollution reduction in the marine environment would also contribute to protect marine mammal populations.

Marine habitats and biodiversity

There are limited data on the degradation of New Zealand's coastal marine habitats and ecosystems, but there is evidence from local case studies and marine monitoring that coastal ecosystems are under the most pressure from human activities (MfE & Stats NZ 2016). Because of the complexity of the marine environment and lack of long-term monitoring data, our understanding of tipping points and the links between the different domains and the extent of cumulative effects is limited (MfE & Stats NZ 2019).

In New Zealand, measures to protect marine biodiversity have focused on the creation of marine reserves and other protected areas, largely through central government regulation under the Marine Reserves Act 1971. The focus of marine reserves to date has been on excluding fishing activity. The potential of marine reserves to increase the ecological health of the broader marine area has not been a major goal (Peart 2008). The Biodiversity Strategy for 2016–2020 set a target of establishing a representative network of marine protected areas by 2018 (Department of Conservation 2016). This target included not only marine reserves but also other less stringent forms of protection such as areas closed to fishing activity under the Fisheries Act 1996. As part of the new Biodiversity Strategy, the government has said it will map marine ecosystems to identify priority threats, implement management actions, and identify new priorities for marine protection. It also plans to implement marine protection initiatives in the Hauraki Gulf, Kermadec Islands and Southern South Island.

There is a need for long-term ecological and biological studies to improve knowledge of population dynamics and ecosystem processes and to gauge different ways in which marine reserves and protected areas can be used as 'reference points' for population parameters, and to understand the appropriate scales and effectiveness of fishery management and other conservation measures (Willis 2013). Experience with the establishment of marine protected areas and marine parks in New Zealand and elsewhere demonstrates their wider benefits to society; directly to conservation, education, recreation and management, and indirectly to fisheries, tourism and coastal planning (Ballantine 2014). Therefore, limits and targets can be used to ensure appropriate representation of habitats and species and ensure that the network is sufficient to be self-sustaining.

Aquaculture effects on coastal water quality

Marine aquaculture is mainly regulated under the RMA, including policies in the New Zealand Coastal Policy Statement (NZCPS). When considering an application for a coastal permit for aquaculture, regional councils must have regard to the NZCPS. Provisions for aquaculture must comply with environmental bottom lines set to protect outstanding natural landscapes and features, outstanding natural character and indigenous biodiversity (Peart 2019). Councils are also required to consider the management of cumulative effects and the setting of thresholds or limits within areas to manage them. This includes setting limits that avoid significant adverse effects on all landscape and natural character values, management of biosecurity risks caused by aquaculture, and also the effects of other activities on aquaculture where they adversely affect water quality within and around the farms.

The processes for replacing expiring resource consents for existing marine farms vary between regions. In 2017, the government proposed a National Environment Standard (NES) for Marine Aquaculture with the aims of developing a more consistent and efficient regional planning framework for existing marine aquaculture activities, within environmental limits (MPI 2017). The rules contained in the NES would supersede any rules in regional coastal plans and provide a framework for councils to consider consent applications. Regional councils, central government and industry would be responsible for implementing the NES in relation to biosecurity management plans for marine farms (MPI 2017). Where there is a need to de-allocate resources (i.e. removal of consent as a result of, for example, exceeding bottom lines), management becomes more challenging. In the context of aquaculture, this situation might arise where the cumulative effects of historic use in an area exceed acceptable limits. It has been suggested that the RMA is not well equipped to deal with this issue and that a regime is required to provide guidance on de-allocation processes across all sectors (Peart 2019).

Although monitoring of marine farms is required under the RMA, this is usually undertaken at the scale of the farm or as part of state of the environment monitoring. Marine aquaculture is associated with a wide range of potential positive and negative effects. These include effects on the water column, which include changes in plankton communities and nutrient cycling (usually small scale and short-term) and effects on benthic habitats and communities (usually more persistent in low flow sites) (MPI 2013). Extremely important are ecological effects that result from the incremental and interacting effects of aquaculture and other stressors from human activity affecting the marine environment or anticipated changes in oceanic conditions associated with climate change (MPI 2013). These cumulative effects could range from estuary-wide to regional scales and over large timeframes. Limits or targets defined at appropriate spatial and temporal scales can help mitigate these cumulative effects.

Information on baseline conditions contributes to understanding the carrying capacity of the ecosystem for marine farm development. We do not have a good understanding

of the carrying capacity of coastal environments in many parts of New Zealand. To inform predictions on carrying capacity of a bay or estuary, appropriate limits and targets would be required. Ideally, these would be associated with water quality indicators (e.g. physico-chemical, ecological) and scaled to farm developments. Evidence from long-term environmental monitoring combined with information on physical structures placed in the marine environment and stocking densities and feeding regimes as the farm develops allows for adaptive management of effects. Monitoring efforts can be tiered as the farm(s) approach or exceed certain standards.

Table 15 summarises our assessment of the need for limit and target setting in relation to five topics in coastal and marine environments.

Table 15. Criteria for limits and targets in the coastal and marine environments to address five topics. Responses are colour coded to illustrate the rationale for the priority assigned to a topic (in line with Figure 10): mostly green criteria suggests a high priority topic, many yellow indicate medium priority, and any orange criteria indicate a low priority topic.

Topic	Evidence of environmental deterioration	Degree of impact on environmental system	Socio-ecological values at stake	Government ability to influence outcomes	**Priority for limit-setting**	Exceeded the desired level for New Zealand	**Mandatory targets?**
Estuary health	Evidence of deterioration along coastal margins and seabed habitats	High	High	High	**High**	Probably	**Yes**
Fish stocks	Some stocks overfished or collapsed	Moderate	High	High	**High**	Yes	**Yes**
Marine mammals	Some species declining, threatened or at risk of extinction	Moderate	High	High	**High**	Yes	**Yes**
Marine habitats and biodiversity	Uncertainty over wider ecological benefits	High	High	High	**High**	Probably	**Yes**
Coastal water quality	Some evidence of eutrophication symptoms at localised scales	Low-Moderate	High	High	**High**	Yes, some areas	**Yes**

5.6. Implementing limits and targets

Previous sections of this report have recommended enacting legislation that requires the central government to establish limits and targets in defined subject areas and to specify a narrative objective for each topic. This section comments on the process through which such limits and targets could be established, implemented and reviewed, including the respective roles of central and local government.

The proposed overarching legislation should direct the government, when it sets a limit, to provide measurable targets and indicators for the narrative objective, so the effectiveness of the policies adopted to implement the limit can be assessed. The legislation should also identify a date by which limits must be established for each subject area, recognising that some are more urgent than others (i.e. some already have been overshot, others might be nearing a boundary, while others are at a safe distance from the boundary but still need future-proofing), and that the process can be lengthy and expensive (see Section 4.2.1 re: lessons from the Freshwater NPS).

The subject areas, topics, objectives and dates for limit setting could be listed in a schedule to the main legislation, enabling the government of the day to add new subjects as new issues are identified. It could be counterproductive, however, if the government could also remove subjects from the schedule—we recommend that this require an act of Parliament. Revisions to the wording of a subject area or associated objectives and dates could be enabled in conjunction with a board of inquiry or similar process.

For each subject area, the government would decide the appropriate instruments through which to establish and implement limits and targets. The selected instrument, for example a national policy statement under the RMA, would specify more detailed objectives and policies, acceptable levels or limits for key parameters, indicators for monitoring progress, timelines for implementation and a process for review. International experience suggests that identification of indicators should include careful consideration of existing data availability and capacity to instate new monitoring or data collection requirements.

Co-governance at both national and regional level is critical for the development of limits and targets and policies to implement them. As Treaty partners, the Crown and iwi/hapū should jointly determine a desired future state and the timing of any transition to get there (an example is provided by the goals in the Vision and Strategy for the Waikato and Waipa rivers[32]).

As stated in the recommended principles (Section 5.4.2), limits should be set nationally when they address global-scale issues, protect human health, and concern

[32] https://waikatoriver.org.nz/wp-content/uploads/2019/03/Vision-and-Strategy-Reprint-2019web.pdf

systems that function at national or multi-regional scales, e.g. migratory marine mammals. Other limits may be set at subnational scales in accordance with local environmental conditions and social and cultural values, especially where these have high spatial variability. Freshwater management is an example of a combined approach—in the Freshwater NPS, central government has specified attributes, minimum acceptable standards, and timeframes that apply nationwide, and directed regional councils to work with their communities to identify local objectives—which might include aiming for a higher level of protection for some water bodies—and implementation plans.

Limits could be established under any of several statutes, and at national, regional, district, catchment and/or local levels. Where central government decides that only sub-national limits are warranted, it would be required to either set these sub-national limits itself or, in devolving that responsibility to local authorities or a board of inquiry, provide clear standards to be met by local limits (e.g. as in the attributes specified in the Freshwater NPS). The government should also consider whether funding for local investigations and decision processes is required to enable timely and effective establishment of limits by councils.

Establishing national or sub-national limits through a board of inquiry has the advantage of providing consistency and a degree of separation from political considerations. This process can reflect the Treaty partnership through appointments to the board (e.g. equal number of Māori and Pakeha members, or having appointments made by a panel with equal representation). The decision-makers should be informed by advisory groups of Māori leaders, science, local government and stakeholder experts, as was done for the proposed 2020 changes to the Freshwater NPS.

For a given subject, central government could specify the process through which limits will be set or could leave this for councils to determine. Collaborative processes may be appropriate, especially where the issue concerns what is socially acceptable as much as what is ecologically required. For example, several regional councils have used collaborative processes to set freshwater objectives, limits and implementation plans because conditions are highly variable, and many parties aspire to achieving a higher level of protection than the bottom line standards in the Freshwater NPS. Experience with these collaborative processes has been mixed (Tadaki et al. 2020) so councils should consider carefully and discuss with mana whenua what process to use.

To manage social and economic disruption, limits are often set at current levels of resource use, even when these are not sustainable. In such cases, the sustainable level should be identified as a target, with interim targets if the process is likely to take more than five years. If a new resource use limit is allocated to existing users (i.e. through ‘grandparenting’), it may be appropriate to reduce or phase out those existing

use permits over time to allow new entrants including Māori who may be inhibited e.g. due to multiple ownership of customary land. Tradable permits are another way of enabling new entrants—these can be reduced over time to avoid existing users getting an inappropriate financial windfall while also providing support for existing users in transitioning to different practices.

In terms of capability, feasibility and adequacy of scientific information, the areas of greatest uncertainty can be precisely where precautionary limits are most needed (Dearing et al. 2014; Steffen et al. 2015b). Subjects with good information are easier to manage on a case by case basis (i.e. without established cumulative limits) precisely because the proximity to the boundary is better understood. In terms of the criteria presented in Section 5.4.3, if a subject area scores low on information certainty but high on the other criteria, getting more information should be prioritised to enable the setting of interim precautionary limits until more definitive information is available.

In most cases, we believe that New Zealand has adequate capability to establish and implement limits, but capacity can be a problem when people with the requisite skills are occupied with other tasks. In other words, New Zealand's ability to establish limits and targets is more a matter of time, resources and focus than one of technical capability.

Decisions about limits and targets are highly charged and can have major Treaty and distributional implications. Scientific evidence needs to be compiled and will be contested, people will want to be heard, collaborative groups will need time to work through competing claims etc. Therefore, New Zealand can run only so many of these processes at any given time. This has implications for how long it would take to work through a schedule with, say, 25 topics of mandated limits and targets. For this reason, we have suggested staggering the implementation of limits and targets by setting dates by which limits must be established for each subject area.

Fortunately, we are not starting from a blank slate. New Zealand has policies and limits in place for many subject areas and topics, and therefore can focus on filling in the gaps and reviewing the effectiveness of existing policies to prioritise those needing more urgent attention.

6. CONCLUSIONS

The concept of limits is central to modern environmental management, although jurisdictions vary widely in whether and how they set, implement, and enforce environmental limits. However, some earth systems exhibit gradual, variable, or complex responses to increasing human pressures, rather than clear threshold effects, so environmental limits cannot be defined based solely on scientific analysis of natural system dynamics. They also require a normative assessment of acceptable levels of system change.

Environmental targets are aspirational statements about the desired state of an environmental system and its outcomes for people. Targets can be used to specify broader environmental goals or objectives, set short-term markers of progress towards longer-term goals, or identify the improvements required to stay within or return to the 'safe operating space' defined by environmental limits. Consequently, targets may be set on a precautionary basis where the aim is to deliver environmental protection—i.e. to prevent or limit degradation of existing environmental quality—or they may be more ambitious, aiming for environmental improvement.

All of the recent analyses of environmental limits that we reviewed—whether global, national, or regional in scale—reported the transgression of one or more environmental boundaries. Existing efforts to manage environmental impacts are not sufficient to prevent the disruption of key Earth system processes that are essential to maintaining the safe operating space for human life. Further, basic human needs are not being met under current political and economic systems, and significant disparity exists both within and across jurisdictions.

In New Zealand, the use of limits and targets is more common in some fields of environmental management than others. In many instances, existing limits and targets are not well coordinated and do not address the wider scope of environmental management for these subject areas. In other cases, complementary measures will be needed to protect environmental integrity and to avoid transgressing ecological, social and cultural boundaries.

Tikanga Māori supports the use of limits for environmental management, yet there has been limited involvement of Māori in limit setting and implementation in New Zealand. Many of the policies we reviewed make no mention of te ao Māori, requirements for engagement, or partnership with tangata whenua in environmental management, thus falling short of Treaty principles of active protection, participation and partnership.

Both international and New Zealand case studies demonstrate the value of legally binding limits and targets to provide a minimum level of protection for environmental systems and drive long-term action for environmental improvement, in a way that is resilient to political changes. We therefore recommend that New Zealand's

environmental management system be strengthened through a legislative requirement to set legally binding limits and targets for key environmental issues in New Zealand.

We recommend the enactment of clear requirements for environmental limit and target setting in a new or amended overarching statute that would govern all other statutory environmental instruments. This overarching legislation would include:

- the subject areas and topics for which limits and targets must be set by statutory instruments
- goals and principles for limits and target setting
- procedural requirements for reporting and review
- governance requirements for oversight and enforcement of limits.

We also recommend that specific, measurable, and timebound targets should be set where current environmental outcomes are less than those articulated in policies, plans, or strategic objectives. Targets provide a focus for action planning, a metric to measure progress, and a basis for holding government to account.

The goals would identify the high-level rationale for setting environmental limits and targets, and the narrative objectives would specify the environmental bottom lines that must be secured through the development of limits and targets for each subject area. The principles would provide guidance on when, at what scale, and how limits and targets should be set for each subject area. In addition, the overarching legislation would set out requirements for reporting and review, overseen by an independent authority that can call to account government agencies that do not meet limit setting requirements or demonstrate sufficient progress towards targets.

Development of the overarching legislation should be governed by Treaty principles, with ample avenues for public participation. Specifically, iwi/hapū representatives should be involved in identifying the goals, topics, narrative objectives, and principles for limit and target setting, followed by wider consultation on the proposed statute.

To be effective, limit-setting legislation must be accompanied by reforms to funding, compliance, and enforcement frameworks. Compliance monitoring and reporting in particular are crucial to ensure that resource users and governments are accountable for their environmental effects.

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9. APPENDICES

Appendix 1. List of workshop participants.

Name	Organisation
Roger Uys	Greater Wellington Regional Council
Andrew Fenemor	Landcare Research
Patrick Kavanagh	Ministry for the Environment
Greg Severinsen	Environmental Defence Society
Joanne Clapcott	Cawthron Institute
Aneika Young	Cawthron Institute
Melanie Mark-Shadbolt	Ministry for the Environment
Alison Dewes	Pāmu Farms of New Zealand
Jim Sinner	Cawthron Institute
Melissa Robson-Williams	Landcare Research
Justine Young	DairyNZ
Stuart Brodie	Ministry for the Environment
Riki Ellison	Waka Taurua
Andrew Baxter	Department of Conservation
Natalie Stewart	Ministry for the Environment
Kirsty Woods	Te Ohu Kaimoana
Carlos Campos	Cawthron Institute
Stanley Tawa	Tuaropaki Trust
Alastair Smaill	Greater Wellington Regional Council
Alan Johnson	Ministry for the Environment
Kiely McFarlane	Cawthron Institute
Rob van Voorthuysen	Van Voorthuysen Environmental
Nilesh Bakshi	Studio Pacific Architecture
Michelle Pawson	Ministry for the Environment

Appendix 2. Decision tree for prioritising topics for environmental limit and target setting.