WAIMAKARIRI
DISTRICT COUNCIL

Waimakariri Natural Environment Strategy

Biodiversity State of the Environment Report

Version 2, June 2024

Contents

About this State of Environment Report

This state of environment report is intended to inform the Waimakariri Natural Environment Strategy (WNES). The strategy is the Council's local response to the degradation of important natural ecosystems and species being reported across the world, including within our District.

Current global biodiversity loss is so great it is called the 'sixth extinction'. The biodiversity crisis and the climate crisis are acknowledged to be closely linked, and healthy and diverse ecosystems can adjust more effectively to climate threats. The contribution nature-based solutions can make to buffering climate impacts by sequestering carbon and protecting built-up areas is also reflected in the strategy.

All aspects of life in Aotearoa New Zealand rely on a thriving natural environment including our physical and mental health, economy and culture. This strategy seeks to restore our connection to the natural world we are a part of so that we feel inspired to better protect it. We need to prioritise the protection and restoration of the natural environment not only for the ecosystems benefits it provides us and those who follow, but also for its own intrinsic worth. A world without dolphins, kiwi, tuatara and Kauri trees seems unimaginable but could become a possibility.

The strategy takes into account strategic directions outlined in the Local Government Act 2002 (4 wellbeings), National Adaptation Plan, National Policy Statement for Indigenous Biodiversity, Aotearoa Biodiversity Strategy and others. It also complements the work of other organisations such as Environment Canterbury's Zone Implementation Plan Addendum (ZIPA), Forest and Bird's 'Make Every Wetland Count' campaign, QEII Trust and the Waimakariri Biodiversity Trust.

The strategy currently consists of three documents plus a summary document which should be read in conjunction with one another.

Background documents

This Biodiversity SOE report describes the current state of indigenous biodiversity within the District and the challenges and opportunities foreseen over the next 30 years. It also provides an overview of biodiversity concepts and relevant legislation.

A review of Council reserve provision also informs the strategy. This will form part of a Reserves SOE report that identifies opportunities, in collaboration with local residents, for increasing natural values in reserves and streetscapes.

Strategy

Provides a high-level strategic framework to guide Council's work in protecting and restoring the natural environment over the next 30 years. Roles range from developing plans and carrying out the work, to supporting the efforts of others, educating people about the issues and opportunities, and advocating for change, both at a national and local level.

Action plan

Contains specific costed actions to be included in the Council's Long Term Plan for implementation between 2024 and 2034.

Preface: Document Background Evidence and Data

This document has been compiled using a combination of qualitative and quantitative scientific research and survey data. Knowledge has also been gathered from literature pertaining to local and indigenous knowledge, societal, media and regulatory documents.

Knowledge from Scientific Research

Scientific research generates knowledge through systemic empiricism (structured and organised learnings from observations). The collection and evaluation of data produces conclusions from research which can be replicated. Good scientific research is peer-reviewed by other scientists working in the same field of expertise to ensure that methodologies, results, analysis and conclusions are ethically and scientifically correct and without conflict of interest. In this manner, scientific research produces conclusions based on tested reasoning (Trussell, Brandt, & Knapp, 1981) and evidence rather than ritual and personal opinion which may be subject to issues such as over-generalisation, selective observation, premature closure (jumping to conclusions), the halo effect (cognitive bias) and false consensus (the tendency to see our own beliefs, opinions, behaviours as typical) (Neuman, 2011).

When reporting on scientific research, the aim should be to present findings which have been generated following good practice and to use them without bias. To ensure this, reporting considerations have been taken into account, such as ensuring the science is not outdated, only partly reported or used in a manner not necessarily appropriate for the desired topic. The table below denotes some considerations for assessing the standard of a piece of research and whether it can be used to oppose or support a particular concept.

Good practice for identifying sound scientific research and principals to consider when reporting studies.

Good Research/Study	Reporting Considerations
Novel, aims to provide further insight	Current – up-to-date research or foundational to current works
Based on relevant, empirical data	Context – type of study suitable for required use
Robust study design and methodology	Source – published by a reputable outlet journal
Ethical and transparent	Transparency – disclose any conflicts of interest
Proper data analysis and observations	Inclusivity – report all findings to remove selective observations and premature closure
Peer-reviewed by subject experts	Robust – ensure the research constitutes good practice
Externally validated	
Undertaken by qualified practitioners	
No conflict of interest	

Knowledge from local, indigenous or societal sources

Indigenous knowledge has been described as “the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings” (UNESCO, 2021). In Aotearoa New Zealand, Kaupapa Māori research and mātauranga is rich, being preserved by tohunga (specialists) and passed down through whakapapa (genealogy), waiata (song), haka (dance), whakataukī (proverbs), pūrākau (legends), kōrero tuku iho (stories), and whakairo (carvings) (Hudson et al., 2020). A strength of this type of knowing is that it holds information that has been captured through practical means and retained and added to over centuries (Durie, 2005). An example of this knowledge is that of rongoā, Māori herbal medicine, now beginning to be recognised by pakeha for its wealth of insight and introduced into the mainstream healthcare system (Gray, 2012).

Similarly, communities in Aotearoa New Zealand also hold local knowledge, particularly those who are stewards of the land such as land managers in a range of industries and organisations. Observations about weather patterns, biodiversity trends, and soil conditions are examples of some local knowledge which can be gathered.

The benefits of local and indigenous knowledge are the longevity and depth of insight of the observations. The use of this type of knowledge encourages respect and appreciation of different cultural experiences in addition to providing valuable information.

Societal, current affairs or popular knowledge has been taken from media sources. The media platforms can often work as an intermediary between the scientists and politicians and the public. When this is done well, high-level, complicated ideas and theories can be disseminated to the public in effective and accessible ways (Atkinson, 2016). Gaining information from the media does have limitations. The mass media are generally commercial, having to make a profit to continue business and this financially motivated pressure can tend to lead media outlets to “perpetuate the cultural myths or create hype” (Neuman, 2011). For this reason, this form of knowledge has been cited as such and supplemented with other forms of knowledge.

Knowledge from Legislation, Reports and Policies

Finally, reports, policy documents and legislative statutes have been referred to throughout the document where appropriate. These are all referenced and can be found via the links provided in the references section. However, as noted in section 5 of this document, many of the regulatory instruments are currently undergoing alterations from central government and will be updated as these changes are adopted.

INTRODUCTION

1. Introduction

1.1 The Natural Environment

The natural environment has been defined as the physical, chemical and biological assets of the environment (Nienhuis, 2009). In Aotearoa New Zealand, it has been further defined as a term that encompasses the living environment (te taiao), which includes all living organisms and the ecological processes that sustain them. By this definition, people are a key part of nature" (Department of Conservation, 2020). It is essential for all aspects of life from a genetic to organism and ecosystem level which includes our growing communities.

The natural environment is dynamic, complex and interconnected. It essentially consists of all biotic (living, biological, indigenous or exotic) and abiotic elements (non-living such as water, nutrients) which interact at various scales of magnitude (Table 1). The diversity captured within the living element of the natural environment (biodiversity) requires, influences and sustains the abiotic elements.

In ecological terms, an individual is the product of genetic diversity which can live in populations of the same species. These populations may have genetic variations to other populations of the same species (intraspecific genetic variation). It is this variation that can assist a species to adapt to their environment.

Genetic Diversity	Organism Diversity	Ecological Diversity
	Individuals	
Populations	Populations	Populations
Individual's chromosomes	Subspecies	Habitats
Genes	Species	Ecosystems
Nucleotides	Genera	Landscapes
	Families	Bioregions
	Phyla	Biomes
	Kingdoms	Biogeographical realms

Table 1. Elements of the natural environment (adapted from Heywood & Baste, 1995). The arrows depict the direction of magnitude of size and complexity. Although each category is presented separately, they are interconnected with populations being found within each category.

Habitats are the biological and abiotic environments required for a species to survive (Pearson, 2008). An ecosystem is a functioning unit comprising all species, both above and below ground, interacting with each other and the physical environment within an area (Lyle, 2008). A landscape comprises a matrix of habitat patches and ecosystems which inform the boundaries of larger scale associations such as bioregions, biomes and biogeographical realms (Pearson, 2008).

The natural environment comprises a structure of ecological units (genes, individuals, communities etc) which interact and perform functions to direct and influence ecological processes. Ecological processes have been defined as:

> *"...all the physical processes and the plant and animal activities which influence the state of ecosystems and contribute to the maintenance of their integrity and genetic diversity, and thereby their evolutionary potential" (Ricklefs* et al*., 1984).*

Examples of processes include primary productivity, energy and trophic/food chain flows, biogeochemical cycles such as climatic and hydrological processes, interactions and movements of organisms and disturbance regimes. Bennett *et al.,* (2009) consider the protection of these processes to be pivotal to the maintenance of resilient ecosystems providing important services which humans depend upon.

1.2 Ecosystem Services and Biodiversity

A functioning natural environment provides the goods and services required to sustain life on earth. However, a key driver in the loss and degradation of the natural environment is the lack of value assigned by market forces (Brown *et al.,* 2015). It has been stated that in the current economic system, there is no accounting for nature which leads to an assumption that the natural environment has no value, thereby driving exploitation (von Hase and ten Kate, 2017).

To remedy the lack of value placed on the natural environment "ecosystems services" were promoted in the early 2000's to describe the benefits, goods and services obtained directly and indirectly from ecosystems. These services are vast and include those which are essential not only to the economy through production means but also those affording a hospitable environment in which communities of different organisms, including humans, can thrive (Millennium Ecosystem Assessment, 2005). Ecosystem services can be divided into four areas:

- **provisioning** which includes the supply of consumables such as food, timber, biochemicals such as medicines;
- **regulating** relating to services such as climate, air quality and water regulation as well as pest and disease control;
- **supporting** indicating photosynthesis, soil formation and nutrient cycling which are the foundation of life and support our primary industries; and
- **cultural services** which provide a sense of place and meaning, spirituality, recreation, mental and physical health and aesthetic values.

Researchers have begun measuring and managing ecosystems based on their functioning and service provision and in recent years, one overall measure has been used; *"the ability of ecosystems to simultaneously provide multiple functions and services"* (Manning *et al.,* 2018). This has been named "ecosystem multifunctionality" and allows for the consideration of many functions and services together to scope for cross-effects and trade-offs.

Biodiversity has a central role in the functioning, stability and health of our ecosystems and ecosystem services although the precise mechanisms continue to be studied (Albrecht *et al.,* 2021; Martin *et al.,* 2019; van der Plas, 2019; Xu *et al.,* 2021). Whilst the term biodiversity may have been overused in recent years to explain the range of organisms residing on the planet, the wider definition is that of the *"diversity within species, between species and of ecosystems"* (Pascual *et al.,* 2021). This definition draws on the fact that biodiversity encompasses all life on earth without prescribing a value or protection hierarchy. Instead, it allows for the pluralistic meaning of biodiversity which reflects our societal structure with different communities deriving various meanings. It also moves away from the notion that only certain ecosystems or species should be considered important enough to be protected and conserved rather than the full suite of life, a major challenge for biodiversity conservation theory and practice (Walker *et al.,* 2021).

This pluralistic definition was not thoroughly integrated into the concept of ecosystem services. The concept was primarily developed by ecologists and economists overlooking the additions that could be made from other disciplines, stakeholders and worldviews such as social sciences and local, particularly indigenous, communities (Diaz *et al.,* 2018). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem services (IPBES) broadened the concept of ecosystem services to include all Nature's Contributions to People, whether conceived to be positive or negative. This revised concept captured the impacts of nature which either enhance or are detrimental to human life quality making it an inclusive approach which is context specific (Pascual *et al.,* 2017). There are three overarching categories of Nature's Contributions to People:

- **Material Contributions** – similar to the provisioning ecosystem services, mainly consumables;
- **Non-material Contributions** – similar to cultural ecosystem services, the aspects of life which effect subjective or psychological life;
- **Regulating Contributions** – similar to the supporting and regulating ecosystem services, the aspects of nature which alter conditions to influence life on earth or generate the material and non-material contributions.

Both ecosystem services and Nature's Contributions to People concepts portray the important message that the natural environment is pivotal to human life on earth in numerous ways, but this relationship is mutually dependent (Diaz *et al.,* 2019). This interconnectedness is integrated in indigenous knowledge for the natural environment and named mātauranga Māori in Aotearoa New Zealand (Wehi *et al.,* 2019.). Whilst the natural environment directly

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impacts the health of communities and the balanced functioning of ecosystems, the priorities and actions of our human communities affect global change and the direction of health for our natural environment and for ourselves (Cardinale *et al.,* 2012; Figure 1).

Biodiversity and Ecosystem Functioning

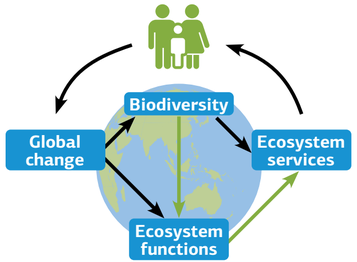

Figure 1. The flow of influence from biodiversity and ecosystems to humanity who can exact global change which in turn affects biodiversity and ecosystems. Humanity is a vital component in the cycle, directing the health of our natural environment from which we receive many contributions (Cardinale *et al.,* 2012).

1.3 Aotearoa New Zealand's Natural Environment

Aotearoa New Zealand is a global biodiversity hotspot, with high values placed on the importance of biological conservation (Kier *et al.,* 2009; Mitttermeier *et al.,* 2005). Indigenous vascular flora and fauna are highly specialised with endemism of approximately 85% for plants, 72% birds, 81% invertebrates, 88% freshwater fish and 100% for reptiles, frogs and bats (Lee and Lee, 2015; Wardle 1991). It is thought that this high level of speciation occurred due to a number of factors including lengthy isolation, geological and climatic fluctuations, and co-evolution, with flightless birds and lizards in place of mammals elsewhere (Cooper and Millener 1993; Lee *et al.,* 2001; McGlone *et al.,* 2001; Waters and Craw 2006). These endemic species have a higher risk of extinction than indigenous species due complex reasons including their limited geographical range and specialised nature of the occupied niche, low number of populations, small or possible declining population size, low fecundity and the requirements for stable environmental conditions (Isik, 2011).

Indigenous vegetation cover has been used as a proxy for indigenous biodiversity in Aotearoa New Zealand and many protected natural areas have been created to conserve the biological heritage. These areas amount to approximately 30% of the total land mass and are mostly in mountainous, wet, steep or cool environments. Land outside of this has gained limited protection leading to impoverished indigenous areas in the drier, flatter, warmer environments and a loss of the ability to safeguard the full complement of biodiversity (Cieraad *et al.,* 2015; Holdaway *et al.,* 2012). This is exemplified on the Canterbury Plains where indigenous habitats are highly fragmented and, in some areas, less than 0.1% remains (Environment Canterbury 2008; Harding *et al.,* 2009; Meurk *et al.,* 1995; Winterbourn *et al.,* 2008).

A report by the Environmental Research Institute noted that indigenous vegetation cover of 10% is critical and figures below this can result in a rapid increase of biodiversity loss due to reduced spatial extent, reduced resource availability and severe fragmentation (Clarkson, 2022). Loss of the unique biodiversity in Aotearoa New Zealand is rapidly occurring within all ecosystem types leading to discussions around the sixth mass extinction episode with species receiving conservation efforts continuing to experience population declines (Dinica, 2022; Hare *et al.,* 2019). Loss of biodiversity leads to altered ecosystem structure, processes, functioning and altered ecosystem services humans derive from them (Dick *et al.,* 2012) In addition to the critical need to preserve the natural environment and biodiversity for health and economic reasons, Aotearoa New Zealand is a signatory to the Convention on Biological Diversity committing the country to halting the decline in biodiversity (Convention on Biological Diversity, 2023).

2. The Natural Environment of Our District

2.1 Overview

The Waimakariri District is found within the central-east of the South Island, encompassing the northern Canterbury Plains. The District comprises 225,500ha with the Waimakariri braided river to the south and the Ashley/Rakahuri braided river system in the north. To the east lies the Pacific Ocean and the District is adjacent to the foothills of Kā Tiritiri o te Moana/Southern Alps to the north-west. Prior to human settlement the braided rivers would have meandered across the plains and the area between them would be periodically inundated comprising scattered wetlands, rivers and streams (Environment Canterbury, 2018).

2.1.1 Mana Whenua

The Waimakariri District is part of the takiwā of Te Ngāi Tūāhuriri Rūnanga. The information below is taken from the Mahaanui Iwi Management Plan and documents produced by Te Rūnanga o Ngāi Tahu (Jolly & Ngā Papatipu Rūnanga Working Group, 2013; Te Rūnanaga o Ngāi Tahu, 2024).

"The Waimakariri rises in the snows of the Southern Alps and its waters never fail. Like other snow fed rivers its flow tends to be greater in warm weather when the snows are melting [creating freshes]... Thus the natural tendency of the river is a periodic flushing out of its channels, which wind among braided shingle beds a kilometre wide when the level is low" (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

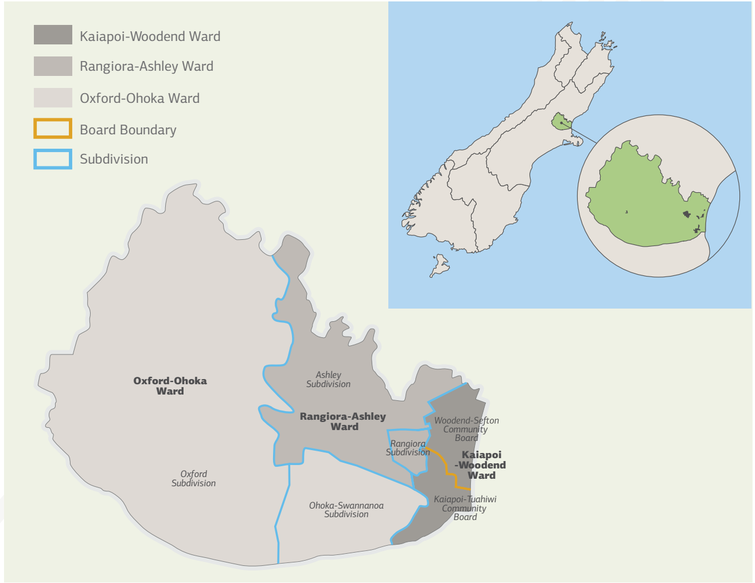

Figure 2. The Waimakariri District location and Ward boundaries (Waimakariri District Council, 2021)

"Tuahiwi is the home of Ngāi Tūāhuriri and has played a vital role in Ngāi Tahu history. The takiwā (district) of Te Ngāi Tūāhuriri Rūnanga centres on Tuahiwi and extends from the Hurunui to the Hakatere river and inland to the Main Divide. Nearby the famous Kaiapoi Pā was established by the first Ngāi Tahu ancestors when they settled Te Wai Pounamu. Kaiapoi Pā was the major capital, trading centre and point from which further penetration of the South Island occurred so the area is a genealogical centre for all Ngāi Tahu whānui (descendants). Kaiapoi Pā was established by Moki's elder brother Tūrākautahi who was the second son of Tūāhuriri, hence "Ngai Tūāhuriri" is the name of the hapū of this area" (Te Rūnanaga o Ngāi Tahu, 2024).

"The name Waimakariri refers to the cold (makariri) mountain fed waters of this braided river. The river was part of a larger network of ara tawhito linking the east coast of Te Waipounamu to the mahinga kai resources of the high country and the pounamu resources of Te Tai Poutini. The Waimakariri and its tributary the Ruataniwha (Cam River) were two of three waterways (the other being the Rakahuri) that continued to sustain Ngāi Tahu even after the land purchases in Canterbury"...

"Before European settlement began in the 1850s, the lower reaches of the Waimakariri and Rakahuri (Ashley) connected with a maze of waterways and wetlands fed by underground springs of the purest artesian water, which nourished a wealth of mahinga kai rich in birdlife, eels, fish and natural vegetation. For this reason, when Crown Commissioner Kemp arrived in 1848 to purchase Canterbury, the Ngāi Tūāhuriri negotiators proposed to retain the 100,000 ha between the Waimakariri and Rakahuri, leaving the territory south of the Waimakariri for the Europeans. This arrangement was denied to them. Instead, their four hundred people were confined to a 1,000 ha reserve at Tuahiwi, with a promise that they would retain their mahinga kai, while the rest of the 100,000 ha they had asked for was allocated to (at first) a dozen or so settlers"...

"The cultural, spiritual, historical and traditional significance of the Waimakariri landscape to Ngāi Tahu history and identity is acknowledged in the NTCSA 1998 [Ngāi Tahu Claims Settlement Act, 1998]. Moana Rua (Lake Pearson) is a Statutory Acknowledgement site. Kura Tawhiti is a Statutory Acknowledgement site and a Tōpuni. The traditional place names Maungatere (Mount Grey) and Kapara Te Hau (Lake Grassmere) are recognised under the Act's dual place names provisions" (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

2.1.2 Recent Environment History

From the 1850s, modification of the waterways began to drain the area for farming and settlement purposes. This reduced the wetland areas and mahinga kai sites and the containment of rivers commenced to alleviate flooding. Presently, the main settlement areas in the District are Rangiora, Kaiapoi, Pegasus, Woodend and Oxford comprising 62% of the population (Figure 2). There are a number of smaller townships scattered throughout but mainly in the east of the District, much of which is reclaimed swamp. The population of the District is one of the fastest growing in New Zealand and anticipated to increase to 102,100 by 2043 with an estimated increase of 16,200 (186.2%) for people 65 years and over between 2013-2043 (Waimakariri District Council, 2023).

During the 2018 census, the District recorded an employment rate of approx. 70% with 30% not in the workforce and less than 3% unemployed (Stats NZ, 2023). Despite the "red-zoning" of 20% of houses in the Kaiapoi area following the 2010-2011 Canterbury earthquakes, much of the population growth occurred after 2011 with increased building and resettlement around Rangiora, Kaiapoi and Pegasus. Some growth may also have occurred due to the conversion of land to dairy farming and the need for housing for farm workers (Sparrow, 2016). The most common occupations for those living within the District in 2018 were construction, manufacturing, retail, professional services, education and training, healthcare and agriculture, forestry and fisheries (Waimakariri District Council, 2021).

2.2 Natural Environment

The Waimakariri District has a wide and varied natural environment, spanning a range of altitudes, species and community compositions,

landforms and environmental conditions including terrestrial, coastal, montane and aquatic habitats. Of prominence are the two braided river systems, the Waimakariri and Ashley/Rakahuri. These ecosystems are globally rare and important for many endangered species (Grey *et al.,* 2006). The Waimakariri River, in particular, has great importance for irrigation of the plains and replenishing freshwater aquifers.

2.2.1 Geology, Soils and Land Use

The District ranges in topography from sea-level to the highest point of Chest Peak at 1936m. Glacial - hydrological movements and climate have substantially influenced the landscape. Following the last ice-age, glaciers began to retreat and melt water channels deposited sediment trapped in the glacier to create the alluvial fans or outwash plains and moraines along with other features such as valleys, kettle holes and truncated spurs (Babe *et al.,* n.d.).

The alluvial deposits of the outwash plains have developed a range of soils which support various ecosystems and land uses. The soils in the east and north plains along with the foothills and Lees Valley are relatively fertile and were the focus of agricultural production until the Waimakariri Irrigation Scheme allowed water from the river to irrigate the stony-silt, thin Lismore soils of the lower plains. Figure 3 illustrates the location of the most versatile soils in the District under the Land Use Capability classification (LUC). This classification details the most versatile soils on an eight point scale gradient with 1 being the most

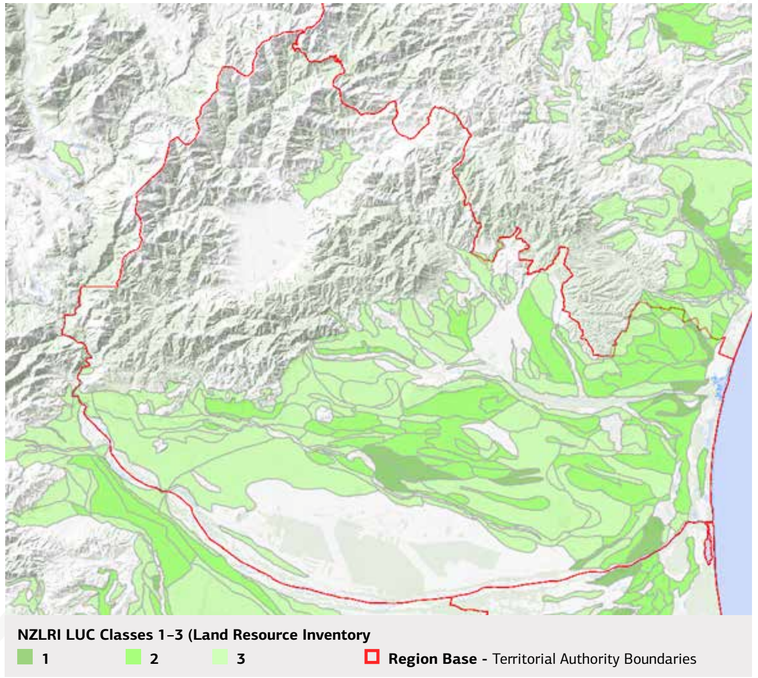

Figure 3. Location of "highly productive land" as assessed through the Land Use Capability classification within the Waimakariri District showing classes 1–3 with 1 being the most versatile.

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versatile soil and 8 being the least. The National Policy Statement for Highly Productive Land classifies LUC 1-3 as "highly productive land". Whilst soil is an important ecosystem regardless of its versatility and productiveness, this classification details the use of soil for production and other purposes (Table 2).

The dominant land use cover in the District is highly producing exotic grassland with at least 40% used for sheep and beef farming and a further 16% used for the dairy sector (Environment Canterbury, 2018; Figure 4). However, there is a trend for a decrease in the amount of farmland across the Canterbury region and a decrease in the amount of land used for dairy production (Stats NZ, 2021). The decrease of land cover under farm use could signal the intensification of land as export income has increased in addition to the increased demand for lifestyle blocks and housing on the outskirts of towns.

2.2.2 Climate

The climate of area is as diverse as the landscape and is broadly classified as *Temperate oceanic Climate* (Broadbent *et al.,* 2022). There are large temperature and rainfall variations with rainfall decreasing with proximity to the coast and temperatures increasing (Figure 5, Macara *et al.,* 2016). NIWA separated the Canterbury region into five zones with regards to climate change with four being relevant to the Waimakariri district (Macara *et al.,* 2020):

- The **plains**, comprising 50% of the District, and characterised by low rainfall, a large annual temperature variation and prevailing winds from north-east and south-west. North-west winds are not frequent but are also important due to their drying capacity, exacerbating soil moisture deficits in an already relatively dry area.
- The **eastern foothills** of the Ashley and Oxford areas, with cooler, wetter weather and north-west winds.
- The **high country** with north-west winds, abundant rainfall and winter snow.
- **Inland sheltered valleys** with low rainfall and large annual and diurnal temperature ranges comprising the Lees Valley.

The mean air temperature fluctuates from around 14-18°C in summer to 4-8°C in winter. These figures do not capture the range of temperatures in the district which can be found at the different altitudes, or the microclimates caused by topographical and atmospheric conditions such as frost basins. The plains tend to receive the most

Table 2. Land Use Capability classification of land suitability for various uses. There are increasing limitations and decreasing versatility of use from classes 1 through to 8.

LUC Class	Arable Cropping	Pastoral Grazing	Production forestry	General
1	High	High	High	Multiple land use
2	↓	↓	↓	
3				
4	Low			
5	Unsuitable			Pastoral or forestry land
6		↓	↓	
7		Low	Low	
8		Unsuitable	Unsuitable	Conservation land

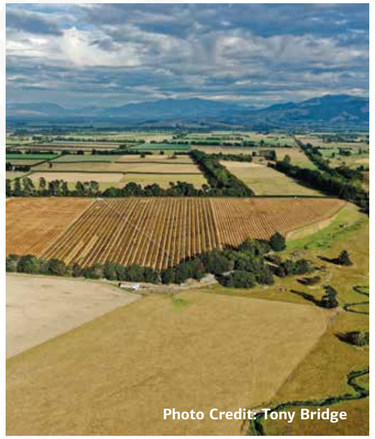
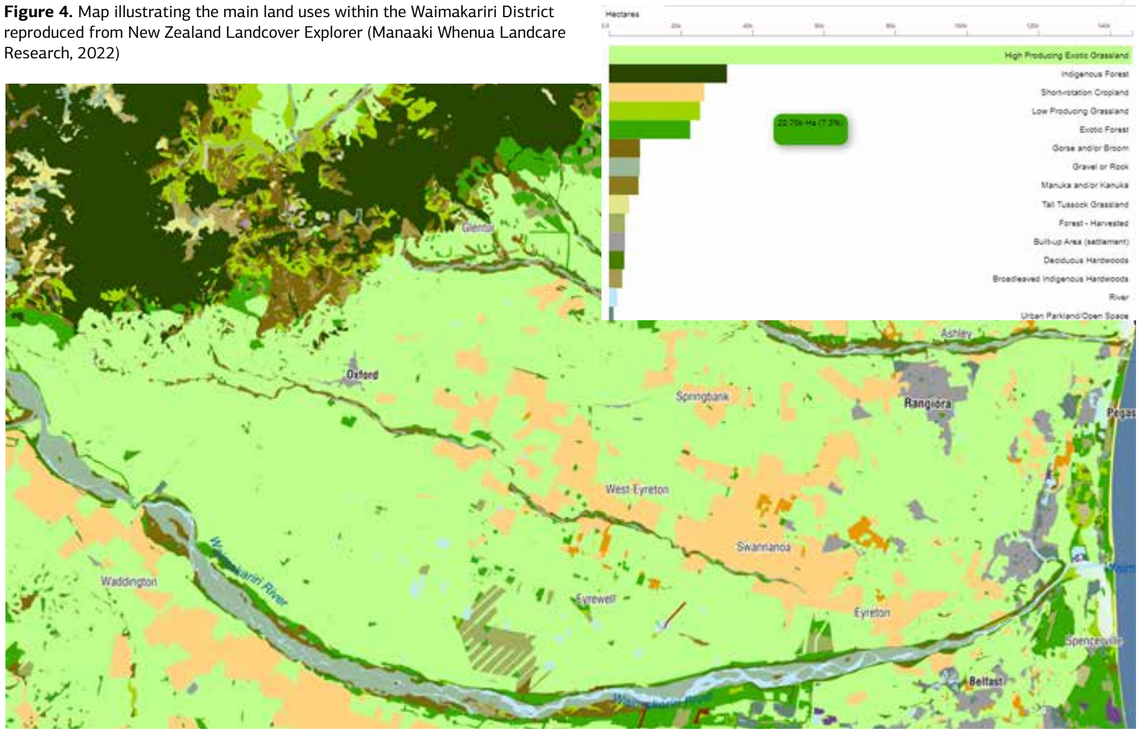


Photo Credit: Tony Bridge

Figure 4. Map illustrating the main land uses within the Waimakariri District reproduced from New Zealand Landcover Explorer (Manaaki Whenua Landcare Research, 2022)



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sunlight hours and some areas, such as Rangiora, can receive strong but not persistent winds in spring and autumn (Macara *et al.*, 2020).

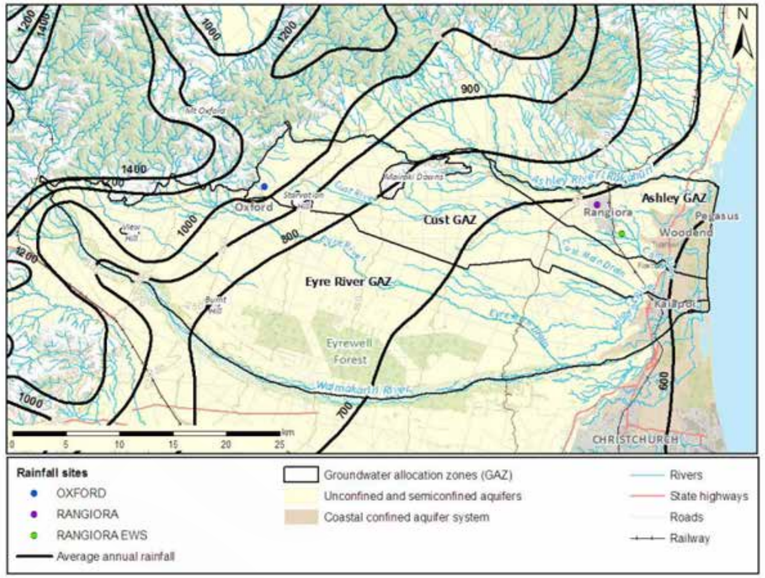
2.2.3 Ecological Districts

The District was divided into five areas based on the interconnected characteristics of topography, geology, climate, soils and the residing flora and fauna (McEwan, 1987). Namely, these areas are the Ashley, High Plains, Low Plains, Oxford and Torlesse ecological districts (Figure 6). Each area is unique and holds a wealth of taonga/treasures including diverse species of fauna and flora many of which are listed as threatened (Table 3). This broad definition of ecological area hides a wealth of ecotones, transitions between one ecological district to the next, and whilst each classification has a distinct character, there are inevitable anomalies.

Canterbury Plains: High and Low Plains

The plains cover over 50% of the District, mainly in the south and east and would have comprised of terraces from the braided river networks encompassing a transitional ecosystem from the dry and easily leached braided riverbeds to the deeper, more nutrient rich soils sustaining forest species and ecosystems. Historically, the area would have comprised hardy, low growing flora such as raoulia (*Raoulia* spp.), within the shifting braided river bed. As the substrate became more stable, a mosaic low growing herbs and tussock grasses would have given rise to almost savannah-like vegetation in the drier areas, hardy shrubs and dry woodland, kānuka shrub and podocarp forest with areas of wetland in the eastern areas where the soils were less porous. Although limited in distribution, there are highly significant areas of calcareous cliffs, scarps and tors present on the plains. These areas are naturally uncommon and contain adapted plant species, of which almost 50% are listed as threatened or data deficient (Rogers, Courtney & Heenan, 2018). These areas are highly vulnerable to habitat loss through quarrying activities, herbivory and weed encroachment.a

Figure 5. Depiction of approx. annual rainfall for the District (taken from Dodson *et al.*, 2012).



Currently, the area represents a highly modified environment in which indigenous vegetation has been severely spatially reduced mainly due to conversion of land for production and settlement (Environment Canterbury 2008). The amount of indigenous land cover remaining in some areas is less than 0.1% being categorised as “acutely threatened” (Walker *et al.*, 2006; Winterbourn *et al.*, 2008) and the existing remnants are small and fragmented, often containing non-regenerating populations (Meurk 2008; Meurk *et al.*, 1995). These habitats contain a large proportion of indigenous and threatened species that are under-represented within the Aotearoa New Zealand protected areas network (Head and Given 2001; Holdaway *et al.*, 2012; Walker *et al.*, 2006).

Canterbury Foothills: Ashley and Oxford

A large proportion of the foothills are mapped as National land of significance by the Department of Conservation and protected as such (Davis *et al.*, 2016; ECan, 2016). This includes the Mt. Oxford, the Ashley Forest and Mt. Thomas Conservation Area containing beech forest habitat supporting rare and threatened species and some sub-alpine shrubland. Both the Ashley and Oxford ecological districts are well provisioned with the majority of the area containing at least 30% indigenous land cover and there are large tracts of land which are connected. There are also podocarp forest remnants at foothills-plains interface such as the Coopers Creek/ View Hill area, and associated wetlands, including Tawera mudfish/kōwaro population.

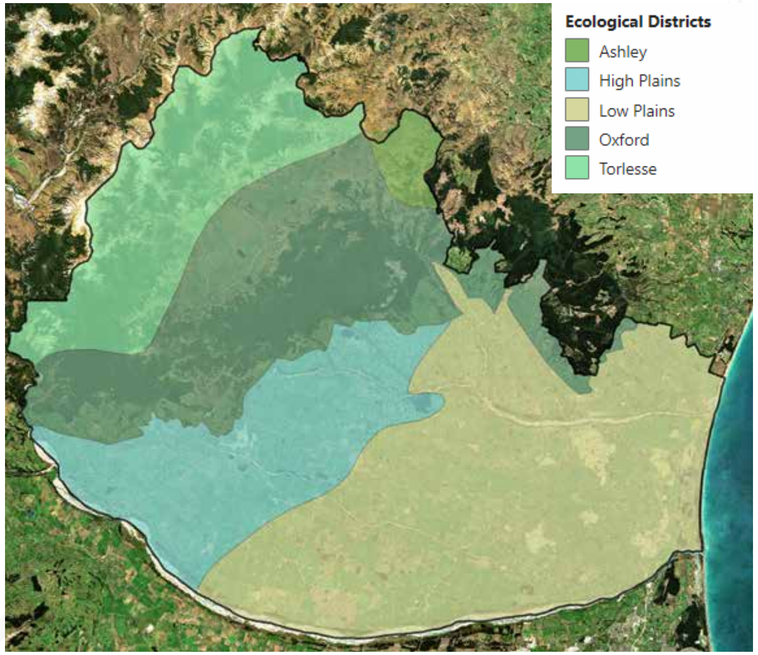


Figure 6. A map of the District showing the ecological districts as described by McEwan (1987).

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Table 3. Ecological District Information

Threat status categories: V = Vulnerable, E = endangered, CE = Critically endangered

Ecological District	Area in District (ha)	Indigenous Vegetation Remaining	Indigenous Vegetation Protected	Naturally Uncommon Ecosystem Type	Example of Important Species in the Ecological District
Low Plains	88,367	<10%	<5%	Braided Rivers (E), Dune Slacks (E), Active sand dunes (E), Coastal lagoons (E).	Geckos and skinks, plants, black-fronted tern/tarapirohe *(Chlidonias albostriatus)*, Canterbury Plains boulder copper butterfly (*Lycena sp).*
High Plains	38,593	<10%	<5%	Basic cliffs, scarps, and tors (V) of Burnthill	Waipara gentian (Gentianella calcis subsp. waipara), freshwater crayfish/kōura (*Paranephrops zealandicus*), long-fin eels/tuna kuwharuwharu (*Anguilla dieffenbachii*).
Ashley	3,775	>30%	>20%	Lake Margins (V)	New Zealand Falcon *(Falco novaeseelandiae)*, Kea *(Nestor notabilis).*
Oxford	55,058	>30%	<25%	Calcareous cliffs, scarps, and tors (V) of View Hill and Okuku.	New Zealand Falcon, Canterbury mudfish *(Neochanna burrowsius)*, Kea.
Torlesse	35,918	>30%	>20%	Inland outwash gravels (CE)	Speargrass *(Aciphylla subflabellata)*, giant weta *(Deinacrida connectans)*, Kea.
Oxford/Torlesse – Lees Valley	21,578	<10%	ND	Ephemeral wetlands (CE)	New Zealand Pipit *(Anthus novaeseelandiae novaeseelandiae)*, geckos and skinks.

The foothills also contain the Lees Valley intermontane basin at approximately 400m above sea level. It has a similar climate to the lowland areas but has lost more than 90% of its indigenous land cover (ECan, 2008). However, in addition to terrestrial dry shrubland, the Lees Valley also comprises important wetland, riparian and swamp wetland, such as Richon Wetland, a 6ha sedgeland area containing the sedge *Carex tenuiculmis* classified as At Risk – Declining and nationally critically threatened Canterbury pink broom (*Carmichaelia tortulosa*) (QEII National Trust, 2008).

Puketeraki: Torlesse High Country

The Torlesse ecological district is a montane area with a cool climate and snow on mountain tops for approximately three months of the year. The Puketeraki Conservation Area is classified as land of National Significance containing beech, tussockland and subalpine habitats. The area receives moderate rainfall 1,000-24,000mm per year, which supports the tussocklands in the valleys, the scattered beech forest and scrub but also the sub-alpine, alpine and fell-field vegetation. Although this area is modified, it is important for birds such as kea (*Nestor notabilis*) and falcon/kārearea (*Falco novaeseelandiae*) and many wetland birds associated with the rivers. The area is also known to have giant weta (*Deinacrida connectans*). The headwaters for the Ashley and Okuku River are found within this area.

Freshwater and Coastal

The Waimakariri District has meandering rivers that are spring fed, rainwater fed or fed by snow melt (Figure 7). These features provide habitat and shelter for a number of rare and endangered species of invertebrates, birds, lizards and indigenous fish. They also have cultural significance as water "connects Ngāi Tahu to the landscape and the cultural traditions of the tūpunas" such as the provision of mahinga kai, the sacred habitats and sites and their function as ara tawhito, access routes to the West Coast/Te Tai Poutini (Jolly & Ngā Papatipu Rūnanga Working Group, 2013). Furthermore, the wetlands and water features of the District provide numerous opportunities for recreational activities such as white-water kayaking, fishing, dragon boating, mana-waka paddling, and power boating to name a few (Waimakariri Water Zone Committee, 2018).

The Waimakariri Zone Implementation Programme divided the District into four catchment areas including the Waimakariri River, the Ashley/Rakahuri River, the lowland streams and coastal lagoons and the Eyre and Cust Rivers (Waimakariri Zone Committee, n.d.). These latter rivers have their headwaters in the Puketeraki Ranges and the Oxford foothills and originally flowed into the Ohoka-Rangiora swamp before being drained in the 1930s through river engineering techniques. These rivers are prized for their spawning trout and recreational benefits and contribute to the Waimakariri/Ashley plain groundwater.

The Waimakariri and the Ashley/Rakahuri braided rivers have been listed as a naturally uncommon ecosystems and given the national designation of "endangered", providing habitat to specialised fauna and flora such as endangered birds (Holdaway *et al.,* 2012; Wiser *et al.,* 2013). These rivers have also been recognised as nationally significant, along with the lowland streams and coastal wetlands including the Ashley/Rakahuri estuary, the Okuku River, the Cam/Ruataniwha River, Kaiapoi River, Tūtaepatu Lagoon, the Pines Beach Wetland, areas of swampland around Loburn (Boffa Miskell, 2010; Davis *et al.,* 2016).

The coastal resource in the east comprises dune systems, coastal freshwater and brackish networks of wetlands, streams and lagoons, including the 49ha spring fed Tūtapatu Lagoon.

Figure 7. Map of main waterways and settlements within the District (Sparrow and Taylor, 2019).

The Ashley/Rakahuri Estuary to the north of the District contains areas of salt marsh, which are rare in Canterbury (ECan, 2008).

2.3 Species

The District is home to a number of nationally threatened species across many habitats and ecosystems (Table 4). The braided river systems are notable for supporting indigenous species renowned as taonga by local iwi including an abundance of rare birds such as banded dotterels *(Charadrius bicinctus),* black fronted terns *(Chlidonias albostriatus)* and godwits *(Limosa lapponica)* following their migration from Alaska: and over 90 species of birds have been recorded at the Ashley/Rakahuri River – Saltwater Creek

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Estuary alone. This site, along with the wider Pegasus Bay wetlands, is designated "Important Bird Areas" by Birdlife International and is recognised by the International Union for the Conservation of Nature (IUCN) as a wetland of "international significance".

In addition, the many streams, springs and wetlands across the district are home to many bird species including the nationally critical Australasian Bittern *(Botaurus poiciloptilus)*. This diversity is in part due to the fact that the braided rivers and spring-fed watercourses contain good quality communities of aquatic macro-invertebrates and aquatic flora (Scarsbrook *et al*., 2007).

The wetlands and watercourses of the District also provide habitat for culturally important aquatic species such as long and shortfin eels *(Anguilla australis)*, koura, īnanga and lamprey with the nationally critical Canterbury mudfish having populations in the Oxford area.

The beech forests in the north and west of the District support rare mistletoe species and plants, along with a range of fungal species, birds and invertebrates. The drylands also support a wealth of rare and threatened plant species including those we may think of as common such as matagouri and kānuka. These habitats also support a range of invertebrates and lizard species (Plate 1).

It is important to note that although the District supports many threatened species, species which do not have a national threat classification should not be overlooked. The diminished nature of the District's indigenous habitat means that all species are important and are imperative for the structure and functioning of ecosystems which also support the rare flora and fauna.

Plate 1. Jewelled gecko camouflaged in foliage.

Table 4. An example of some of the rare and threatened species present in the Waimakariri District.

Species	Threat Category	Conservation Status	Habitat
Birds			
Australasian bittern ***Botaurus poiciloptilus***	Threatened	Nationally critical	Vegetated wetlands
New Zealand Falcon ***Falco novaeseelandiae***	Threatened	Nationally endangered	Predominantly foothills
Black-fronted tern ***Chlidonias albostriatus***	Threatened	Nationally endangered	Braided riverbeds
White-fronted terns ***Sterna striata aucklandorna***	Threatened	Nationally vulnerable	Rivers and coast
Wrybill ***Anarhyncus frontalis***	Threatened	Nationally increasing	Braided rivers
Arthropods			
Robust Grasshopper ***Brachaspis robustus***	Threatened	Nationally endangered	Braided rivers
Crayfish/kōura ***Paranephrops zealandicus***	At risk	Declining	Wetlands
Sand Scarab ***Pericoptus frontalis***	At risk	Naturally uncommon	Beaches, braided rivers

Table 4 continued.

Species	Threat Category	Conservation Status	Habitat
Lizards			
Jewelled gecko ***Naultinus gemmeus***	At risk	Declining	Drylands and shrublands
Canterbury grass skink ***Oligosoma aff. poluchroma Clade 4***	At risk	Declining	Drylands and shrublands
Waitaha/Canterbury gecko ***Woodworthia cf. brunnea***	At risk	Declining	Rocky dryland, shrublands
Fish			
Canterbury mudfish ***Neochanna burrowsius***	Threatened	Nationally critical	Wetlands
Lamprey ***Geotria australis***	Threatened	Nationally vulnerable	Wetlands
Longfin eel ***Anguilla dieffenbachii***	At risk	Declining	Wetlands
Īnanga ***Galaxias maculatus.***	At risk	Declining	Wetlands
Plants			
Dryland button daisy ***Leptinella filiformis***	Threatened	Nationally critical	Drylands
Canterbury Plains Tree Daisy ***Olearia adenocarpa***	Threatened	Nationally critical	Drylands, braided rivers
Armstrong's whipcord ***Veronica armstrongii***	Threatened	Nationally endangered	Drylands
Everlasting Daisy ***Helicrysum dimorphum***	Threatened	Nationally endangered	Dry scrubland
Kānuka ***Kunzea serotina***	Threatened	Nationally vulnerable	Forest and shrubland
Waipara gentian ***(Gentianella calcis subsp. waipara)***	Threatened	Nationally critical	Limestone areas
Matagouri ***Discaria toumatou***	At risk	Declining	Drylands

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3. Pressures and Threats

Globally the world is experiencing a loss of biodiversity which is being named the sixth extinction (Ceballos *et al.*, 2010).

Species are being lost at a greater magnitude than seen previously and at "a rate thousands of times higher than the background rate". This loss is progressing quickly, significantly destructive and cumulative in the effect on ecosystems, their functioning and services impacting human health and society in many ways (Rodríguez-Rodríguez & Martínez-Vega, 2022; Atkins & Macpherson, 2022). To exacerbate the situation, in Aotearoa New Zealand there are the high levels of endemism which puts species at a higher risk of extinction, as discussed in the introduction. In 2019, a report written by the Ministry for the Environment and Stats NZ, identified nine main issues facing New Zealand's natural environment (MfE & StatsNZ, 2019). These can be summarised into five categories: direct habitat loss, habitat degradation, invasive species, climate change and societal pressures and change.

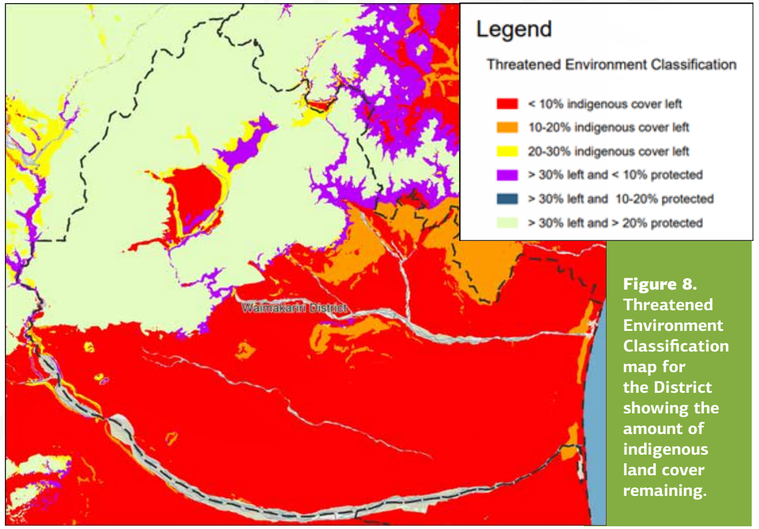

Figure 8. Threatened Environment Classification map for the District showing the amount of indigenous land cover remaining.

3.1 Direct Habitat Loss

Much of the District has less than 10% indigenous vegetation remaining (Figure 8). The loss of habitat and ecosystems and their ecological linkages have been executed through direct removal and/or destruction to enable activities such as urban development, agricultural practices, mineral extraction (Ausseil *et al.*, 2011). In recent years, exotic plantation forest, often using invasive species (Bellingham *et al.*, 2023), has been the main driver for indigenous forest loss (Ewers *et al.*, 2006).

Direct habitat loss and fragmentation has been indicated as the primary threat to global biodiversity (Fraser *et al.*, 2015; Groom *et al.*, 2006; Weidong *et al.*, 2002). Although the primary effect of habitat loss is the reduced spatial area and fragmentation, there are independent and interdependent consequences such as patch area, edge effects, isolation, fragment shape and landscape matrix influences (Ewers & Didham, 2006; Didham *et al.*, 2012).

The species-area curve is a fundamental concept in ecology which notes that increased spatial area correlates to increased species richness (Lawton, 1999). Primarily the increase in species with increasing area is attributed to the environmental heterogeneity (the variance afforded in the ecosystem). This diversity leads to more niches, habitats and resources, increased shelter opportunities and an increase for speciation incidents (the evolution of species creating novel and distinct species) (Stein *et al.*, 2014). Therefore, should an area become reduced in size, the opposite of these effects will be true leading to fewer species. Biodiversity, the variety of biological components in an ecosystem (genes, species, functional traits), increases the ecosystem functioning and the capacity for ecosystem services. Therefore, habitat loss directly impacts biodiversity which affects the amount and quality of ecosystem services (Felipe-Lucia *et al.*, 2020).

The resulting isolation and fragmentation of the ecosystem has a bearing on genetic and evolutionary principals and how resilient it is partly due to the lack of flow of genes, species, interactions and ecosystem services through the wider landscape matrix (Fraser *et al.*, 2015). There is some evidence that fragmentation may lead to positive impacts such as introduced pollinators associated with cropping systems also providing that function within indigenous, fragmented remnants. However, the impacts of fragmentation are often slow and can result in extinctions (Forbes *et al.*, 2020) requiring mitigation and management of habitat loss and fragmentation to help to sustain ecosystems and their services (Mitchell *et al.*, 2015). Furthermore, Haddad *et al.*, (2015) stated that the effects of fragmentation have not been fully acknowledged with detrimental and surprising effects continuing for decades. They warn that the ability to *"sustain biodiversity and ecosystem services will hinge upon the total amount and quality of habitat left in fragments, their degree of connectivity, and how they are affected by other human-induced perturbations such as climate change and invasive species"*.

The concept of patch area is connected to the habitat loss responses of edge effects and fragment shape. The edge effect is the influence of one ecosystem on another at their boundaries. Smaller and irregular shaped patches have larger edge effects due the to increased area (Figure 9). These effects can be positive, negative or neutral (Fraser *et al.*, 2015). For example, in remnant areas of indigenous vegetation edge effects were detected over 50m into the vegetation patch altering the abiotic and biotic structure, composition and function of the ecosystem (Dollery, 2017; Didham *et al.*, 2015). In these situations, this also led to a decrease in native species and an increase in exotic, often invasive, species.

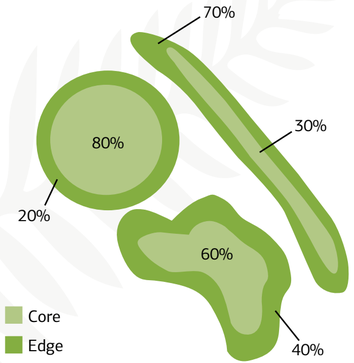

Figure 9. An example of the consequences of edge effects on the core ecosystem areas of different size and shape (taken from Taormina, 2019).

3.2 Habitat Degradation

Habitat degradation is defined as "the gradual deterioration of habitat quality" which can be difficult to identify due to the slow transformation of the ecosystem and the extended life cycles of some species (Fischer & Lindenmayaer, 2007). This is particularly evident in the kānuka shrublands south

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of the Waimakariri District. The kānuka trees remain but cannot reproduce due to habitat degradation altering the soil chemistry and enabling competitive exotic species to outcompete seedlings (Dollery *et al.,* 2022; Meurk *et al.,* 1995). For these reasons, some have argued that degradation is more serious than habitat loss (Doak, 1995).

Degradation can occur from altered abiotic conditions such as soil chemistry and thermal regimes, or from biotic changes such as invasions from exotic species. A range of activities can be drivers for degradation such as agricultural and forestry practices (fertilser use, grazing, logging), urban pressure (wastewater treatment, polluted runoff), horticultural processes (use of pesticides and herbicides), climate change and invasive pest and weed species. The main forms of degradation acknowledged for Aotearoa New Zealand were from farming activities and urban areas and particularly their effect on our waterways with nutrients, sediment and pathogens being reported (MfE & Stats NZ, 2019). However, these inputs can also alter our terrestrial systems, changing the chemistry and structure of ecosystems, markedly the soil ecosystem, leading to invasions of exotic species and habitats which are unsuitable for the indigenous species which once resided there (Dollery, 2017; Didham *et al.,* 2015).

Degraded habitats directly impact the use of natural environment for humans. Pollution in waterways can impact the quality for recreational activities such as swimming and fishing (Davies-Colley, 2013; Monaghan *et al.,* 2008; Morrison *et al.,* 2009). Furthermore, whilst certain human activities such as agriculture and urban development can have an effect on the degradation of the natural environment, the reverse is also true. The continued degradation of the soil ecosystem has an impact on multiple ecosystem services utilised by the production sector which require increased inputs to mitigate (Hu *et al.,* 2023). For example, degradation due to soil compaction and associated impacts on soil structure such as loss of aggregation has been estimated to cost NZ$75–611m annually for dairy farms in Aotearoa New Zealand (Foote *et al.,* 2015).

3.3 Invasive Species

There has been much debate, discussion and research into the effects of invasive species in recent years in Aotearoa New Zealand and globally, mammals have been noted as one of the driving changes in habitat degradation, modification and species extinctions (Mack *et al.,* 2000; Parkes, 2017). In Aotearoa New Zealand, the only mammals known pre-human settlement were bats. There are now 31 species with 23 of those being listed as invasive and responsible for the loss of 40% of bird species (Cowan and Tyndale-Biscoe, 1997; Duncan and Blackburn, 2004). However, other species of invasive animals such as wasps (Vespula spp.) are also having a significant impact on native species and ecosystem functioning (Clout, 2001).

In addition to fauna, there are significant plant invasive species. Invasion of areas by pine trees has been shown to degrade the soil fungi community (Sapsford, 2022). Plant-fungi relationships are important for over 90% of plants on earth (Brundrett, 2004). Therefore, a loss of soil fungal diversity drives the loss of above ground biodiversity (Hooper *et al.,* 2000). Exacerbating the issue is the persistence of exotic seed in soil banks and seed rain which aids reinvasion for exotic species that can further degrade natural areas (Overdyck & Clarkson, 2012).

In Canterbury, 52 species of plants and animals are listed within the Canterbury Pest Management Plan. Not all of these species are currently found within the District and work is being undertaken to contain the distribution. Presently, only 16 species are recorded on iNaturalist although this does not indicate other pest species are not present and remain undetected (Table 5, Figure 9). In addition to those species named as pests, there are also "Organisms of Interest" which are monitored for their future impact on biodiversity and could be controlled as pests should it be necessary. Examples are species such as hedgehogs (Erinaceus europaeus), Himalayan balsam *(Impatiens glandulifera)* and hawthorn *(Crataegus monogyna).* Mustelids and possums are controlled under the National Pest Management Strategy for Bovine Tuberculosis.

Both faunal and floral pests can have detrimental effects on the natural environment and the native ecosystems within Aotearoa New Zealand. Invasive species are listed as drivers for over 50% of extinct species but are the sole driver in 20% of cases (Duenas, 2021). The eradication or containment of pest species is complex as a reduction in one species may result in competitive release for another. This was seen in the beech forests around Nelson where stoat trapping saw an increase in the rat population (Whittau *et al.,* 2023).

Invasive species also have the means to degrade ecosystems by being vectors for disease and changing the ecosystem functioning with effects on conditions such as trophic levels, energy input, substrate chemistry, available light (Dollery *et al.,* 2022; Garvey *et al.,* 2022; Krull *et al.,* 2015; Standish *et al.,* 2001).

In addition to the impact on biodiversity and ecosystem services, invasive species can also harm the agricultural and horticultural sectors. For example, rodents and possums directly eating or destroying crops and the spread of bovine tuberculosis from possums and mustelids (Livingstone *et al.,* 2015; Russell *et al.,* 2015). In fact, Nimmo-Bell (2021) estimated that pest species caused NZ$2.4b worth of damage in 2020. Whilst impacts to the productive natural environment can reduce the GDP for the country, there are also fears that the invasions could harm the image of the country as "clean and green" leading to reduced tourism and marketing opportunities (Owens, 2017).

Table 5. Pest species listed on the Canterbury Pest Management Plan and indicated to be found within the Waimakariri District on iNaturalist.

Common Name	Latin Name	Known Location
Banana Passionfruit	*Passiflora triparita, P. pinnatistipula*	Rangiora, Oxford
Boneseed	*Chrysanthemoides monilifera*	Waikuku Beach
Broom	*Cytisus scoparius, Genista monspessulana, Cytisus multiflorus*	District-wide
Pine species and wilding conifers	*Pinus contorta, P. nigra, P. uncinate, P. mugi, P. Sylvestris*	Hill country
Darwin's barberry	*Berberis darwinii*	Kaiapoi
Feral rabbit	*Oryctolagus cuniculus*	District-wide
Gorse	*Ulex europaeus*	District-wide
Curly waterweed	*Lagarosiphon major*	Lowland streams
European larch	*Larix decidua*	Hill country
Old Man's Beard	*Clematis vitalba*	District-wide
Possum	*Trichosurus vulpecula*	District-wide
Purple loosestrife	*Lythrum salicaria*	Rangiora
Common cordgrass	*Sporobolus anglicus*	Kaiapoi
Common thyme	*Thymus vulgaris*	Oxford
Wild Russell Lupin	*Lupinus polyphyllus*	Hill country and Waimakariri Riverbank
Woolly nightshade	*Solanum mauritianum*	Waimakariri Riverbank

Examples of pest species within the Waimakariri District including gorse (left), old man's beard (centre) and curly waterweed (right).



3.4 Climate Change

The predicted impact of climate change upon the natural environment and biodiversity is complicated with the magnitude currently uncertain. The National Institute of Water & Atmospheric Research (NIWA) modelled climate using the data from International Panel on Climate Change data stated in their fifth and sixth reports to explore projections for 2090 (Broadbent *et al.,* 2022;

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Macara *et al.,* 2020: IPCC, 2014). The projections were based on various scenarios referred to as representative concentration pathways (RCPs):

- RCP8.5 – business as usual with increasing CO_2, CH_4 and N_2O emissions leading to a mean temperature increase of 2°C in 2050 and 3.7°C by 2100;
- RCP6.0 - stabilisation with slightly increasing CO_2, CH_4 and N_2O emissions leading to a mean temperature increase of 1.3°C in 2050 and 2.2°C by 2100;
- RCP4.5 – stabilisation with no increasing CO_2, CH_4 and N_2O emissions leading to a mean temperature increase of 1.4°C in 2050 and 1.8°C by 2100;
- RCP2.6 – mitigation with reductions in CO_2, CH_4 and N_2O emissions leading to a mean temperature increase of 1°C in 2050 and 1°C by 2100.

Although uncertain, it is thought that by 2100 Canterbury will see a rise in sea level change of approximately 0.8m and a rise in temperature of between 1.5-3.5°C. There will be increased wildfires, droughts and extreme weather events. Rainfall patterns will change, and wind intensity will change with more hot days and a decrease in frost days and snow days. The impacts are thought to be two-fold; direct impacts such as the damage caused by heat stress, and indirect which are those that impact changes in the environment and cause harm such as landslides.

These climate changes will inevitably influence the natural environment, human communities and biodiversity leading to habitat loss and degradation but also alterations in disease patterns and pest interactions (Alley and Gantrell, 2019). Effects are stated to be already occurring with heat waves, droughts and increased rainfall affecting different parts of the country (Corlett, 2021; Harrington & Frame, 2022). In 2023, the West Coast experienced an exceptionally warm marine environment which could lead to lower productivity in the oceans and warm land surfaces (Morton, 2023). Also in 2023, sporadic rainfall events and storms wreaked havoc across the North Island causing loss of lives, property and infrastructure and isolating communities, leaving them with limited food, energy and communication resources (McLure, 2023). These events prompted the Aotearoa New Zealand Minister for Climate Change to express anger and sadness at the lost decades of action working to slow climate change (McLure & Graham-McLay, 2023).

Elevated temperatures may negatively affect the growth of organisms. Increased nutrients due to altered flows and elevated temperatures in the freshwater environment could lead to algal blooms in lakes and rivers impacting biodiversity, human health, and recreation values of the natural environment (Keegan *et al.,* 2021). The impacts for the coastal environments include ocean acidification which will have significant changes with regard to food web structures and productivity and sea level rise and flooding degrading the coastal environments (Willis *et al.,* 2007).

In urban areas, there may be a negative impact on the growth of plants, particularly trees, exacerbating the heating of urban areas due to the "urban heat island effect", (the phenomenon whereby urban areas are warmer than surrounding areas due to the lack of natural vegetation, heat absorbing materials and associated human activities) (Esperon-Rodriguez *et al.,* 2022: Fryd *et al.,* 2012; Hunt & Waykiss, 2011; McCarthy *et al.,* 2010; Ministry for the Environment, 2022). The increased temperatures in urban areas could impact significantly on the health of communities (Heaviside *et al.,* 2017; Shahmohamadi, *et al.,* 2011; Ministry for the Environment, 2022).

3.5 Societal Pressures and Changes

The global human population is increasing and estimated to reach 9 billion by 2050, placing increasing demands on the natural environment for space and resources (Foresight, 2011). However, the demographics, perceptions and values of the increased population is unknown. In 2005, the fact that people were spending less time outdoors which was changing their worldview and causing many physical and mental health issues was highlighted and termed, "nature deficit disorder" (Louv, 2005). In addition to the health effects, there is some evidence that nature deficit disorder may lead to a diminished understanding of the natural world (Ecological intelligence) and a decline in stewardship (Divya & Naachimuthu, 2020; Whitburn *et al.,* 2020). An often quoted and similar concept in Aotearoa New Zealand is the "extinction of experience" whereby nature and particularly indigenous biodiversity is superseded by exotic species and the built environment which become the norm (Meurk *et al.,* 2016).

In addition, Craig *et al.,* (2000) contend that the perception of Aotearoa New Zealand's public conservation land as "free to enter" infers that it has no economic value. If nature in protected areas has no value, it can be implied that there is little value to nature in the remaining 70% of land which is not protected. Therefore, due to this devaluation, it seems logical to replace indigenous species with exotic and financially rewarding species potentially at the detriment to the natural environment.

Despite these viewpoints, worldwide there are millions of people who support environmental conservation groups such as the Worldwide Fund for Nature or local groups such as the Royal Society for the Protection of Birds (UK) and Forest and Bird (NZ) (Rands *et al.,* 2010). In Aotearoa New Zealand, there are over 600 community groups involved in ecological restoration and a number of these are represented in the District such as the Ashley-Rakahuri Rivercare Group, the Silverstream Volunteers and the Waimakariri Biodiversity Trust (Hulme, 2020). The perception of the natural environment by the public can have both positive and negative implications for conservation and local support is important to sustain conservation projects, therefore the monitoring of perceptions is pertinent (Bennett, 2019; Niemiec, 2022).

Support for conservation of the natural environment has been found to be linked to the perceptions of "good governance" and "social Impacts" (Bennett, 2019) and fluctuations in the economic climate can have a bearing on the how the natural environment is perceived, prioritised and managed. Sandbrook *et al.,* (2022) contend that the type of recovery chosen by governments following the Covid-19 pandemic will have dramatic influence on the trajectory of biodiversity and the natural environment.

Societal pressures can also lead to changes in regulation and policy, impacting support and funding either negatively or positively. Currently, much of the protection around the natural environment involves rules and penalties that require intensive enforcement which can be lacking due to resource limitation.. However, another suggested method is to positively incentivise diligent landowners for their sustainable use of land (Norton *et al.,* 2020). Furthermore, there is a long overdue acknowledgement of indigenous and local knowledge and in Aotearoa New Zealand mātauranga Māori is gaining increased recognition for its importance, particularly for matters concerning the natural environment (Harmsworth. 2020).

Considering all of these points, there are calls for a multidisciplinary approach to conservation and the natural environment acknowledging the "complex intertwinement between the sanitary, social, economic, political, ecological and ideological dimensions of the current crisis" (Prieur, 2020).

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4. Underpinning Environmental and Biodiversity Concepts

Considering all the threats to the natural environment and biodiversity conservation, an integrated approach across landscapes, disciplines, policy and interested organisations and communities is required (Maseyk *et al.*, 2019).

To achieve this, there are several concepts and working examples that have been influential in the creation of the Natural Environment Strategy and these are outlined below.

4.1 Indigenous and Local knowledge

The content of Section 4.1 is derived from writings from Ngāi Tūāhuriri Rūnanga found within the Mahaanui Iwi Management Plan, documents produced by Te Rūnanga o Ngāi Tahu and related academic texts. The Council welcomes ongoing input from Te Ngāi Tūāhuriri Rūnanga regarding the further development of the Natural Environment Strategy documents.

Internationally, indigenous and local knowledge and worldviews are crucial for environmental conservation offering diverse perspectives grounded in theories of interconnectedness between people and the environment (Nemogá *et al.*, 2022; Timoti *et al.*, 2017).

In Aotearoa New Zealand, indigenous Māori have an "intricate, holistic and interconnected relationship with the natural world and its resources, with a rich knowledge base – mātauranga Māori – developed over thousands of years and dating back to life in Polynesia and trans-Pacific migrations" (Harmsworth & Awatere, 2013). Māori culture is based on connection to the land and a belief that humans are part of nature and what affects part, affects the whole (Te Ahukaramū Charles Royal, 2005). As such, te reo Māori encompasses a number of words and underpinning knowledge regarding environmental concepts (Box 1).

> *Our natural environment – whenua, waters, coasts, oceans flora and fauna – and how we engage with it, is crucial to our identity, our sense of unique culture and our ongoing ability to keep our tikanga and mahinga kai practices alive. It includes our commemoration of the places our tūpuna moved through in Te Waipounamu, and the particular mahinga kai resources and practices we used to maintain our ahi kā anchoring our whakapapa to the landscape. Wherever we are in the world, these things give us our tūrangawaewae. They form our home and give us a place to return and mihi to and provide us with what we need to be sustained as Ngāi Tahu"* (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

The concepts and practices of indigenous peoples with regard to environmental management have been described as synergistic with adaptive

Box 1. Te Reo Māori language and concepts for the natural world.

The Mahaanui Iwi Management Plan defined some of the language and concepts central to the natural world for the local rūnanga (Jolly & Ngā Papatipu Rūnanga Working Group, 2013). These include:

- **Whakapapa** – Whakapapa (genealogy) is the central pillar of Ngāi Tahu's framework for managing resources, setting out and effectively explaining the relationships between the various elements of the world around us, including human beings.
- **Kaitiakitanga** – fundamental to the relationship of Ngāi Tahu and the environment. The responsibility of kaitiakitanga is twofold: first, there is the ultimate aim of protecting mauri and, second, there is the duty to pass the environment to future generations in a state which is as good as, or better than, the current state. To Ngāi Tahu, kaitiakitanga is not a passive custodianship, nor is it simply the exercise of traditional property rights, but entails an active exercise of responsibility in a manner beneficial to the resource.
- **Mana whenua** – the right to exercise authority over a particular area, its resources and its people. Manawhenua is passed on by way of whakapapa and is protected and secured through the on-going exercise of one's rights to resources in a manner consistent with tikanga. Inevitably, with mana comes responsibility. Ki uta ki tai – from the mountains to the sea, the whole landscape.
- **Manaakitanga** - the custom of being aware of and caring for the needs of your guests. In turn, the mana of the tāngata whenua is both upheld and enhanced. The loss of the ability of tāngata whenua to provide for guests in this way can also be seen as a loss of mana.
- **Wāhi tapu** - places of particular significance that have been imbued with an element of sacredness or restriction (tapu) following a certain event or circumstance. Wāhi tapu sites are treated according to tikanga and kawa that seek to ensure that the tapu nature of those sites is respected. Of all wāhi tapu, urupā are considered to be the most significant.
- **Wāhi taonga** - "places treasured" due to their high intrinsic values and critical role they have in maintaining a balanced and robust ecosystem (e.g. spawning grounds for fish, nesting areas for birds and freshwater springs). They are prized because of their capacity to shape and sustain the quality of life experience and provide for the needs of present and future generations, and as places that connect and bind current generations to their ancestral land and practices.
- **Mauri** – Mauri is often described as the 'life force' or 'life principle' of any given place or being. It can also be understood as a measure or an expression of the health and vitality of that place or being. The notion embodies the Ngāi Tahu understanding that there are both physical and metaphysical elements to life, and that both are essential to overall well-being. It also associates the human condition with the state of the world around it. Mauri, therefore, is central to kaitiakitanga; that is, the processes and practices of active protection and responsibility by Manawhenua for the natural and physical resources of the takiwā.
- **Mahinga Kai** - The Ngāi Tahu Claims Settlement Act 1998 describes mahinga kai as "the customary gathering of food and natural materials and the places where those resources are gathered." Mahinga kai are central to Ngāi Tahu's culture, identity and relationship with landscapes and waterways of Te Waipounamu.
- **Ki Uta Ki Tai** - reflects the holistic nature of traditional resource management, particularly the interdependent nature and function of the various elements of the environment within a catchment.

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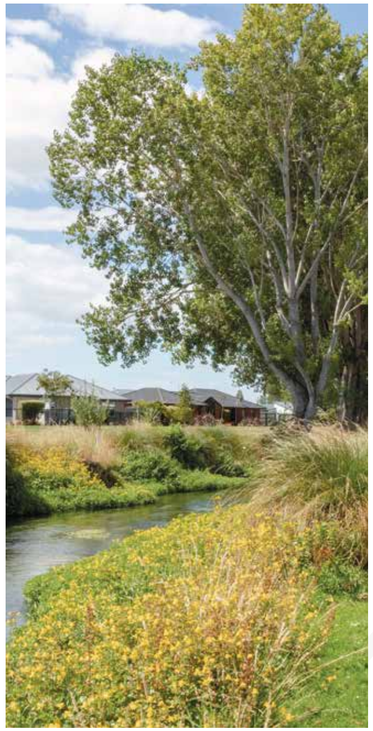

management due to the systematic learnings encountered through feedbacks (Berkes *et al.,* 2000) However, historically, Māori concepts and input have been devoid in policy and planning instruments (Erueti *et al.,* 2023).

Fortunately, Māori concepts and ideologies have gained increased recognition in recent years with greater inclusion in governance (Joseph & Benton, 2021). McAllister *et al.,* (2023) listed some of the recent inclusions of Māori-led or collaborative work to improve environmental conservation outcomes, stating that "*the Treaty settlement era has seen a resurgence and reconnection between the environment and people, which has resulted in cultural concepts, including kaitiakitanga, being incorporated in policy … and research*". For example, tikanga (Māori beliefs, values and concepts) was integrated into the Resource Management Act 1991 (RMA) and the concepts of Te Mana o te Wai and Te Mana o te Taiao were integrated into national policy, although when the presence of these was reviewed in the RMA it was suggested the concept be strengthened in legislation (Randerson *et al.,* 2020). The need to design legislation and policy from the perspective of mana whenua and begin engagement at the initiation of decision making was also highlighted.

The Natural Environment Strategy is heavily influenced by the legislation and policies which are emerging from central government. The National Policy Statement for Indigenous Biodiversity, the Aotearoa New Zealand Biodiversity Strategy and its Implementation Plan all state that co-leadership and decision making, as far as is accepted by mana whenua, is required (Department of Conservation, 2020; MfE, 2022; Resource Management Act, 1991). Alongside the positive move to fully embrace indigenous culture, is a call to also integrate local knowledge by creating and maintaining relationships with people who have had a long-standing relationships with the natural environment, such as farmers, naturalists and community residents (Saunders *et al.,* 2021). To enable a resilient natural environment, all sectors of the community have a part to play and those driving initiatives need to be flexible and integrate worldviews, knowledge and different approaches.

Aside from the vast knowledge, governance and stewardship indigenous and local knowledge can convey to environmental conservation, it also provides opportunities to redress some of the inequities and increase the overall wellbeing of communities in Aotearoa New Zealand. By reintroducing the suppressed elements of indigenous and local knowledge, traditions and culture into Aotearoa New Zealand society, communities can regain an attachment to identity and improve mental and physical wellbeing (Million, 2013; Wells *et al.,* 2006)

4.2 More, Bigger, Better, Joined

As discussed previously, biodiversity is a main driver in the maintenance of ecosystem functioning and processes, including the ecosystem services attained by humans (section 1.3). To protect these services, biodiversity is a key component to be protected, managed and enhanced.

In 2010, to understand and stymie the loss of biodiversity, promote ecosystem processes and functioning and create a healthy environment for all, the UK government instructed an independent review written by an esteemed group of experts headed by Sir John Lawton. The report titled "Making space for nature" was significant for UK nature conservation and highlighted the need for natural areas with biodiverse complexity

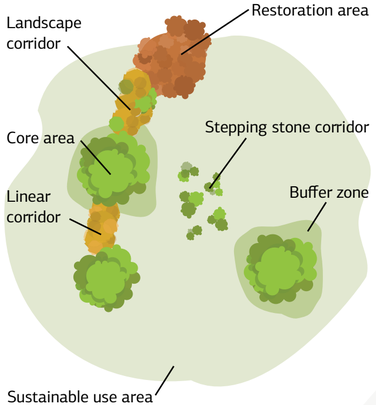

Figure 10. Diagrammatic representation of the "More, Bigger, Better, Joined" theory (adapted from Lawton *et al.,* 2012).

to be "more, bigger, better, joined" (Lawton *et al.,* 2010, Figure 10). The review continues to influence policy nearly 25 years on due to the evidence-based quality of the research (Lawton *et al.,* 2020). At the core was the theory of metapopulation dynamics, the concept evaluating species movements, ecology and persistence through space and time, particularly in fragmented landscapes (Hanski, 1998). Qualifying the theory, Gonzalez *et al.,* (1998) carried out experiments and found that fewer, smaller, isolated patches of habitat lead to a reduction, and sometimes extinction, of species.

At a similar time, Aotearoa New Zealand scientists were also concluding that ecological corridors for birds from mountains to the sea were important (Meurk & Hall, 2006). This research was the basis for the Te Ara Kakariki organisation in the Selwyn District which today offers advice, assistance, and funding to landowners in order to create "greendots", corridors of native plantings which indigenous species can use to navigate the landscape (Te Ara Kakariki, 2023). Below is a description of the ecological and scientific reasoning underpinning "more, bigger, better, joined" in a local context.

4.2.1 More

Aotearoa New Zealand has lost vast amounts of indigenous vegetation since the arrival of humans through degradation or removal and the Waimakariri District now has less than 10% cover in the majority of the land area (Ewers *et al.,* 2006). However, research has shown that there is a threshold of 10% vegetation cover, under which there is a rapid decline in species diversity and increased fragmentation (Clarkson *et al.,* 2018). This figure is extrapolated from global research ranging from a persistence threshold of 10-20% and species-specific research which identifies that some species, such as some birds and migratory species, may persist in environments with greater inter-patch distance provided they are not isolated, whilst other species, such as certain insect species, require remnants to be located in close proximity (Boscolo & Paul Metzger, 2011; Tischendorf *et al.,* 2005). Having more habitat patches allows for the inter-patch distance to be reduced.

Aside from supporting biodiverse ecosystems, more habitat patches within an area can substantially increase the dispersal of a range of species and enhance the regenerative capacity of the natural environment. Essentially, more habitat patches, reduces the effects of fragmentation, particularly for migratory species (Bender *et al.,* 1998). For flora, this can lead to the dispersal of propagules transported from one habitat patch to another resulting in the regeneration of plant species in the surrounding area (Meurk & Hall, 2006). This has been observed in the surrounds of Riccarton Bush, Christchurch, whereby seeds of plants such as Kahikatea (*Dacrycarpus dacrydioides*) have been dispersed into neighbouring properties (Doody *et al.,* 2010). Therefore, the process of restoration becomes passive whereby functioning ecosystems begin to restore and regenerate the landscape through natural mechanisms. This style of restoration can

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also lead to better plant performance. It has been shown that where plants are grown from seed in situ they tend to have higher survival rates (Dollery, 2017).

In Aotearoa New Zealand, there are substantial opportunities for urban areas to contribute to the protection and restoration of habitat patches (Clarkson 2018). Plants in gardens and urban areas can provide food for humans and fauna, particularly for frugivorous and seed eating bird species which can disperse the seed into the wider habitat (Meurk & Hall, 2006). This can be beneficial for increasing pollinator abundance and addressing food scarcity issues. However, the plant species in question is important as it may also promote weed issues, such as the spread of cherry trees in recent times (Meurk et al., 2019; Williams *et al.,* 2008)..

Climate Change

Although the "more" theory is focused on biodiversity, providing more habitat patches also assists with the urban heat island effect and cooling of the District in times of elevated temperatures, particularly those associated with climate change. A study from China found that increased greenspaces in urban areas was the key determinant lowering land surface temperatures. However, the density of these patches and the edge effects also had an influence and could combine to be an effective mechanism to reducing the urban heat island effect (Maimaitiyiming *et al.,* 2014).

It is known that the urban heat island effect can be mitigated by tree cover (Chaston *et al.,* 2022). Christchurch City Council has adopted this theory in the "Urban Forest Plan", ensuring the city has at least 20% forest cover to help mitigate climate change effects (Christchurch City Council, 2003). However, there is also benefit in having green areas which comprise non-trees (vegetation under 3.5m). Urban areas are filled with low albedo materials (dark in colour and subject to increased heat absorption and retention) whereas green spaces are high albedo capacity and allow for cooling (Alexandri & Jones 2006). This includes green spaces, green roofs and green walls which do not often contain trees but have great benefit for reducing heat in urban areas, potentially providing biodiverse habitats and progressing sustainable building practices (Cristiano *et al.,* 2021; Razzaghmanesh, *et al.,* 2016; Salata *et al.,* 2015; Williams *et al.,* 2014).

Productive Landscapes

It is apparent that by having more biodiverse habitat patches, the ecosystem services of an area will be increased. These services affect human health on a broad scale but can also increase the benefits and value of productive landscapes. Introducing more biodiverse areas into productive land can increase pollination services, predation for pests, soil physical and chemical health, water and air pollution mitigation and human health (Tscharntke *et al.,* 2015). An example of harnessing the ecosystem services to increase productivity is the "Greening Waipara" project. The project encouraged a range of plants in between the rows of vineyard grapes to promote functional agricultural biodiversity harbouring predators for pest species rather than using expensive pesticides Barnes *et al.,* 2008).

4.2.2 Bigger

As discussed in section 3.1, patch size and edge-effect are important for the conservation of certain species, the functioning of ecosystems and the maintenance of ecosystem services/Nature's Contributions to People. Essentially, the bigger the patch, the more heterogeneity in habitat and niche availability for a biodiverse species composition leading to increased functioning of processes (Hill & Curran, 2003; Lawrence, 2005; Lawton *et al.,* 2010). Smaller patches of habitat are less resilient to changes such as natural disturbance and climate change and therefore extinctions and loss of ecosystem services are expected. Larger patch sizes can integrate sufficient buffers to protect the inner core habitats (Norton *et al.,* 2018).

Most greenspaces owned by the Waimakariri District Council are small. An overview of these greenspace areas can be found in the Natural Environment Strategy: Reserves State of Environment Report. It highlights that most of the largest greenspaces in the District are recreation/sports fields which have limited ecological integrity and are highly managed limiting the amount of ecosystem services/Nature's Contributions to People derived from them. In the whole District there are only 16 natural areas amounting to a land coverage of 215.5ha with 51ha of that land represented by the Silverstream Reserve in Clarkville and 85ha represented by a land purchase in 2023 which is as yet undeveloped. The rest are small, ranging from 0.03ha to 20.3ha, and in many of these reserves there are large areas maintained as mown, exotic grass cover such as those found in Matawi Park, Kaiapoi Lakes and Hegan Reserve.

Lawns involve substantial inputs of time and resources to maintain and present limited benefits to the natural environment aside from providing a manicured space for recreation, helping to mitigate the urban heat island effect and water management through increasing the infiltration of an area (Ignatieva *et al.,* 2020; Watson *et al.,* 2020). This latter effect can be marginal in some areas since many lawn areas comprise degraded soils due to compaction and loss of soil structure (Sills & Carrow, 1983). The reduced physical size and occurrence may also be influencing the loss of nature experiences for communities and decreasing the respect for biodiversity (Lin *et al.,* 2018).

It is important to have a range of habitat sizes which are connected. Increasing the size will increase connections between habitats making them more resilient, supporting the ecological integrity that is required to gain ecosystem services/Nature's Contributions to People from them and maintaining visibility and connection to the natural world (Lawton *et al.,* 2010).

4.2.3 Better

Lawton *et al.,* (2010) stated that the quality of habitat patches could be improved through better management practices and the protection afforded to them. Protection afforded to ecosystems through various methods is "critical

to conserving and sustaining native biodiversity" (Norton *et al.,* 2018). It is especially vital that remnant areas of indigenous habitat are identified to enable protection mechanisms and seek compensation should the protection not be carried out. An example of protection failing to safeguard environments within the Waimakariri District was the case of a kānuka stand which was protected as a QEII covenant and a Significant Natural Area in the local District Plan, being removed by the landowner to further the agricultural productivity of the area (Young, 2014).

However, some researchers have pointed to the fact that the protectionist view of nature conservation could be harming the natural environment. Craig *et al.,* (2000) remark that the natural environment within protected areas in Aotearoa New Zealand are seen to be free resources with little economic value which consequently leads to the idea that land outside of protection has no value. The knock-on effect is a reduced value for land outside of protected areas which is then replaced with economically viable, and mainly exotic, species. This is also reflected in the laws of Aotearoa New Zealand with the RMA being an "effects based" piece of legislation and rather reactionary towards effects of activities rather than taking a holistic and sustainable approach to environmental resources (Craig, 2004).

Therefore, whilst protection against harm for the natural environment is important, it does not safeguard or secure the sustainability or quality of ecosystems and should be viewed as the beginning of the conservation effort (Norton, 1988). In Aotearoa New Zealand, it has been highlighted that approximately 70% of the land and most of the sea is managed unsustainably with the remaining 30% of land held as reserves primarily protected for conservation purposes but which still experiences major threats (Craig *et al.,* 2000). The effects of habitat deterioration due to adjacent

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landuse, pests species invasions, climatic changes and fragmentation must be managed to enable the sustainability of the natural environment.

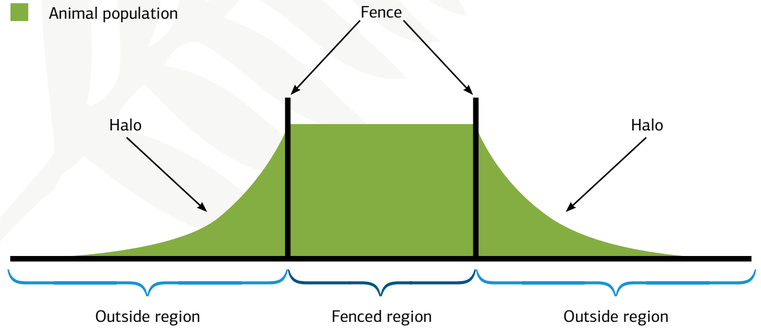
Supporting innovative use and management approaches can support the health and resilience of the natural environment. Examples include the urban wild approach (see section 4.4 of this report), forest technological innovations, landscape analysis using Geographical Information Systems, the "smarter targeting of erosion control" research and regenerative agriculture (Manaaki Whenua - Landcare Research, 2023a; Picuno *et al.,* 2015; Raihan & Tuspekova, 2023).

The regenerative agriculture approach was described by Rodale (1983) as *"one that, at increasing levels of productivity, increases our land and soil biological production base. It has a high level of built-in economic and biological stability. It has minimal to no impact on the environment beyond the farm or field boundaries"*. It can include techniques such as no-tillage, cover crops and green manures to ensure organic matter within soils is maintained, reduction in pesticide and herbicide use and enhancement of the microbiology of the soil which has been shown to have a positive relationship to the nutrients in food stuff grown (Bergess *et al.,* 2019; Mcguire, 2018; Merfield, 2019). These practices produce a positive feedback loop by helping to mitigate climate change (due to continually covered soil surfaces, sequestration of carbon into soils) and increase biodiversity which in turn provide further ecosystem services which promote the health and productivity of the land (Bargaz *et al.,* 2018).

The Halo Effect

An ecosystem which is functioning and comprises a diverse suite of species, habitats and resources, can extend its influence into areas outside of the prescribed boundaries, known as the "halo effect" (Brudvig *et al.,* 2009, Figure 11). This has been observed in the Waikato where control of predators allowed for the spillover of tui (*Prosthemadera novaeseelandiae*) from within the Maungatautari Ecosanctuary to over 20km outside. This phenomenon has also been detected from the Zealandia Ecosanctuary in Wellington with previously rare birds entering the city, such as kākā (*Nestor meridionalis septentrionalis*), tīeke (saddleback - *Philesturnus rufusater*) and toutouwai (North Island robin - *Petroica longipes*) (Miskelly, 2018). In Christchurch, similar mechanisms have been occurring with plants being dispersed outside the fenced boundaries of the Riccarton Bush and found in neighbouring gardens and parks (Doody *et al.,* 2010).

Figure 11. Diagrammatic example of the halo effect (adapted from AMSI, 2023).



4.2.4 Joined

The Lawton report outlined the necessity of ecological connectivity through landscapes to sustain species survival and ecosystem sustainability. The basis for linked habitats is found in theories of island biogeography and metapopulations (MacArthur and Wilson, 1968; Diamond & May, 1976; Hanski, 1998) that together define the dynamic relationships between species arrivals, extinctions and isolation. In recent years, this theory of ecological connectivity has become a fundamental concept in landscape design (Hilty, Lidicker Jr., & Merenlender, 2006). Corridors provide for the movement of organisms, gametes, nutrients and energy in addition to offering habitat, a means for dispersal, home range movement and long-distance range shifts, particularly in response to climate change (Fischer *et al.,* 2009; Hilty *et al.,* 2019). Corridors can be continuous, such as riparian corridors and shelterbelts, or discontinuous such as stepping stones and migratory stopovers.

Research suggests that connectivity and the arrangement of ecological restoration sites be developed at a regional scale with links to urban centres and other depleted environments (Clarkson *et al.,* 2018). Ecological networks allowing species to move through developed landscapes (for example, urban or agricultural) allow for greater species persistence in the wider environment (Noss & Cooperrider, 1994). Noss & Cooperrider (1994) developed six rules for the maintenance of biodiversity which encompass the "More, Bigger, Better, Joined" theory. These are:

1. Large reserves are better than small reserves.
2. A single large reserve is better than a group of small ones of equivalent total area.
3. Reserves close together are better than reserves far apart.
4. Round reserves are better than long, thin ones.
5. Reserves clustered compactly are better than reserves in a line.
6. Reserves connected by corridors are better than unconnected reserves.

The second rule was controversial, and much debate led to the agreement that both size and duplication of sites were important. The inclusion of the final rule regarding corridors was also questioned. Corridors may provide habitat linkages for pests and disease which could harm biodiversity in certain areas and continuous corridors may be costly when resources could be directed towards increasing the size of remnant vegetation stands (Radford *et al.,* 2004). Morse (2022) noted that corridors could be more beneficial for some species than others. There have now been numerous studies indicating the advantages of linking habitats with a shift in focus from corridors to connectivity (Beier & Noss, 1998; Soulé & Terborgh, 1999).

Connectivity can increase the halo effects of biodiverse areas when the species found within ecosanctuaries have sufficient habitat and resources outside of the protected boundaries to disperse into surrounding areas (Brudvig *et al.,* 2009). This has been observed in Christchurch where increasing connectivity and inter-patch distance improved the ranges of kereru and paradise shelduck (Nguyen *et al.,* 2021). This theory and research are the basis behind the organisation, Te Ara Kakariki, plantings of "green dots". The organisation helps facilitate restoration patches of linked habitat to enable movement of species across the Selwyn District and enhance the wildlife populations, particularly of those species which disperse seeds (Te Ara Kakariki, 2023). The reverse of this effect can also be true as the resources outside of the biodiverse areas supplement provisions for species found within (MacLeod *et al.,* 2012).

4.3 Nature Based Solutions

As a society, we face many changes in the coming years. Issues of water and food security, human health, disaster risk and climate change all pose significant threats for human populations and the natural world (Cohen-Shacham *et al.,* 2016, Figure 12). Nature-based solutions represent the ways that we can work with the natural world to enhance their working and produce nature-

Figure 12. Diagrammatic illustration of nature-based solutions (taken from Cohne-Shacham *et al.,* 2016).

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Table 6. Examples of nature-based solutions in New Zealand.

NbS Approach	Case-study	Reference
Ecosystem restoration	Restoration of forests and natural ecosystems to enhance carbon sequestration and mitigate climate change.	Ausseil *et al.,* 2013
Issue specific ecosystem related approaches	Addressing sea-level rise using managed retreat and restoration of salt marsh.	Orchard & Scheil, 2021
Infrastructure related approaches	Benefit of vegetation, including food forests and pocket parks, (green infrastructure) in urban areas to reduce the heat island effect and assist food scarcity issues.	Tapper *et al.,* 1981
Ecosystem-based management approaches	Integrating green areas in cities, in combination with grey water systems, to assist with pluvial flooding events.	Huang *et al.,* 2020
Ecosystem protection	Protection and restoration of coastal seagrass communities to mitigate coastal erosion and inundation.	Kiddle *et al.,* 2021; Ondiviela *et al.,* 2014

Box 2. What are Nature-based Solutions?

The European Commission (2015) describes nature-based solutions as "actions which are inspired by, supported by or copied from nature". The IUCN report notes that nature-based solutions are a range of different approaches which focus on the enhancement of ecosystem services to initiate meaningful solutions to the myriad of issues facing society at present (Cohen Shacham *et al.,* 2016). The report states that nature-based solutions:

- "embrace nature conservation norms (and principles);
- can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions);
- are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
- produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
- maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
- are applied at the landscape scale;
- recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services; and
- are an integral part of the overall design of policies, and measures or actions, to address a specific challenge."

Franzeskaki (2019) analysed a number of nature-based solutions around the world and found that for them to be effective they required:

1. Attractiveness to initiate engagement and investment by citizens;
2. Creation of useful urban spaces;
3. A number of active stakeholders and fora;
4. Experiments which are based on trust between the experimenters and the citizens;
5. A collaborative governance;
6. Inclusive narrative; and
7. Measurement and monitoring which yield useful, effective and replicable results.

based solutions to the issues we face (Seddon *et al.,* 2019, Box 2). Cohen-Shacham *et al.,* (2016) divided nature-based solutions into the following five categories that can be implemented alone or as an integrated system:

- ecosystem restoration;
- issue specific ecosystem related approaches such ecosystem-based disaster risk reduction;
- infrastructure related approaches such as the use of green infrastructure;
- ecosystem-based management approaches such as the integrated water management strategies; and
- ecosystem protection approaches (Table 6).

Example of an urban area in Christchurch landscaped with native plants and stones for pollinators.

The theory of nature-based solutions has been used as an umbrella term which is gaining momentum and being used in various ways with different terms. These include "ecosystem-based adaptation such as restoration efforts; ecosystem-based management, urban green and blue infrastructure, ecological restoration, ecological engineering, forest landscape restoration, ecosystem-based mitigation, ecosystem-based disaster risk reduction, natural capital and potentially biomimicry and biophilic design" (Kiddle *et al.,* 2021). As noted, there are unifying aspects which involve the appreciation, understanding and acknowledgement that the natural world has an ability to mitigate changes within society.

4.4 The Need for Urban Wild

4.4.1 Creation of Living Cities

Facilitating more, bigger, better and joined natural environments does not only extend to the rural or uncultivated areas of the District. Whilst urban centres account for only 1% of land cover currently in Aotearoa New Zealand, it is estimated that over 80% of population growth in the future years will occur in the urban fringe, extending into surrounding landscapes (Stats NZ Tatauranga Aotearoa, 2021a). Globally, cities consume 75% of natural resources and the population shift to urban areas in Aotearoa New Zealand signifies an increase in ecosystem service requirements to ensure our human communities remain healthy (Muller *et al.,* 2010).

Muller *et al.,* (2010) described urban biodiversity as "the variety and richness of living organisms ... and habitat diversity found in and on the edge of human settlements". It has been stated that urban areas in Aotearoa New Zealand are relatively greener than elsewhere in the world with access to larger parks and greenspaces (Meurk, Blaschke & Simcock, 2013). However, the urban landuse offers an altered set of environmental conditions including light levels, climate, soil conditions, pollution incidence; altered ecological conditions with fragmentated habitats and different indigenous species; and are more dynamic with different disturbance regimes and pressures from multiple uses (Sullivan *et al.,* 2009; Wallace & Clarkson, 2019). These conditions create novel ecosystems and have been shown to be a significant threat to indigenous biodiversity, adversely affect water and air quality and contribute to climate change (Chakravarthy *et al.,* 2019; Grimm *et al.,* 2008; Pedersen Zari *et al.,* 2021). For these reasons, urban ecological restoration projects have been steadily increasing internationally (Clarkson & Kirby, 2016).

The urban environment is dominated by the preference for exotic species and an abundance of lawns in tidy, manicured parcels within streetscapes and urban parks (Stewart *et al.,* 2009; Stewart *et al.,* 2010). This is deemed detrimental to biodiversity in a number of ways such as not providing sufficient habitat and resources for species residing in the cities, not providing connectivity through the developed areas to wild habitats outside the urban boundaries and by diminishing the visibility of indigenous biodiversity by using exotic species in landscaping and city artwork.

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Innovative projects to enhance the natural environment through sensitive landscaping are emerging. The appearance of native, low-growing herb lawns, green walls and roofs are being considered in landscape design to facilitate ecosystem services within cities and allow persistence and movement of species within and through developed areas (Ignatieva *et al.,* 2008). Whilst the size of ecological restoration projects within cities may be limited, there has been shown to be a positive relationship between patch size and connectedness and biodiversity (Beninde *et al.,* 2015). However, in Aotearoa New Zealand research has found that even small patches of native vegetation, such as the efforts of individual residents in their gardens or local council-maintained roadside plantings, are useful for naturally regenerating plant species leading to the idea of creating corridors through the built environment (Clarkson & McQueen, 2004; Sullivan *et al.,* 2009).

There is a need to view each non-impervious area within cities as an opportunity to enhance our natural environment, increasing the biodiversity and ecosystem services provided. Aotearoa New Zealand's cities have a wealth of opportunity for biodiversity (Clarkson *et al.,* 2007). For example, urban areas with spatial heterogeneity and intermediate disturbance may enhance the biodiversity of an area (Beninde *et al.,* 2015). In practice this could be roadside areas containing deadwood, bare earth, plants suitable for pollinator species such as nectar producing species for birds and lizards and host plants of invertebrates. In Auckland, Pollinator Paths, a registered charity, is helping people to take action to fill their streetscapes with habitat suitable for pollinators (Pollinator Paths, 2021). Similarly, Palmerston North City Council has a programme to enhance the green corridors around and through the city to ensure wildlife is thriving (Palmerston North City Council, 2023). Predator management may also be required in cities to ensure that biodiversity is not adversely affected, and efforts are not wasted. Predator Free Wellington is an organisation which is engaging the local community in various sectors from individuals to organisations to eradicate predators and protect their biodiversity (Predator Free Wellington, 2023). Initiatives such as these may allow cities to become biodiverse sanctuaries in their own right.

4.4.2 Connecting People and Nature

Approximately 85% of the Aotearoa New Zealand population resides in urban areas (EHINZ, 2023). For this demographic, urban biodiversity may be the first and, in some situations, only encounter with nature (Freeman *et al.,* 2015; Muller *et al.,* 2010). As stated in section 3.5 of this report, connecting people with nature is increasingly important for matters of physical and mental health, stewardship and creativity (Cox *et al.,* 2017; Hartig *et al.,* 2014; Helford, 2000). This was observed during the Covid-19 lockdown periods where residents from Aotearoa New Zealand reconnected with their local environment which led to insights about taking better care of nature and others in the community (Stronge *et al.,* 2023).

There are opportunities within the landscaping design of our urban centres to promote connection and offer relevance to biodiversity by being visible and legible in the streetscapes. Ignatieva *et al.,* (2008) define this legibility as "reading our history as we walk through the landscape" and mentions that plant signatures, combinations of plants (real plants and artifacts) reminiscent of wild habitats, are a useful tool for achieving this.

4.5 Collaboration and Partnerships

It has been argued that environmental and ecological restoration is "as much about people as about the natural environment" (Norton *et al.,* 2016). For kaitiakitanga and environmental stewardship, collaboration and partnerships with tangata whenua are essential. The necessity for Māori leadership within the natural environment sector has been increasingly embraced in policy and law, rightfully supporting iwi and hapū to act as kaitiaki (Ruru *et al.,* 2017). Indigenous-led projects have been shown to result in outcomes which support restoration of both species and habitat resilience and allows for detailed and "nuanced" insights through the inclusion of mātauranga Māori (Rayne *et al.,* 2020).

Example of the use of art on a public toilet to reflect nature and aid connectedness for communities close to the Waimakariri River, Canterbury.

Inter-agency collaborations and partnerships are becoming increasingly important for nature conservation and the natural environment (Peters *et al.,* 2015). A strong, local community foundation for projects appears to be the most efficient model. The work achieved by these groups collectively outweighs that which can be accomplished by a single agency (see Table 7 for a list of some environmental groups operating in Aotearoa New Zealand). However, it has been

Table 7. Examples of some environment groups operating in the Waimakariri District and their projects (taken from WDC, 2021).

Name of group/organisation	Key projects and future plans
Ashley Gorge Reserve Advisory Group	Oversee the development of Ashley Gorge Reserve and protect, enhance and maintain the biodiversity and recreational opportunities of the area.
Ashley/Rakahuri Rivercare Group	A local group of volunteers who aim to protect birds and ecosystems on and around the Ashley Rakahuri River.
Birds NZ	A society promoting the study of birds, data collation, conservation and management.
Braided River Aid (BRaid Inc)	Braided river protection for habitats and species.
Canterbury Botanical Society	Promotes the study of indigenous biodiversity, particularly Canterbury indigenous flora, and undertakes an advocacy role.
Kaiapoi Food Forest	Building community self-reliance through the development of a food forest and community space that aims to connect, nourish, educate and inspire.
Keep New Zealand Beautiful, local groups	Maintaining gardens around the District.
Matawai Park Reserve Advisory Group	Group advising on the management of Matawai Park to retain and enhance biodiversity and recreation.
Royal Forest and Bird Protection Society of New Zealand and local branches	Independent conservation organisation focusing on the protection and enhancement of "wildlife and wild places".
Sefton Saltwater Creek Catchment Group	Monitoring, managing and enhancing the Saltwater Creek Catchment.
Silverstream Reserve Advisory Group and volunteers	Advisory and volunteer work to enhance the recreational and nature conservation values of the Silverstream Reserve and surrounding ecosystems.
Taranaki Reserve Advisory Group	Monitoring and managing the Taranaki Reserve.
Te Kōhaka o Tūhaitara Trust	Restoration and enhancement of the local coastal environment and education and research opportunities into coastal ecosystems issues.
Waimakariri Biodiversity Trust	Provision of information/resources to enhance/protect areas of biodiversity throughout the District.
Waimakariri Landcare Trust	Support sustainable land development, alternative land use options and education for landowners.
Waimakariri Lifestyle Block Owners Group	A group of interested volunteers who have lifestyle blocks and wish to protect, maintain and enhance the local environment.
Waimakariri Water Zone Committee	Local volunteers and rūnanga, regional and local council staff aim to implement water management work in the Waimakariri District.

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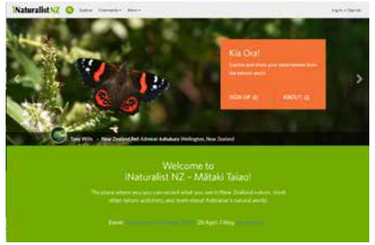
noted that coordination of the groups is required to achieve efficient results (Norton *et al.,* 2018).

Educational campaigns by governmental and non-governmental organisations and partnerships highlighting the situation for nature conservation can be effective at mobilising communities into action. Aucklanders (rural and urban) were found to have strong support for spending on conservation and could recall high profile endangered species such as Hectors dolphin and kiwi due to the advocacy of nature conservation groups (Seabrook-Davidson & Brunton, 2014). Financial support was also evident in the South Island with 90% of mainly urban dwellers willing to have rates increased or to pay $10 to fund indigenous planting schemes on private and public land (Kaval *et al.,* 2009).

Citizen science is another mechanism becoming increasingly used by those involved with the natural environment. It involves members of the public working in collaboration with organisations and researchers to collect meaningful data relating to the natural environment which can be used in a number of ways such as to inform management plans, restoration sites, and pest control programs. This collaboration can generate more insight than researchers can collect individually and can foster a greater appreciation and public support for science and nature (Ganzevoort *et al.,* 2017; Richardson *et al.,* 2020). The ability to inspire and include people in important scientific issues can lead to empowerment and aid to foster "transformative social-ecological change" (Pereira *et al.,* 2020).

Citizen science is most useful in urban and peri-urban environments due to the density of the population residing in such areas. Examples of citizen science include monitoring change in populations such as the "Garden Bird Survey" in which households have a week in which to record the birds they see in a particular place, usually their gardens (Manaaki Whenua – Landcare Research, 2023). This project is a collaboration not only between researchers and community but a number of organisations including Manaaki Whenua – Landcare Research, Forest and Bird, iNaturalistNZ and NZ Birds, to name a few.

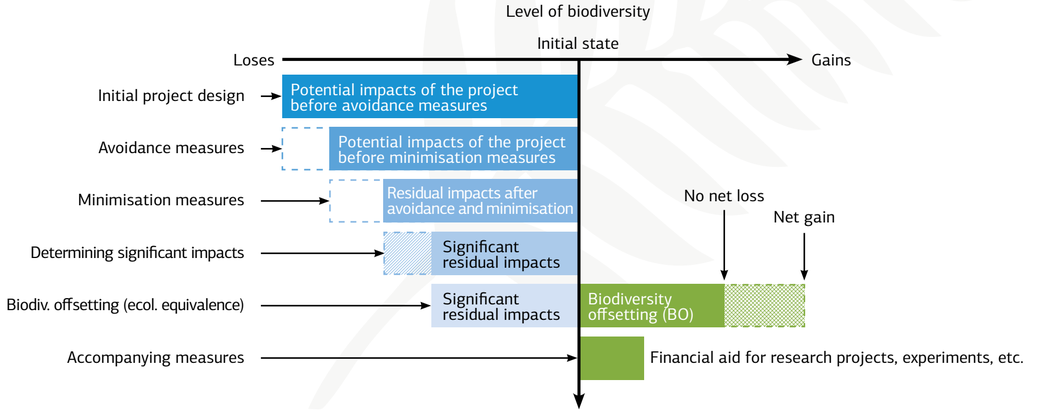


4.6 Effect Management Hierarchy

Internationally, the mitigation hierarchy has been designed to address impacts to the environment from certain practices, land uses and developments. The concept is simply to avoid, minimise or compensate (restore or offset) for any adverse effects (Gardner *et al.,* 2013). Avoidance is the first stage but where this cannot be achieved, impacts are reduced as much as possible. If there are residual impacts, these are then compensated for (Figure 13). The concept has developed many different terms in different countries such as 'no net loss', 'biodiversity gain', 'ecological compensation', and the terms themselves can convey a vagueness open to misinterpretation leading to confusion (Bull *et al.,* 2016).

In Aotearoa New Zealand, the mitigation hierarchy concept was given the name 'effects management hierarchy' in the National Policy Statement for Indigenous Biodiversity 2023. Essentially, it comprises the first three steps of the mitigation hierarchy followed by the management of anything more than minor adverse residual effects using compensation techniques. Initially, any impacts are sought to be avoided. If all impacts cannot be avoided, measures need to be taken to minimise the adverse effects and mitigate effects. Where residual effects remain, the enhancement of biodiversity elsewhere is required (offsetting). If this is not feasible, compensation for the effects is required which will not incur any biodiversity net gain as the enhancing of biodiversity will not be

Figure 13. The mitigation hierarchy, adapted from Bezombes, 2017.



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comparable to that which is impacted. If none of these actions can be achieved, the activity should be avoided (Table 8).

The first stage of the hierarchy is to "anticipate and prevent" adverse effects to the natural environment (Ekstrom *et al.,* 2015). Avoiding impacts has the greatest certainty for the biodiversity resource, and it removes the need for what could be costly mitigation, remediation and compensation activities (Roper-Lindsay *et al.,* 2018). The costs incurred include direct project costs for measures such as restoration or species translocation but also losses arising from impacted biodiversity. The latter are often not monitored sufficiently following the work to assess the full impacts (Glasson *et al.,* 2013; Treweek & Thomson, 1997).

Furthermore, there are calls to strengthen the "avoid" step as the first principle in the concept due to concerns that it is often overlooked when certain criteria are not fulfilled. These were noted as "political will, regulation, process, capacity and technical knowledge" (Phalan *et al.,* 2018). For avoidance to be fully considered, there needs to be political backing for biodiversity conservation in policies and regulations ensuring biodiversity is seen as pivotal infrastructure and then ensuring the capacity and technical knowledge of people involved in creating meaningful change. These comments could also be applied to the minimise and remedy mitigation options where the backing, capacity and knowledge is required to ensure there is meaningful impact mitigation (Hunter *et al.,* 2021).

Table 8. The Effects Management Hierarchy explained (adapted from MfE, 2022)

Management Measure	Explanation
Biodiversity Mitigation Management	
Avoid	Avoid damaging biodiversity by adapting the project, methods, footprint etc.
Minimise	Minimise effects by adapting the project.
Remedy	Remedy/restore biodiversity "at the point of impact".
Residual Effects Management	
Offset	Where the avoidance, minimising and remedying of adverse impacts is not enough to "redress effects", biodiversity enhancement can occur elsewhere to achieve no net loss and potentially biodiversity gain (only in terms of mitigation and not with regard to the project in question).
Compensation	Similar to offsets but used where an offset is not feasible. Compensation measures do not incur any biodiversity net gain as they are not comparable and therefore are a worse option than offsetting.
No activity	**The project cannot proceed if there will be adverse impacts that cannot be mitigated or compensated for.**

The "residual effects management" actions can be seen as the least supportive for biodiversity and the last resort for a project to proceed. In some habitats such as the coastal environment which meets certain policy definitions, the effects management hierarchy cannot proceed beyond the avoidance or the remedy step (Greater Wellington Regional Council, 2020). The first step to consider in residual effects management is biodiversity offsetting. Offsets have been described as "conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects, so as to ensure no net loss of biodiversity" (ten Kate *et al.,* 2004).

It has been further defined as the protection against net loss of a biodiversity target (such as a species population of habitat extent) (Maron *et al.,* 2012). Meseyk *et al.,* (2018) outline the principles that underpin good offsetting projects which include criteria such as acknowledging that not all adverse effects can be compensated for by offsetting and the fact that when offsetting the impact needs to be considered on the project site but also the offset site.

Compensation is not the same as biodiversity offsetting. It represents the worst outcome for biodiversity, purely compensating for the losses incurred from the adverse impacts, but does not equate to a "no net loss" situation. Maseyk *et al.,* (2018) define the offset-compensation continuum as a risk continuum including:

1. Like-for-like offset – the biodiversity resource is enhanced elsewhere to generate a no net loss result. The biodiversity equivalence includes the type, amount, suitable timescale and equivalence over space;
2. Trading-up offset – the replacement of enhancement measures for a biodiversity resource of lesser conservation value for one with greater. This must be determined by experts due to the subjective nature;
3. Environmental compensation – compensation may be applied to different biodiversity targets thereby making any gains or losses unquantifiable and potentially subjective; and
4. Other compensation – compensation which does not benefit biodiversity such as the offer of social or recreation gains. This is unquantifiable, subjective and involves definite biodiversity losses.

UNDERPINNING ENVIRONMENTAL AND BIODIVERSITY CONCEPTS

5. Legislation and Policy

The natural environment is the focus for many pieces of legislation, policy and guidance at an international, national, regional and local scale.

These statutory instruments are constantly being updated, particularly on a national scale with elections potentially eliciting changes in government every 3 years. Some of the legislation and policies which are current, relevant or have guided the formation of the Natural Environment Strategy are outlined below (Figure 14).

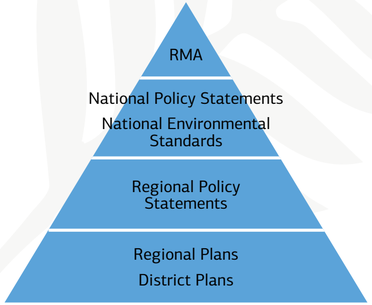


Figure 14. Hierarchy of Aotearoa New Zealand's Planning Instruments

5.1 International Agreements

Aotearoa New Zealand is a signatory to many agreements. Whilst these conventions are not legally binding unless woven into national law, there are some obligations and legal effects although this is often seen as insufficient (Wallace, 2015). The most apparent negative effect is that of disregarding the convention and losing respect within the international community. The international agreements most relevant to Aotearoa New Zealand are:

- International Plant Protection Convention (1952)
- Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975) (CITES in law through Trade in Endangered Species Act 1989)
- Convention on the Conservation of Migratory Species of Wild Animals (1979)
- Convention on Biological Diversity (1992)
- Kunming - Montreal Global Biodiversity Framework (see Figure 15 for detail).

Figure 15.

Themes and targets outlined in the Kunming-Montreal Global Biodiversity Framework to be completed by 2030 and in order to achieve outcome-oriented goals by 2050 (permission from Environment and Climate Change Canada, 2023).

The 23 Targets of the Kunming-Montreal Global Biodiversity Framework. Targets highlighted in dark green are particularly relevant for Ecosystems and People.	1 Biodiversity inclusive spatial planning of all areas	2 Effective restoration of 30% of areas of degraded ecosystems	3 Protected areas, '30 by 30'
4 Conservation of species	5 Sustainable use, harvesting and trade of wild species	6 Invasive alien species management	7 Reduce pollution risks
8 Minimise the impact of climate change	9 Benefits from sustainable use of wild species	10 Sustainable management in agriculture, fisheries and forestry	11 Restore, enhance and maintain nature's contributions to people
12 Green and blue urban spaces	13 Equitable sharing of benefits from genetic resources	14 Mainstreaming biodiversity and its multiple values	15 Involve businesses and financial institutions
16 Sustainable consumption choices	17 Biosafety measures	18 Reform harmful incentives	19 Financial resources
20 Capacity building and development	21 Data, information and knowledge	22 Representation and participation of indigenous Peoples and local communities	23 Gender equity

LEGISLATION AND POLICY

5.2 National Legislation

It has been acknowledged that legislation and policy regarding the natural environment in Aotearoa New Zealand is outdated. Currently there are 24 Acts created over 70 years which do not include full consideration of indigenous or local knowledge, the improved scientific knowledge of recent years or the changing social environment of Aotearoa New Zealand (Allan, 2021). It has been highlighted that despite the increase in knowledge surrounding our natural environment, threatened species continue to decline and this is partly due to the "political and legal inertia" (Hare *et al.,* 2019).

Therefore, reviews and reform of much of the legislation to better reflect the current situation of our natural environment, society and the future challenges have been ongoing. Below is a brief description of the legislation at the current time of writing. However, it should be noted that the coalition Government elected in 2023 has documented its intentions in the 100-day plan to establish "a permanent Rural Regulation Review Panel to assess all regulations affecting the primary sector and propose solutions to cut red tape" which is likely to alter some of the legislation outlined below (National Party, 2023).

5.2.1 Resource Management Act 1991 and the reform

The Resource Management Act 1991 (RMA) came into force in the early 1990's with the purpose of promoting the sustainable management of natural and physical resources. It is administered by regional councils and territorial authorities with regional councils primarily managing air, water, soil, and the coastal marine area and territorial authorities primarily managing land use and subdivision.

The RMA constitutes an effects-based management approach whereby the effects of activities, rather than the party carrying out the activity or the activity itself, are assessed. It attempts to integrate human actions as part of the functioning ecosystem to reach sustainable management (Craig *et al.,* 2000).

However, the RMA does not cover the management of all natural resources with the harvesting of shellfish, marine pollution, use of minerals, covered by other legislation. The Act itself is highly complicated, with insufficient guidance and relies on compliance monitoring which has been shown to seldom occur at a rate which is effective (Brower *et al.,* 2018; Fischer, 2022; Miller, 2003; Millis, 2020; Palmer & Clarke, 2022). For many years, there has been a call for all legislation to effectively communicate to one another rather than the current situation where multiple statutory instruments can be contradictory at best or utterly unclear at worse (Palmer & Clarke, 2022).

The Randerson report (Randerson, 2019) reviewed the RMA and recommended it be replaced with legislation that incorporates Te Tiriti o Waitangi, te Ao Māori and future challenges such as climate change into new legislation. Under the Labour government (2017-2023) conservation and resource management law reform initiated the review and repeal of the RMA and replacement with three Acts: Strategic Planning Act (SPA), the Natural and Built Environment Act (NBA) and the Climate Adaptation Act (CAA) (MfE, 2022a). The National Adaptation Plan, released in 2022, outlined the approach and steps that can be taken to achieve climate adaptation (MfE, 2022b).

In 2023, the new Acts were repealed by the National Coalition Government and replaced by the Resource Management (Natural and Built Environment and Spatial Planning Repeal and Interim Fast-Track Consulting) Bill 2023. This was done so that the government could review and achieve the following goals:

- *"strengthen our strategy and stewardship, using better evidence to support priorities in national environmental management*
- *coordinate our relationships, reducing the demand on our partners and supporting them in their environmental management roles*
- *embed Te Ao Māori and Te Tiriti capability to uphold our statutory and Treaty settlement responsibilities*
- *embed an organisation-wide focus on climate change adaptation and mitigation.*
- *centralise enabling services to better support our people" (MfE, 2023).*

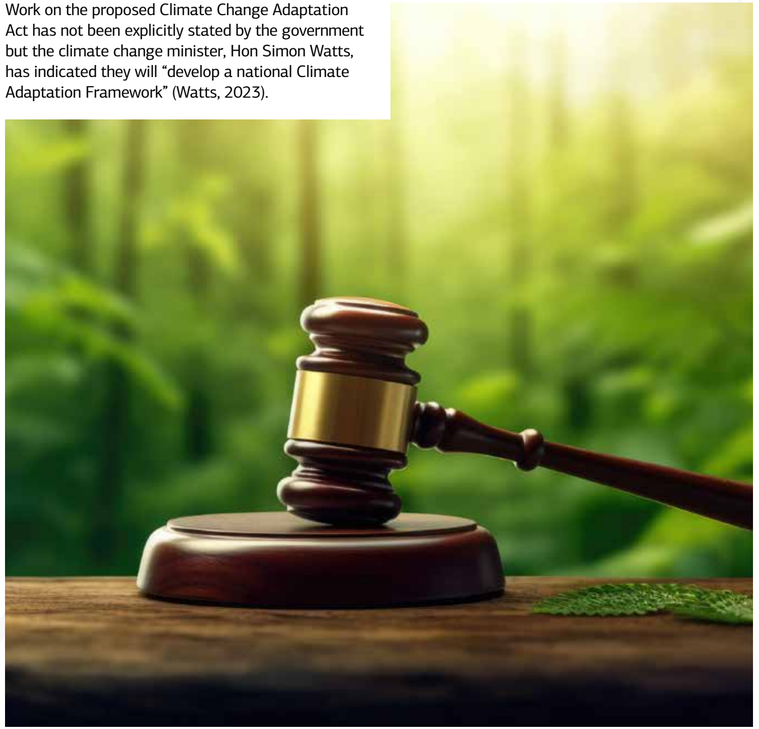
This bill essentially governs the use of resources under the RMA as it did prior to the previously described new Acts being announced. There are few alterations from the RMA 1991, but of significance is the retention of the NBA's fast-track consenting process and the amendments to the National Policy Statement for freshwater Management. The bill remains in force until an alternative resource management system is developed.

The government has signalled that the "fast-track consenting one-stop-shop" is desired to rapidly progress approvals for infrastructure and industry and will feature in the RMA reform (Bishop & Jones, 2024). This would include provisions for regional and national projects of significance (criteria for these is currently undefined).

The other areas where the 2023 bill amends the RMA 1991 are:

- Freshwater consents – the National Policy Statement for Freshwater Management 2020 is currently under review and, rather than notifying freshwater plans by the end of 2024, the Bill provides Councils an extra 3 years allowing for review of the policy statement;
- Requiring authorities – the bill repeals the right for Council Controlled Organisations to have authority for the designation of land for specific planning and consenting purposes (for example, schools or roads);
- Treaty Settlements – expired consent application information (particularly time-bound or expired requirements) will not be provided to Post-Settlement Governance Entities;
- Mana Whakahono ā Rohe – the co-governance tool for tangata whenua and local authorities has been repealed and if any agreements had been initiated, they will need to begin again under the RMA (MfE, 2023a).

Work on the proposed Climate Change Adaptation Act has not been explicitly stated by the government but the climate change minister, Hon Simon Watts, has indicated they will "develop a national Climate Adaptation Framework" (Watts, 2023).



LEGISLATION AND POLICY

Figure 16. Representation of the conservation law reform proposed under the Labour Government (Department of Conservation, 2022)

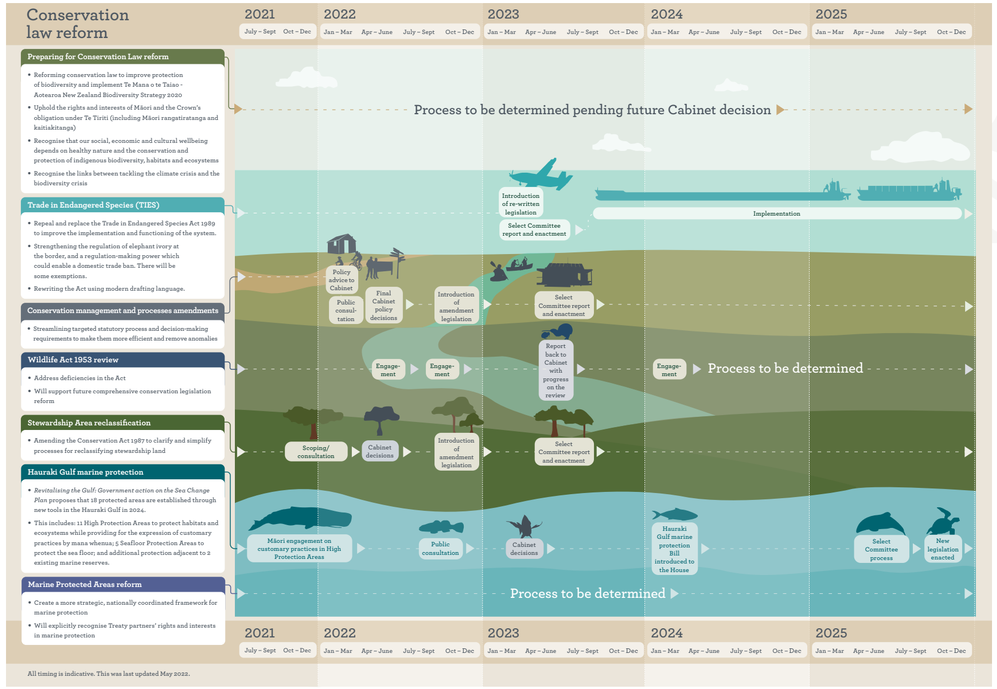


Table 9. Legislation relating to the natural environment but not directly relevant to the Natural Environmental Strategy (adapted from Environment Foundation, 2021).

Legislation	Description	Administered by:
Native Plants Protection Act 1934	Protection of native plants.	DOC
Queen Elizabeth the Second National Trust Act 1977	An Act to *"encourage and promote, for the benefit of New Zealand, the provision, protection, preservation and enhancement of open space"*.	DOC
Wild Animal Control Act 1977	Provides for control of wild, exotic animals and the establishment of recreational hunting areas.	DOC
Trade in Endangered Species Act 1989	Protects and conserves endangered species threatened by trade in addition to restricting their export and import fulfilling obligations under CITES.	DOC
Forests Act 1949	Control of logging, milling and export of indigenous trees and promotion of sustainable forestry.	Ministry for Primary Industries
Biosecurity Act 1993 & GIA Deed 2012	Enables the exclusion, eradication and management of pests and unwanted organisms. The Act was modified to allow for government and industry to work together for positive outcomes. This legislation is being reformed to better reflect the current situation.	MPI
Crown Pastoral Land Act 1998 and The Crown Pastoral Land Reform Act 2022	To ensure sustainable pastoral farming retaining the inherent values (cultural, ecological, landscape, heritage and scientific) of the land.	LINZ
Local Government Act 2002	Provides for local authorities to play a broad role in promoting the social, economic, environmental, and cultural wellbeing of their communities, taking a sustainable development approach. It requires that Long Term and Annual Plans are produced that set out Councils' intended work programmes including funding for biodiversity.	Territorial Authorities

5.2.2 Environmental Legislation

Similar to the RMA, there are at least 24 Acts regarding the conservation of the environment. These are complicated, inconsistent and outdated (Allan, 2021; Department of Conservation, 2023a). Therefore, these Acts are also in the process of being updated and replaced (Figure 16). However, Table 9 shows some of the main pieces of legislation currently applicable.

The most prominent conservation Acts are summarised below.

Wildlife Act 1953

The Wildlife Act is the primary law for governing and protecting threatened animals in Aotearoa New Zealand. It deals with both native and exotic species with most native species being absolutely protected and safeguarded from hunting, killing, harassment, injury or possession of the whole animal or part thereof (eggs, feathers etc). The Act also allows for the creation and management of wildlife sanctuaries, refuges and reserves.

This 70-year-old piece of legislation has gained significant criticism for the lack of an integrated approach to wildlife protection. Wallace & Fluker (2015) cite the quoted shortfalls including a lack of focus on species recovery and management, a disjoint between conservation and resource management, a limited stance on species take and habitat protection, no regard given to the management of predators and the discretionary allowance for taking threatened species. In addition, the Wildlife Act has been criticised for being "inconsistent and alarmingly under-resourced". Due to the age of the legislation,

there is no regard of current or future challenges such as climate change, no regard for mātauranga Māori, kaitiakitanga and rangatiratanga are not provided for and the legislation is not fit for purpose with many protected species still experiencing drastic declines (Department of Conservation, n.d).

The process to review the Wildlife Act is underway starting with exploring the issues. The Department of Conservation aims to engage cultural use practitioners, technical experts and industry/sector representatives to assist and guide the process (Department of Conservation, n.d; Figure 17).

Conservation Act 1987

This piece of legislation was enacted to enable *"the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations"*.

In effect, the Act created the Department of Conservation (DOC), established the Fish & Game Council, New Zealand Conservation Authority, Conservation Boards and Crown-owned conservation areas. The conservation areas comprise land specifically held for conservation objectives. DOC explain the eight categories of conservations areas as (Department of Conservation, 2023):

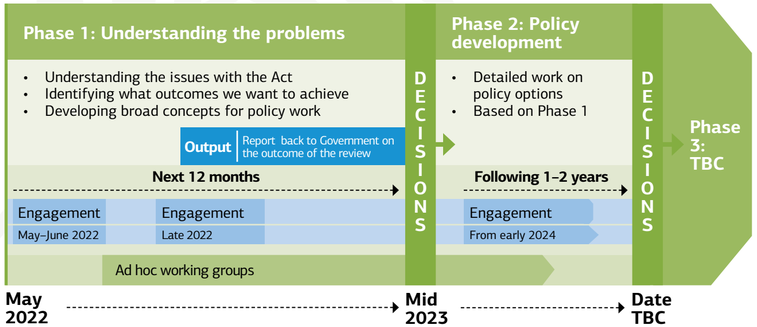
- Conservation parks, managed for their natural and historic resources and to be used by the public for recreation and enjoyment;
- Wilderness areas, managed to protect indigenous biodiversity with any development excluded;
- Ecological areas, managed to protect prescribed values and resources;
- Sanctuary areas, managed to protect natural resources for scientific purposes;
- Watercourse areas, land protected via the Conservation Act, Reserves Act or QEII which is adjacent to inland water also under protection which is managed for conservation and recreation;
- Amenity areas, managed for the natural or historic resources with a focus on public engagement;
- Wildlife management areas, areas managed for biodiversity;
- Marginal strips, land adjacent to the sea, lakes or rivers for maintenance of natural or historic resources and to allow access to the adjacent waters;
- Stewardship areas, maintained for natural and historic values but can be disposed of following full and clear public consultation; and
- Administrative, land used for conservation information centres, office or similar.

In addition to managing land held under the Act, there is also a responsibility to produce management strategies and advocate for nature conservation.

National Parks Act 1980

This Act preserves "in perpetuity as national parks, for their intrinsic worth and for the benefit, use, and enjoyment of the public, areas of Aotearoa New Zealand that contain scenery

Figure 17. Projection of process for reviewing the Wildlife Act 1953 (Department of Conservation, N.D)



of such distinctive quality, ecological systems, or natural features so beautiful, unique, or scientifically important that their preservation is in the national interest". There are 13 National Parks important for tourism and nature conservation.

Reserves Act 1977

This Act was created to define the system around acquiring, protecting and managing areas for conservation, recreation and educational uses. Control and management of the reserve is afforded to the organisation that vested the reserve. Under this Act there are nine categories of reserve as defined by DOC (Department of Conservation, 2023):

- National Reserves with nationally important values;
- Recreation Reserves for physical and aesthetic enjoyment such as recreation and sporting activities;
- Historic Reserves which protect features of historic significance;
- Scenic Reserves protected for their scenic interest, beauty and intrinsic worth;
- Nature Reserves, protected by permits, which protect and preserve indigenous flora, fauna or natural features;
- Scientific Reserves, often protected by permit, to protect and preserve areas for the purpose of education and research;
- Government Purpose Reserves are areas preserved for a particular reason stated by government such as gravel extraction;
- Local Purpose Reserves are areas protected for local reasons; and
- Wilderness Areas maintained in a natural state without manmade features.

5.3 National Policy Documents

5.3.1 National Policy Statement for Indigenous Biodiversity (NPSIB)

National Policy Statements are produced in order to prescribe objectives and policies which allow the purpose of an Act to be achieved. They are not legislative and do not contain rules. However, National Policy Statements must be given effect to and guide the decision-making and development of legislative plans at every level of government to ensure the purpose of the Act is achieved. The District and Regional Plans are required to give effect to a NPS. The NPSIB (2023) relates to the protection, maintenance and enhancement of all indigenous biodiversity. Below is a description of the NPSIB as it stands at time of writing. However, the government has indicated that it will "commence an urgent review into the implementation of the National Policy Statement on Indigenous Biodiversity before any implementation, including implementation of Significant Natural Areas and review the current ones" (Taituarā, 2023).

The NPSIB is based on principles of "the mauri and intrinsic value of indigenous biodiversity", in addition to the interconnectedness to people and wellbeing. It comprises seven elements:

(a) prioritise the mauri, intrinsic value and wellbeing of indigenous biodiversity;

(b) take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi);

(c) recognise the bond between tangata whenua and indigenous biodiversity based on whakapapa relationships;

(d) recognise the obligation and responsibility of care that tangata whenua have as kaitiaki of indigenous biodiversity;

(e) recognise the role of people and communities (including landowners) as stewards of indigenous biodiversity;

(f) enable the application of te ao Māori and mātauranga Māori;

(g) form strong and effective partnerships with tangata whenua.

In order to protect, maintain and enhance indigenous biodiversity, the NPSIB requires the maintenance of biodiversity with no reduction in species population size; species occupancy across their natural range; properties and functions of ecosystems; full range and extent of habitats and ecosystems; connectivity and buffering; and resilience and adaptability of ecosystems. It describes the Effects Management Hierarchy that should be applied when assessing adverse effects to biodiversity as a top-down approach; from avoiding the adverse effects to the activity not being permitted where mitigation or compensation is not adequate (see section 4.6 of this report).

It requires consistent identification of significant natural areas (SNAs) whilst allowing existing land uses that do not further deteriorate those

biodiverse or important natural resources. It discusses targets for indigenous land cover of at least 10% in urban areas and requires regional council to create or update regional biodiversity strategies whilst also monitoring and managing highly mobile fauna.

5.3.2 Aotearoa New Zealand Biodiversity Strategy

Released in 2020 and named Te Mana o te Taiao, this document presents a framework for biodiversity management in Aotearoa New Zealand (Department for Conservation, 2020). The underpinning concept is "te mauri hikahika o te taiao" which purports that nature is vibrant and vigorous with people perceived as part of nature: "we can only thrive when nature thrives". The document outlines five outcomes:

- Ecosystems from mountain tops to ocean depths are thriving;
- Indigenous species and their habitats across the country and beyond are thriving;
- People's lives are enriched through their connection with nature;
- Treaty partners and tangata whenua are exercising their full role as Rangatira and kaitiaki; and
- Prosperity is intrinsically linked with thriving biodiversity.

These are achieved by three pou/pillars which are "getting the system right", empowering people and addressing the direct pressures (Figure 18). The timelines for the outcomes to be achieved are 2025, 2030 and 2050.

5.3.3 Implementation Plan

The Implementation Plan outlines the steps that can be taken to implement the Aotearoa New Zealand Biodiversity Strategy over the next 30 years. The document has been described as a "living document" and will be updated every five years to report on progress to date and ensure it aligns with the future goals. It outlines action required to achieve the outcomes noting the lead agency and the expected timeframe.

5.3.4 National Policy Statement for Freshwater Management and National Environmental Standards for Freshwater

Although not directly dealt with in the Natural Environment Strategy, freshwater regulations requires acknowledgement due to the interface between land and water.

National Environmental Standards are regulations which set standards for resources (MfE, 2021). The NES freshwater (NESF) came into force in 2020 to address the protection of natural wetlands and urban and rural streams and rivers, to provide for fish passage, and address agricultural intensification and excessive nutrient use on land which has a detrimental effect on the freshwater systems.

In conjunction with the NESF, Te Mana o te Wai (the National Policy Statement for Freshwater Management (NPS-FM)) was gazetted in 2020, then updated in 2023 (MfE, 2022c). Applying to both freshwater and groundwater, importantly, it outlined a hierarchy of water priorities. These were firstly the health and wellbeing of water bodies and freshwater ecosystems, followed by the health needs of people, and lastly the ability for people and communities to provide for social, economic and cultural wellbeing.

The policy is intended to be given effect to via Regional and Local District Plans to stymie the loss and deterioration of wetlands and river values, to improve fish passage, to ensure Māori freshwater values are identified and acted upon, to take a "whole catchment" perspective, species and habitats are protected, water use is monitored and used efficiently. There are also targets for freshwater to be suitable for primary contact with regard to 80% by 2030 and 90% by 2040 and this is monitored whilst enabling communities to be involved with the protection and enhancement of freshwater environments. Importantly, both pieces of policy are to be reviewed and replaced by central government as outlined in the coalition agreement (Tu, 2023). It is hoped that the replacement will:

- "rebalance Te Mana o te Wai to better reflect the interests of all water users.
- Allow district councils more flexibility in how they meet environmental limits and seek advice on how to exempt councils from obligations as soon as practicable" (Taituarā, 2023).

5.4 Regional and District Plans

Central Government can set National Environmental Standards and National Policy Statements which can direct the work and focus of regional and local councils. Regional plans can set direction for an entire region. For Canterbury these include the Canterbury Land and Water Regional Plan, Canterbury Air Regional Plan and Coastal Environment Regional Plan. Non-mandatory, regional strategies also influence environmental outcomes. These include the Canterbury Biodiversity Strategy (ECan, 2008) and the draft Canterbury Climate Action Plan. District Plans primarily manage land use activities and subdivision.

Figure 18. Pictorial representation of the Aotearoa New Zealand Biodiversity Strategy.

LEGISLATION AND POLICY

References

Albrecht, J., Peters, M. K., Becker, J. N., Behler, C., Classen, A., Ensslin, A., ... & Schleuning, M. (2021). Species richness is more important for ecosystem functioning than species turnover along an elevational gradient. Nature ecology & evolution, 5(12), 1582-1593.

Alexandri, E., & Jones, P. (2006, September). Ponds, Green Roofs, pergolas and high albedo materials; which cooling technique for urban spaces. In proceedings of the 23rd Conference of Passive and Low Energy Architecture, Geneva, Switzerland. Alley, M. R., & Gartrell, B. D. (2019). Wildlife diseases in New Zealand: recent findings and future challenges. New Zealand veterinary journal, 67(1), 1-11.

Allan, K. (2021). Modernising conservation law to better reflect today's thinking. Retrieved from beehive.govt.nz/release/modernising-conservation-law-better-reflect-today%E2%80%99s-thinking February, 2023.

AMSI, (2023). Will halo's be the saviour of Australia's endangered mammals? Retrieved from vrs.amsi.org.au/halos-saviour-australias-endangered-mammals/, April, 2023.

Atkins, J., & Macpherson, M. (2022). Introduction: Why Are Species Extinction and Biodiversity Collapse Relevant to the Financial Markets, Accounting and Governance?. In Extinction Governance, Finance and Accounting (pp. 1-10). Routledge.

Atkinson, I.A.E. (2001) Introduced mammals and models for restoration. Biol. Conserv. 99, 81–96

Atkinson, J. (2016). The political role of television in New Zealand. Politics and the Media, 273-291.

Ausseil, A. G. E., Dymond, J. R., & Weeks, E. S. (2011). Provision of natural habitat for biodiversity: quantifying recent trends in New Zealand. Biodiversity loss in a changing planet, 201-220.

Ausseil, A. G. E., Kirschbaum, M. U., Andrew, R. M., McNeill, S., Dymond, J. R., Carswell, F., & Mason, N. W. (2013). Climate regulation in New Zealand: contribution of natural and managed ecosystems. Ecosystem services in New Zealand–conditions and trends, 386-399.

Babe, J., Thompson, H., Mcalister, W. H., & Mcintosh, P. (n.d.) The Forces that Shape the Upper Waimakariri Catchment. Retrieved from: canterbury.ac.nz/media/documents/oexp-science/geography/community-engagement/geog-309/2022/The-Forces-that-Shape-the-Upper-Waimakariri-Catchment.pdf February, 2023.

Bargaz, A., Lyamlouli, K., Chtouki, M., Zeroual, Y., & Dhiba, D. (2018). Soil microbial resources for improving fertilizers efficiency in an integrated plant nutrient management system. Frontiers in microbiology, 9, 1606.

Barnes, A. M., Wratten, S. D., & Sandhu, H. S. (2008). Harnessing biodiversity to improve vineyard sustainability. In Organic Fruit Conference 873 (pp. 67-74).

Bellingham, P.J., Arnst, E.A., Clarkson, B.D. *et al.,* (2023). The right tree in the right place? A major economic tree species poses major ecological threats. Biol Invasions 25, 39–60. doi.org/10.1007/s10530-022-02892-6

Bender, D. J., Contreras, T. A., & Fahrig, L. (1998). Habitat loss and population decline: a meta-analysis of the patch size effect. Ecology, 79(2), 517-533.

Beninde, J., Veith, M., & Hochkirch, A. (2015). Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. Ecology letters, 18(6), 581-592.

Bennett, A. F., Haslem, A., Cheal, D. C., Clarke, M. F., Jones, R. N., Koehn, J. D., ... & Yen, A. L. (2009). Ecological processes: a key element in strategies for nature conservation. Ecological Management & Restoration, 10(3), 192-199.

Bennett, N. J., Di Franco, A., Calò, A., Nethery, E., Niccolini, F., Milazzo, M., & Guidetti, P. (2019). Local support for conservation is associated with perceptions of good governance, social impacts, and ecological effectiveness. Conservation letters, 12(4), e12640.

Beier, P., & Noss, R. F. (1998). Do habitat corridors provide connectivity? Conservation Biology, 12(6), 1241-1252.

Berkes, F., Colding, J., Folke,. (2000). Rediscovery of traditional ecological knowledge as adaptive management. Ecological applications 10(5): 1251–1262.

Bezombes, L. (2017). Development of a methodological framework to assess ecological equivalence: application in the context of the mitigation hierarchy in France. AGRIS

Biosecurity Act 1993. legislation.govt.nz/act/public/1993/0095/latest/DLM314623.html

Bishop, C., Jones, S. (2024) Fast track consenting in the fast lane. Retrieved February 2024 from: beehive.govt.nz/release/fast-track-consenting-fast-lane

Boffa Miskel (2010) Canterbury Regional Landscape Study Review. Boffa Miskel, Christchurch.

Boscolo, D., & Paul Metzger, J. (2011). Isolation determines patterns of species presence in highly fragmented landscapes. Ecography, 34(6), 1018-1029.

Broadbent, A., Sood, A., Stuart, S., Macara, G., Zammit, C. (2022) Waimakariri District Climate Change Scenario: Technical Report. NIWA Taihoro Nukurangi, Wellington.

Brown, M.A., *et al. (2015).* Vanishing nature: facing New Zealand's biodiversity crisis. Environmental Defence Society Incorporated.

Brudvig, L. A., Damschen, E. I., Tewksbury, J. J., Haddad, N. M., & Levey, D. J. (2009). Landscape connectivity promotes plant biodiversity spillover into non-target habitats. Proceedings of the National Academy of Sciences, 106(23), 9328-9332.

Brundrett, M. (2004). Diversity and classification of mycorrhizal associations. Biological reviews, 79(3), 473-495.

Brundtland, G. H. (1987). Our Common Future World Commission On Environment And Development. Retrieved February 2024 from: un-documents.net/our-common-future.pdf

Bull, J.W.; Gordon, A.; Watson, J.E.M.; Maron, M. (2016) Seeking Convergence on the Key Concepts in 'No Net Loss' Policy. J. Appl. Ecol., 53, 1686–1693

Burge, O. R., Innes, J. G., Fitzgerald, N., Guo, J., Etherington, T. R., & Richardson, S. J. (2021). Assessing the habitat and functional connectivity around fenced ecosanctuaries in New Zealand. Biological Conservation, 253, 108896.

Burgess PJ, Harris J, Graves AR, *et al.,* (2019). Regenerative Agriculture: Identifying the Impact; Enabling the Potential. Report for SYSTEMIQ. Cranfield: Cranfield University.

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., ... & Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59-67.

Ceballos, G., García, A., & Ehrlich, P. R. (2010). The sixth extinction crisis: Loss of animal populations and species. Journal of Cosmology, 8(1821), 31.

Cieraad, E., Walker, S., Price, R. and Barringer, J. (2015). An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments. New Zealand Journal of Ecology 39, 309.

Chakravarthy, K., Charters, F., & Cochrane, T. A. (2019). The impact of urbanisation on New Zealand freshwater quality. Policy Quarterly, 15(3).

REFERENCES

Chapin, F. S., Matson, P. A., Mooney, H. A., & Vitousek, P. M. (2002). Principles of terrestrial ecosystem ecology. Springer-Verlag, New York.

Chaston, T. B., Broome, R. A., Cooper, N., Duck, G., Geromboux, C., Guo, Y., ... & Hanigan, I. C. (2022). Mortality Burden of Heatwaves in Sydney, Australia Is Exacerbated by the Urban Heat Island and Climate Change: Can Tree Cover Help Mitigate the Health Impacts?. Atmosphere, 13(5), 714.

Christchurch City Council (2023) Our Urban Forest Plan for Ōtautahi Christchurch. Christchurch City Council, NZ. Retrieved February 2023 from: ccc.govt.nz/assets/Documents/Consultation/2023/02-February/CUS5882-Urban-Forest-Plan-A4-WEB.pdf

Clarkson, B. (2022). Reversing Biodiversity Decline in Aotearoa New Zealand. Policy Quarterly, 18(2), 61-70.

Clarkson, B. D., & Kirby, C. L. (2016). Ecological restoration in urban environments in New Zealand. Ecological management & restoration, 17(3), 180-190.

Clarkson, B. D., Kirby, C. L., & Wallace, K. J. (2018). Restoration targets for biodiversity depleted environments in New Zealand. Hamilton, New Zealand: Environmental Research Institute Te Pūtahi Rangahau Taiao, The University of Waikato.

Clarkson, B., & McQueen, J. C. (2004). Ecological restoration in Hamilton City, North Island, New Zealand. In Proceedings of the 16th international conference, Society for Ecological Restoration, Victoria.

Clarkson BD, Wehi PM, Brabyn LK. (2007). A spatial analysis of indigenous cover patterns and implications for ecological restoration in urban centres, New Zealand. Urban Ecosystems 10:441–457

Clout, M. (2001). Where protection is not enough: active conservation in New Zealand. Trends in Ecology & Evolution, 16(8), 415-416.

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. IUCN: Gland, Switzerland, 97, 2016-2036.

Conservation Act 1978. legislation.govt.nz/act/public/1987/0065/latest/DLM103610.html

Convention on Biological Diversity (2018) List of parties to the Convention on Biological Diversity. cbd. int/information/parties. shtml (accessed January 2023).

Cooper, R. A., and Millener, P. R. (1993) The New Zealand biota: historical background and new research. Trends in Ecology & Evolution 8, 429-433.

Corlett, GE. (2021) A land divided by climate extremes: what the IPCC report says about New Zealand. The Guardian, UK. Accessed February 2023 from: theguardian.com/world/2021/aug/10/a-land-divided-by-extremes-what-the-ipcc-report-says-about-new-zealand-climate-change

Cowan, P. E., and C. H. Tyndale-Biscoe. (1997). Australian and New Zealand mammal species considered to be pests or problems. Reproduction, Fertility and Development 9:27-36.

Cox DTC, Shanahan DF, Hudson HL, Plummer KE, Siriwardena GM, Fuller RA, Anderson K, Hancock S, Gaston KJ. (2017). Doses of Neighborhood Nature: The Benefits for Mental Health of Living with Nature. BioScience 7:173.

Cristiano, E., Deidda, R., & Viola, F. (2021). The role of green roofs in urban Water-Energy-Food-Ecosystem nexus: A review. Science of the Total Environment, 756, 143876.

Craig, J., Anderson, S., Clout, M., Creese, B., Mitchell, N., Ogden, J., ... & Ussher, G. (2000). Conservation issues in New Zealand. Annual Review of ecology and Systematics, 31(1), 61-78.

Craig, J. L. (2004). Science and sustainable development in New Zealand. Journal of the Royal Society of New Zealand, 34(1), 9-22.

Crown Pastoral Land Act 1998. legislation.govt.nz/act/public/1998/0065/latest/DLM426894.html

Davis, C. M., Head, N., Myers, S. C., & Moore, S. H. (2016). Department of Conservation guidelines for assessing significant ecological values. Publishing Team, Department of Conservation.

Davies-Colley, R. J. (2013). River water quality in New Zealand: an introduction and overview. Ecosystem services in New Zealand: conditions and trends. Manaaki Whenua Press, Lincoln, 432-447.

Department of Conservation (N.D.) Wildlife Act Review Summary Brochure: What is the Wildlife Act and what does it do? Department of Conservation. Retrieved from: doc.govt.nz/globalassets/documents/about-doc/role/legislation/wildlife-act-summary-brochure.pdf May, 2023.

Department of Conservation (2020). Te Mana o Te Taiao - Aotearoa New Zealand Biodiversity Strategy 2020. Department of Conservation, Wellington.

Department of Conservation (2023) Conservation Act 1987. Retrieved from: doc.govt.nz/about-us/our-role/legislation/conservation-act/, February 2023.

Department of Conservation (2023a) Modernising conservation legislation. Retrieved from: doc.govt.nz/about-us/our-role/legislation/conservation-law-reform/, May 2023.

Diamond, J. M., & May, R. M. (1976). Island biogeography and the design of natural reserves. In R. M. May (Ed.), Theoretical Ecology: Principles and Applications (pp. 163-186). Philadelphia, PA: W.B. Saunders.

Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneth, A., ... & Zayas, C. N. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. Science, 366(6471), eaax3100.

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z., *et al.* (2018). Assessing Nature's Contributions to People. Science 359, 270–272. doi:10.1126/science.aap8826

Dick, J., Stephenson, J., Kirikiri, R., Moller, H., & Turner, R. (2012). Listening to the kaitiaki: consequences of the loss of abundance and biodiversity of coastal ecosystems in Aotearoa New Zealand. Mai Journal.

Didham, R. K., Kapos, V., & Ewers, R. M. (2012). Rethinking the conceptual foundations of habitat fragmentation research. Oikos, 121(2), 161-170.

Didham R K, Barker G M, Bartlam S, Deakin E L, Denmead L H, Fisk L M, Peters J M, Tylianakis J M, Wright H R and Schipper L A (2015) Agricultural intensification exacerbates spillover effects on soil biogeochemistry in adjacent forest remnants. PLoS One 10, e0116474.

Divya, C., & Naachimuthu, K. P. (2020). Human nature connection and mental health: What do we know so far?. Indian Journal of Health and Well-being, 11(1-3), 84-92.

Doak, D. F. (1995). Source-sink models and the problem of habitat degradation: general models and applications to the Yellowstone grizzly. Conservation Biology, 9(6), 1370-1379.

Dodson, M., Aitchinson-Earl, P., Scott, L. (2012) Ashley-Waimakariri groundwater Resources Investigation. Environment Canterbury, Canterbury NZ. Retrieved from: citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=dd36a88afef897fc366ccff74e2602e8c3221d51

Dollery, R. (2017). 'Ecological restoration of dryland kanuka communities in an irrigated agricultural landscape.', PhD thesis. Lincoln University. researcharchive.lincoln.ac.nz/handle/10182/8524

Dollery, R., Bowie, M. H., & Dickinson, N. M. (2022). The ecological importance of moss ground cover in dry shrubland restoration within an irrigated agricultural landscape matrix. Ecology and Evolution, 12(4), e8843.

Doody, B. J., Sullivan, J. J., Meurk, C. D., Stewart, G. H., & Perkins, H. C. (2010). Urban realities: the contribution of residential gardens to the conservation of urban forest remnants. Biodiversity and conservation, 19, 1385-1400.

Duncan, R. P., and T. M. Blackburn. (2004). Extinction and endemism in the New Zealand avifauna. Global Ecology and Biogeography 13:509-517.

Durie, M. (2005). Indigenous knowledge within a global knowledge system. Higher Education Policy, 18(3), 301-312.

EHINZ (2023). Urban-rural profile. Retrieved from ehinz.ac.nz/indicators/population-vulnerability/urbanrural-profile/#:~:text=Most%20people%20live%20in%20main%20urban%20areas,-Most%20New%20Zealanders&text=14.1%25%20lived%20in%20large%20urban,Zealanders%20lived%20in%20rural%20areas. April, 2023.

Ekstrom, J., Bennun, L. & Mitchell, R. (2015) A Cross-Sector Guide for Implementing the Mitigation Hierarchy. Cross Sector Biodiversity Initiative, London, UK.

Environment and Climate Change Canada (2023) Toward a 2030 Biodiversity Strategy for Canada: Halting and Reversing Nature Loss. Environment and Climate Change Canada. Retrieved from: canada.ca/en/services/environment/wildlife-plants-species/biodiversity/2030-biodiversity-strategy-canada.html

Environment Canterbury (2008). A biodiversity strategy for the Canterbury Region. Environment Canterbury. Christchurch, New Zealand.

Environment Canterbury (2016.) Land of National Significance. Retrieved from: ecan.maps.arcgis.com/home/item.html?id=651952dd4c1c448fb17d08aff381ea79. December 2022.

Environment Canterbury (2018). Waimakariri Water Zone Committee: Draft Zone Implementation Programme Addendum. Christchurch, New Zealand.

Environment Canterbury (2018). Canterbury Regional Pest Management Plan: 2018-2038. Retrieved from: ecan.govt.nz/your-region/your-environment/our-natural-environment/pest-management/ May, 2023.

Environment Foundation (2021). Environment Guide: Legislation. Retrieved from: environmentguide.org.nz/issues/biodiversity/im:2506/legislation/ May, 2023.

Erueti, B., Tassell-Matamua, N., Pomare, P., Masters-Awatere, B., Dell, K., Te Rangi, M., & Lindsay, N. (2023). 'Pūrākau o te Ngahere': Indigenous Māori Interpretations, Expressions and Connection to Taonga Species and Biosecurity Issues. Knowledge Cultures, 11(1), 34-54.

Esperon-Rodriguez, M., Rymer, P. D., Power, S. A., Challis, A., Marchin, R. M., & Tjoelker, M. G. (2020). Functional adaptations and trait plasticity of urban trees along a climatic gradient. Urban Forestry & Urban Greening, 54, 126771.

EC—European Commission. (2015) Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities. Final Report of the Horizon2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities; European Commission: Brussels, Belgium.

Ewers, R. M., & Didham, R. K. (2006). Confounding factors in the detection of species responses to habitat fragmentation. Biological reviews, 81(1), 117-142.

Ewers, R. M., Kliskey, A. D., Walker, S., Rutledge, D., Harding, J. S., & Didham, R. K. (2006). Past and future trajectories of forest loss in New Zealand. Biological conservation, 133(3), 312-325.

Felipe-Lucia, M. R., Soliveres, S., Penone, C., Fischer, M., Ammer, C., Boch, S., ... & Allan, E. (2020). Land-use intensity alters networks between biodiversity, ecosystem functions, and services. Proceedings of the National Academy of Sciences, 117(45), 28140-28149.

Fischer, S. (2022). A Review of Current Regional-Level Environmental Monitoring: Reporting and Enforcement in Aotearoa New Zealand. Policy Quarterly, 18(2), 28-35.

Fischer, J., & Lindenmayer, D. B. (2007). Landscape modification and habitat fragmentation: a synthesis. Global ecology and biogeography, 16(3), 265-280.

Fischer, J., Lindenmayer, D.B., Hobbs, R. (2009). Landscape pattern and biodiversity. pp. 431–437. In Levin S. A. (ed.), The Princeton guide to ecology, New Jersey.

Fitzgerald, N., Innes, J., & Mason, N. W. (2019). Pest mammal eradication leads to landscape-scale spillover of tūī (Prosthemadera novaeseelandiae) from a New Zealand mainland biodiversity sanctuary. Notornis, 66, 181-191.

Frantzeskaki, N. (2019) Seven lessons for planning nature-based solutions in cities. Environmental science & policy 93: 101-111.

Freeman, C., Van Heezik, Y., Hand, K., & Stein, A. (2015). Making cities more child-and nature-friendly: A child-focused study of nature connectedness in New Zealand cities. Children, Youth and Environments, 25(2), 176-207.

Forbes, A. S., Wallace, K. J., Buckley, H. L., Case, B. S., Clarkson, B. D., & Norton, D. A. (2020). Restoring mature-phase forest tree species through enrichment planting in New Zealand's lowland landscapes. New Zealand Journal of Ecology, 44(1), 1-9.

Foresight, U. (2011) The future of food and farming. Final Project Report, London, The Government Office for Science.

Forests Act 1949. legislation.govt.nz/act/public/1949/0019/latest/DLM255626.html

Foote, K. J., Joy, M. K., & Death, R. G. (2015). New Zealand dairy farming: milking our environment for all its worth. Environmental management, 56, 709-720.

Fraser, P. L., Ewers, R. M., & Cunningham, S. (2015). The ecological consequences of habitat loss and fragmentation in New Zealand and Australia. Austral Ark: The State of Wildlife in Australia and New Zealand (eds A. Stow, N. Maclean and GI Howell) pp, 45-64.

Fryd, O., Pauleit, S., & Bühler, O. (2012). The role of urban green space and trees in relation to climate change. CABI Reviews, (2011), 1-18.

Ganzevoort, W, van den Born, R, Halffman, W and Turnhout, S. 2017. Sharing biodiversity data: citizen scientists' concerns and motivations. Biodiversity & Conservation, 26(12): 2821–2837. DOI: doi.org/10.1007/s10531-017-1391-z

Gardner, T.A., von Hase, A., Brownlie, S., Ekstrom, J.M.M., Pilgrim, J.D., Savy, C.E. et al. (2013) Biodiversity offsets and the challenge of achieving no net loss. Conservation Biology, 27, 1254–1264.

Garvey, P. M., Glen, A. S., Clout, M. N., Nichols, M., & Pech, R. P. (2022). Niche partitioning in a guild of invasive mammalian predators. Ecological Applications, 32(4), e2566.

Glasson, J., Therivel, R., Chadwick, A. (2013). Introduction to environmental impact assessment. Routledge, Abingdon, UK.

Gonzalez, A., Lawton, J. H., Gilbert, F. S., Blackburn, T. M., & Evans-Freke, I. (1998). Metapopulation dynamics, abundance, and distribution in a microecosystem. Science, 281(5385), 2045-2047.

Gray, D., Scarsbrook, M. R., & Harding, J. S. (2006). Spatial biodiversity patterns in a large New Zealand braided river. New Zealand Journal of Marine and Freshwater Research, 40(4), 631-642.

Gray, K. (2012). The use of rongoā in contemporary physiotherapy: An exploratory study. Auckland, New Zealand: The Health Research Council of New Zealand.

Greater Wellington Regional Council (2020) Managing adverse effects on indigenous biodiversity in the Wellington Region: A guide to implementing the effects management hierarchy in the Natural Resources Plan. Greater Wellington Regional Council, Wellington, NZ.

Grimm, N.B., Faeth, S.H., Golubiewski, N.E., Redman, C.L., Wu, J., Bai, X. *et al.* (2008). Global change and the ecology of cities. Science, 319, 756–760

Groom, M. J., Meffe, G. K., Carroll, C. R., & Andelman, S. J. (2006). Principles of conservation biology (No. Sirsi) i9780878935185). Sunderland: Sinauer associates.

REFERENCES

Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D., ... & Townshend, J. R. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. Science advances, 1(2), e1500052.

Hanski, I. (1998). Metapopulation dynamics. Nature, 396(6706), 41-49.

Harding M, Nature Heritage Fund and New Zealand Department of Conservation-Canterbury Conservancy (2009) Canterbury land protection strategy: a report to the Nature Heritage Fund Committee. Nature Heritage Fund, Wellington [N.Z.].

Hare, K. M., Borrelle, S. B., Buckley, H. L., Collier, K. J., Constantine, R., Perrott, J. K., ... & Towns, D. R. (2019). Intractable: species in New Zealand that continue to decline despite conservation efforts. Journal of the Royal Society of New Zealand, 49(3), 301-319.

Harrington, L. J., & Frame, D. (2022). Extreme heat in New Zealand: a synthesis. Climatic Change, 174(1-2), 2.

Harmsworth, G. (2002). Indigenous concepts, values and knowledge for sustainable development: New Zealand case studies. In 7th Joint Conference on the Preservation of Ancient Cultures and the Globalization Scenario. India (pp. 22-24).

Harmsworth, GR., Awatere, S. (2013). Indigenous Māori knowledge and perspectives of ecosystems. In: Dymond J ed. Ecosystem services in New Zealand—conditions and trends. Lincoln, Manaaki Whenua Press. Pp. 274–286.

Hartig T, Mitchell R, de Vries S, Frumkin H. 2014. Nature and Health. Annu. Rev. Public Health 35:207–28.

Heywood, V. H., & Watson, R. T. (1995). Introduction. In: (ed. V.H. Heywood)Global biodiversity assessment (Vol. 1140). Cambridge University Press, Cambridge.

Head, N., and Given, D. (2001). Threatened plants of Canterbury including a revised species list. Canterbury Botanical Society Journal, 35.

Heaviside, C., Macintyre, H., & Vardoulakis, S. (2017). The urban heat island: implications for health in a changing environment. Current environmental health reports, 4, 296-305.

Helford, R. M. (2000). Constructing nature as constructing science: expertise, activist science and public confl ict in the Chicago wilderness. In: Gobster, P. H.; Hull, R. B. ed. Restoring Nature. Perspectives from the social sciences and humanities. Washington DC, Island Press. Pp. 119–142.

Hill, J. L., and P. J. Curran. (2003) Area, shape and isolation of tropical forest fragments: effects on tree species diversity and implications for conservation. Journal of Biogeography 30:1391-1403.

Hilty, J. A., Keeley, A. T., Merenlender, A. M., & Lidicker Jr, W. Z. (2019). Corridor ecology: linking landscapes for biodiversity conservation and climate adaptation. Island Press. Wasington, US.

Hilty, J. A., Lidicker Jr., W. Z., & Merenlender, A. M. (2006). Corridor Ecology: The Science and Practice of Linking Landscapes for Biodiversity Conservation. Washington, Covelo, London: Island Press.

Hilty, J., Worboys, G. L., Keeley, A., Woodley, S., Lausche, B., Locke, H., ... & Tabor, G. M. (2020). Guidelines for conserving connectivity through ecological networks and corridors. Best practice protected area Guidelines Series, 30, p-122.

Holdaway, R. J., Wiser, S. K., and Williams, P. A. (2012). Status assessment of New Zealand's naturally uncommon ecosystems. Conservation Biology 26, 619-629.

Hooper, D. U., Bignell, D. E., Brown, V. K., Brussard, L., Dangerfield, J. M., Wall, D. H., ... & Wolters, V. (2000). Interactions between Aboveground and Belowground Biodiversity in Terrestrial Ecosystems: Patterns, Mechanisms, and Feedbacks: We assess the evidence for correlation between aboveground and belowground diversity and conclude that a variety of mechanisms could lead to positive, negative, or no relationship—depending on the strength and type of interactions among species. Bioscience, 50(12), 1049-1061.

Hu, W., Cichota, R., Beare, M., Müller, K., Drewry, J., & Eger, A. (2023). Soil structural vulnerability: Critical review and conceptual development. Geoderma, 430, 116346.

Huang, Y., Tian, Z., Ke, Q., Liu, J., Irannezhad, M., Fan, D., ... & Sun, L. (2020). Nature-based solutions for urban pluvial flood risk management. Wiley Interdisciplinary Reviews: Water, 7(3), e1421.

Hudson, M., Whaanga, H., Waiti, J., Maxwell, H., Davis, K., Arahanga, T. A., . . . Taitoko, M. (2020). Visualising Mātauranga Māori for iwi outcomes. New Zealand Science Review., 76(1-2), 42-48.

Hulme, P. E. (2020). Plant invasions in New Zealand: global lessons in prevention, eradication and control. Biological invasions, 22(5), 1539-1562.

Hunt, A., & Watkiss, P. (2011). Climate change impacts and adaptation in cities: a review of the literature. Climatic change, 104(1), 13-49.

Hunter, S. B., zu Ermgassen, S. O. E., Downey, H., Griffiths, R. A., & Howe, C. (2021). Evidence shortfalls in the recommendations and guidance underpinning ecological mitigation for infrastructure developments. Ecological Solutions and Evidence, 2(3), e12089.

Ignatieva, M., Haase, D., Dushkova, D., & Haase, A. (2020). Lawns in cities: from a globalised urban green space phenomenon to sustainable nature-based solutions. Land, 9(3), 73.

Ignatieva, M., Meurk, C. D., Van Roon, M., Simcock, R., & Stewart, G. H. (2008). How to put nature into our neighbourhoods: Application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners. Landcare Research Science Series No.35, Manaaki Whenua Press, Christchurch.

IPCC (ed.) (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Işik, K. (2011). Rare and endemic species: why are they prone to extinction? Turkish Journal of Botany, 35(4), 411-417.

Jolly, D., & Ngā Papatipu Rūnanga Working Group. (2013). Mahaanui Iwi Management Plan. Christchurch., from: mahaanuikurataiao.co.nz/wp-content/uploads/2019/08/Full-Plan.pdf

Joseph, R., Benton, R. (Eds.), (2021). Waking the Taniwha: Māori Governance in the 21st Century. Wellington, Thomson Reuters NZ Ltd

Kaval, P., Yao, R., & Scrimgeour, F. (2009). The economic value of biodiversity in New Zealand: results from a household survey. University of Waikato, Hamilton NZ.

Keegan, L. J., White, R. S., & Macinnis-Ng, C. (2022). Current knowledge and potential impacts of climate change on New Zealand's biological heritage. New Zealand Journal of Ecology, 46(1), 1-24.

Kier G, Kreft H, Lee T M, Jetz W, Ibisch P L, Nowicki C, Mutke J and Barthlott W (2009) A global assessment of endemism and species richness across island and mainland regions. Proceedings of the National Academy of Sciences 106, 9322-9327.

Kiddle, G. L., Pedersen Zari, M., Blaschke, P., Chanse, V., & Kiddle, R. (2021). An Oceania urban design agenda linking ecosystem services, nature-based solutions, traditional ecological knowledge and wellbeing. Sustainability, 13(22), 12660.

Krull, C. R., Galbraith, J. A., Glen, A. S., Nathan, H. W., Stow, A., Maclean, N., & Holwell, G. I. (2015). Invasive vertebrates in Australia and New Zealand. Austral Ark, 680.

Laurance, W. F. (2005) When bigger is better: the need for Amazonian mega-reserves. Trends in Ecology & Evolution 20:645-648

Lawton, J.H. (1999) Are there general laws in ecology? Oikos, 84, 177–192.

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J., & Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra, UK.

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J., & Wynne, G.R. (2020) Making Space for Nature: 10 years on. Retrieved from: nbn.org.uk/wp-content/uploads/2020/09/MakingSpaceforNature_10years_final.pdf

Lee, D. E., Lee, W. G., and Mortimer, N. (2001) Where and why have all the flowers gone? Depletion and turnover in the New Zealand Cenozoic angiosperm flora in relation to palaeogeography and climate. Australian Journal of Botany 49, 341-356.

Lee WG and Lee DE. (2015). New Zealand – a land apart. In: Stow A, Maclean N, and Holwell GI (Eds). Austral ark: the state of wildlife in Australia and New Zealand. Cambridge, UK: Cambridge University Press.

Livingstone, P. G., Hancox, N., Nugent, G., & De Lisle, G. W. (2015). Toward eradication: the effect of Mycobacterium bovis infection in wildlife on the evolution and future direction of bovine tuberculosis management in New Zealand. NZ veterinary journal, 63(sup1), 4-18.

Lin, B. B., Egerer, M. H., & Ossola, A. (2018). Urban gardens as a space to engender biophilia: evidence and ways forward. Frontiers in Built Environment, 4, 79.

Local Government Act 2002. legislation.govt.nz/act/public/2002/0084/latest/DLM170873.html

Louv R. (2005) Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder. Chapel Hill, NC, USA: Algonquin Books of Chapel Hill.

Lyle, J. T. (2008). Ecosystem Management. In: Conservation Biology. Springer, Dordrecht.

Macara, G. (2016) The Climate and Weather of Canterbury: 2nd Edition. In NIWA Science and Technology Series Number 68. NIWA, Canterbury NZ.

Macara, G., John-Mark Woolley, Petra Pearce, Sanjay Wadhwa, Christian Zammit, Abha Sood, Scott Stephens (2020). Climate change projections for the Canterbury Region. NIWA. Wellington, New Zealand.

MacArthur, R. H., & Wilson, E. O. (1963). An equilibrium theory of insular zoogeography. Evolution, 373-387.

Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout, and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications 10:689-710.

Maimaitiyiming, M., Ghulam, A., Tiyip, T., Pla, F., Latorre-Carmona, P., Halik, Ü., ... & Caetano, M. (2014). Effects of green space spatial pattern on land surface temperature: Implications for sustainable urban planning and climate change adaptation. ISPRS Journal of Photogrammetry and Remote Sensing, 89, 59-66.

MacLeod, C. J., Tinkler, G., Gormley, A. M., & Spurr, E. B. (2012). Measuring occupancy for an iconic bird species in urban parks. New Zealand Journal of Ecology, 36(3), 1-10.

Manaaki Whenua – Landcare Research (2023). Garden Bird Survey. Retrieved from: gardenbirdsurvey.nz/, April 2023.

Manaaki Whenua – Landcare research (2023a) Smarter Targeting of Erosion Control (STEC). Retrieved from: landcareresearch.co.nz/discover-our-research/land/erosion-and-sediment/smarter-targeting-of-erosion-control/ May 2023.

Manaaki Whenua – Landcare Research (2022). Threatened Environment Classification in Our Environment. Retrieved April 2023 from: ourenvironment.scinfo.org.nz/maps-and-tools/app/Habitats/lenz_tec

Martin, E. A., Dainese, M., Clough, Y., Báldi, A., Bommarco, R., Gagic, V., ... Steffan-Dewenter, I. (2019). The interplay of landscape composition and configuration: New pathways to manage functional biodiversity and agroecosystem services across Europe. Ecology Letters, 22(7), 1083–1094. doi.org/10.1111/ele.13265

Maron, M., Hobbs, R.J., Moilanen, A., Matthews, J.W., Christie, K., Gardner, T.A., Keith, D.A., Lindenmayer, D.B & McAlpine, C.A. (2012) Faustian bargains? Restoration realities in the context of biodiversity offset policies. Biological Conservation, 155, 141–148.

Maseyk, F. J., Dominati, E. J., & Mackay, A. D. (2019). More than a'nice to have': integrating indigenous biodiversity into agroecosystems in New Zealand. New Zealand Journal of Ecology, 43(2), 1-12.

Maseyk, F. J., Dominati, E. J., Death, R. G., & Mackay, A. D. (2022). Progressing the consideration of indigenous biodiversity in farm planning processes in New Zealand. New Zealand Journal of Agricultural Research, 65(6), 534-546.

Maseyk, F., Ussher, G., Kessels, G., Christensen, M., & Brown, M. (2018). Biodiversity Offsetting under the resource management Act: A guidance document. Prepared for the Biodiversity Working Group on behalf of the BioManagers Group.

McAllister, T., Hikuroa, D., & Macinnis-Ng, C. (2023). Connecting Science to Indigenous Knowledge: kaitiakitanga, conservation, and resource management. New Zealand Journal of Ecology, 47(1), 3521.

McCarthy, M. P., Best, M. J., & Betts, R. A. (2010). Climate change in cities due to global warming and urban effects. Geophysical research letters, 37(9).

McEwan, M., (1987) Ecological regions and districts of New Zealand. Department of Conservation. Wellington, New Zealand.

McGlone, M., Duncan R., and Heenan P., (2001). Endemism, species selection and the origin and distribution of the vascular plant flora of New Zealand. Journal of Biogeography 28, 199-216.

McGuire, A., (2018) Regenerative Agriculture: Solid Principles, Extraordinary Claims. Available at: csanr.wsu.edu/regen-ag-solid-principles-extraordinary-claims/ Retrieved May 2023.

McLure, T., (2023) Cyclone Gabrielle worst storm to hit New Zealand this century, says PM. The Guardian, UK. Accessed February 2023 from: theguardian.com/world/2023/feb/13/cyclone-gabrielle-new-zealand-declares-national-state-of-emergency

McLure, T., Graham-McLay, C. (2023) New Zealand minister decries climate crisis 'lost decades' in wake of Cyclone Gabrielle. The Guardian, UK. Accessed February 2023 from: theguardian.com/world/2023/feb/14/new-zealand-minister-delivers-furious-speech-about-lost-decades-spent-bickering-over-climate-crisis

Merfield CN (2019) An analysis and overview of regenerative agriculture. Report number 2-2019. Lincoln, NZ: The BHU Future Farming Centre.

Meurk C, Bellingham P J and Macmillan B. (1995). The last kānuka landscape on the Canterbury Plains. Canterbury Botanical Society Journal 29, 11-24.

Meurk, C. D., Blaschke, P. M., & Simcock, R. (2013). Ecosystem services in New Zealand cities. Ecosystem services in New Zealand: conditions and trends. Manaaki Whenua Press, Lincoln, 254-273.

Meurk, C. D., & Hall, G. M. (2006). Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. New Zealand journal of ecology, 131-146.

Meurk C. (2008) Vegetation of the Canterbury Plains and downlands. The natural history of Canterbury. University of Canterbury Press, Christchurch, New Zealand, 195-250.

Meurk, C. D., Sullivan, J., & McWilliam, W. (2016). Vegetation history and dynamics in New Zealand: Future scenarios and improved trajectories towards restoring natural patterns. Vegetation structure and function at multiple spatial, temporal and conceptual scales, 517-528.

REFERENCES

Meurk, C. D., Sullivan, J. J., Dawson, M. I., Butt, J., & Shanks, A. (2019) What do we do with the weeds of Canterbury? Emerging biosecurity risks for Canterbury's natural biota and timely responses. Canterbury Botanical Society 50 (38-54)

MfE and Stats NZ (2019) Environment Aotearoa 2015. Ministry for the Environment & Statistics New Zealand: Wellington, New Zealand.

MfE and Stats NZ (2019a) Environment Aotearoa 2019 Glossary. Retrieved February 2024 from: environment.govt.nz/assets/Publications/Files/EA2019-glossary.pdf

MfE (2021). Everyday guide to the Resource Management Act: Understanding national direction. MfE, Wellington, New Zealand.

MfE (2022). National Policy Statement for Indigenous Biodiversity; Exposure Draft. Ministry for the Environment, Wellington, New Zealand.

MfE (2022a). Resource management reform: the Natural and Built Environment Act One of three new laws that will replace the Resource Management Act 1991. Te Kāwanatanga o Aotearoa New Zealand Government, Wellington. Retrieved from: environment.govt.nz/assets/publications/rm-reform-natural-and-built-environment-act.pdf

MfE (2022b). Adapt and thrive: Building a climate resilient New Zealand: Draft national adaptation plan: Managed retreat, New Zealand Government, Wellington

MfE (2022c). Essential freshwater 2022 amendments. Te Kāwanatanga o Aotearoa New Zealand Government, Wellington Retrieved from: environment.govt.nz/news/essential-freshwater-2022-amendments/

MfE (2023). RM reform update - December 2023. Seventeenth edition. Understanding the RMA and how to get involved. Te Kāwanatanga o Aotearoa New Zealand Government, Wellington Retrieved January 2024 from: environment.govt.nz/news/rm-reform-update-december/

MfE (2023a). Changes to resource management. Retrieved February 2024 from: environment.govt.nz/what-government-is-doing/areas-of-work/rma/changes-to-resource-management/

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being: Current State and Trends, Volume 1 (R. Hassan, R. Scholes, & N. Ash Eds.). Washington, United States of America: Island Press.

Miller, C. L. (2003). Measuring quality: the New Zealand experience. Built Environment (1978-), 336-342.

Million, D. (2013). Therapeutic nations: Healing in an age of Indigenous human rights: University of Arizona Press.

Miskelly, C. M. (2018). Changes in the forest bird community of an urban sanctuary in response to pest mammal eradications and endemic bird reintroductions. Notornis, 65(3), 132-151.

Mitchell, M. G., Bennett, E. M., & Gonzalez, A. (2015). Strong and nonlinear effects of fragmentation on ecosystem service provision at multiple scales. Environmental Research Letters, 10(9), 094014.

Mitttermeier R, Gil P, Hoffman M, Pilgrim J, Brooks T, Mittermeier C, Lamoreux J and Da Fonseca G (2005) Hotspots revisited: earth's biologically richest and most endangered terrestrial ecoregions. Washington, DC: Conservation International.

Ministry for the Environment. (2022). Aotearoa New Zealand's first national adaptation plan. Wellington. Ministry for the Environment.

Monaghan, R. M., De Klein, C. A., & Muirhead, R. W. (2008). Prioritisation of farm scale remediation efforts for reducing losses of nutrients and faecal indicator organisms to waterways: A case study of New Zealand dairy farming. Journal of environmental management, 87(4), 609-622.

Morrison, M. A., Lowe, M. L., Parsons, D. M., Usmar, N. R., & McLeod, I. M. (2009). A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. New Zealand aquatic environment and biodiversity Report, 37, 100.

Morse, H. (2022). Modelling Endemic and Invasive Species' Biodiversity Corridors in the Southern North Island of Aotearoa New Zealand (Doctoral dissertation, Open Access Te Herenga Waka-Victoria University of Wellington).

Morton, G. (2023) Hotter than Northland: West Coast's 'exceptional' marine heatwave breaks records. NZ Herald, NZ. Accessed February 2023 from: nzherald.co.nz/nz/hotter-than-northland-west-coasts-exceptional-marine-heatwave-breaks-records/GHI3J7Q66RHTLIGAA67P2DBH6U/

Muller, N., Werner, P., & Kelcey, J. G. (Eds.). (2010). Urban biodiversity and design. John Wiley & Sons.

Müller, N., Ignatieva, M., Nilon, C. H., Werner, P., & Zipperer, W. C. (2013). Patterns and trends in urban biodiversity and landscape design. Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment, 123-174.

National Parks Act 1980. legislation.govt.nz/act/public/1980/0066/latest/whole.html

National Party (2023). National's 100 day Action Plan. Retrieved February 2024 from: assets.nationbuilder.com/nationalparty/pages/18431/attachments/original/1696107664/100_Day_Action_Plan.pdf?1696107664

National Policy Statement for Freshwater Management 2020. Retrieved from: environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020-amended-january-2024/#:~:text=The%20National%20Policy%20Statement%20for,Management%202014%20(amended%202017).

Native Plants Protection Act 1934. legislation.govt.nz/act/public/1934/0015/latest/whole.html

National Policy Statement for Indigenous Biodiversity, 2023. Retrieved from environment.govt.nz/assets/publications/biodiversity/National-Policy-Statement-for-Indigenous-Biodiversity.pdf

Natural and Built Environment Act 2023. legislation.govt.nz/act/public/2023/0046/latest/LMS501892.html

Nemogá, Gabriel R., Amanda Appasamy, and Cora A. Romanow. (2022). Protecting Indigenous and Local Knowledge Through a Biocultural Diversity Framework. The Journal of Environment & Development 31.3, 223-252.

Neuman, W. L. (2011). Social research methods: Qualitative and quantitative approaches (7th ed). Boston, MA: Pearson Education.

New Zealand Parliament Pāremata Aotearoa (2023). RMA reform at select committee stage. Retrieved from parliament.nz/en/pb/sc/select-committee-news-archive/rma-reform-at-select-committee-stage/#:~:text=The%20Natural%20and%20Built%20Environment%20Bill%20aims%20to%20set%20out,primary%20replacement%20for%20the%20RMA. May, 2023.

Niemiec, R., Berl, R. E., Gonzalez, M., Teel, T., Salerno, J., Breck, S., ... & Crooks, K. (2022). Rapid changes in public perception toward a conservation initiative. Conservation Science and Practice, 4(4), e12632.

Nienhuis, P.H. (2009). The Natural Environment. In: Boersema, J.J., Reijnders, L. (eds) Principles of Environmental Sciences. Springer, Dordrecht. doi.org/10.1007/978-1-4020-9158-2_10

Ngāi Tahu Claims Settlement Act 1998 legislation.govt.nz/act/public/1998/0097/latest/DLM429090.html

Nguyen, T. T., Meurk, C., Benavidez, R., Jackson, B., & Pahlow, M. (2021). The effect of blue-green infrastructure on habitat connectivity and biodiversity: a case study in the Ōtākaro/Avon River catchment in Christchurch, New Zealand. Sustainability, 13(12), 6732.

Nimmo-Bell (2021) Economic costs of pests to New Zealand. Ministry of Agriculture and Forestry Biosecurity New Zealand Technical Paper no. 2009/31

Norton D. A. (1988) Managing for the long term. Forest & Bird 19(2), 32–34

Norton, D. A., Butt, J., & Bergin, D. O. (2018). Upscaling restoration of native biodiversity: A New Zealand perspective. Ecological Management & Restoration, 19, 26-35.

Norton, D. A., Suryaningrum, F., Buckley, H. L., Case, B. S., Cochrane, C. H., Forbes, A. S., & Harcombe, M. (2020). Achieving win-win outcomes for pastoral farming and biodiversity conservation in New Zealand. New Zealand Journal of Ecology, 44(2), 1-9.

Norton, D. A., Young, L. M., Byrom, A. E., Clarkson, B. D., Lyver, P. O. B., McGlone, M. S., & Waipara, N. W. (2016). How do we restore New Zealand's biological heritage by 2050?. Ecological management & restoration, 17(3), 170-179.

Noss, R. F., & Cooperrider, A. Y. (1994). Saving Nature's Legacy: Protecting and Restoring Biodiversity. Washington D.C., & Covelo, California: Island Press.

Ondiviela, B., Losada, I. J., Lara, J. L., Maza, M., Galván, C., Bouma, T. J., *et al.* (2014). The role of seagrasses in coastal protection in a changing climate. Coast. Eng. 87, 158–168. doi: 10.1016/j.coastaleng.2013.11.005

Orchard, S., & Schiel, D. R. (2021). Enabling nature-based solutions for climate change on a peri-urban sandspit in Christchurch, New Zealand. Regional Environmental Change, 21(3), 66.

Owens, B. (2017). The big cull. Nature, 541(7636), 148-150.

Overdyck, E., & Clarkson, B. D. (2012). Seed rain and soil seed banks limit native regeneration within urban forest restoration plantings in Hamilton City, New Zealand. New Zealand Journal of Ecology, 177-190.

Palmer, G., & Clarke, R. (2022). A new Natural Environment Act is Needed-Now. Policy Quarterly, 18(2), 3-9.

Palmerston North City Council (2023). Green Corridors. Retrieved from: pncc.govt.nz/Community/Community-projects-and-programmes/Green-Corridors. April, 2023

Parkes JP, Nugent G, Forsyth DM, Byrom AE, Pech RP, Warburton B, Choquenot D. (2017). Past, present and two potential futures for managing New Zealand's mammalian pests. New Zealand Journal of Ecology. 41:151–161.

Pascual, U., Adams, W. M., Díaz, S., Lele, S., Mace, G. M., & Turnhout, E. (2021). Biodiversity and the challenge of pluralism. Nature Sustainability, 4(7), 567-572.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., *et al.* (2017). Valuing Nature's Contributions to People: the IPBES Approach. Curr. Opin. Environ. Sustainability 26-27, 7–16. doi:10.1016/j.cosust.2016.12.006

Pearson, S. (2008). The Conservation of Habitat and Landscape. In: Conservation Biology. Springer, Dordrecht.

Pedersen Zari, M., MacKinnon, M., Varshney, K., & Bakshi, N. (2022). Regenerative living cities and the urban climate–biodiversity–wellbeing nexus. Nature Climate Change, 12(7), 601-604.

Pereira, L., Davies, K, den Belder, E, Ferrier, S, Karlsson-Vinkhuyzen, S, Hyejin, K, Kuiper, J, Okayasu, S, Palomo, M, Pereira, H, Peterson, G, Sathyapalan, J, Schoolenberg, M, Alkemade, R, Ribeiro, S, Greenaway, A, Hauck, J, King, N, Lazarova, T, Ravera, F, Chettri, N, Cheung, W, Hendriks, R, Kolomytsev, G, Leadley, P, Metzger, J-P, Ninan, K, Pichs, R, Popp, A, Rondinini, C, Rosa, I, van Vuuren, D and Lundquist, C. (2020). Developing multiscale and integrative nature–people scenarios using the Nature Futures Framework. People and Nature, 2(4): 1172–1195. DOI: doi.org/10.1002/pan3.10146

Peters, M. A., Hamilton, D., & Eames, C. (2015). Action on the ground: a review of community environmental groups' restoration objectives, activities and partnerships in New Zealand. New Zealand Journal of Ecology, 39(2), 179-189.

Phalan, B., Hayes, G., Brooks, S., Marsh, D., Howard, P., Costelloe, B., ... & Whitaker, S. (2018). Avoiding impacts on biodiversity through strengthening the first stage of the mitigation hierarchy. Oryx, 52(2), 316-324.

REFERENCES

Picuno, P., Sica, C., Dimitrijevic, A., Tortora, A., Capobianco, R.L., Statuto, D. (2015). New Technologies for the Sustainable Management and Planning of Rural Land and Environment. In: Vastola, A. (eds) The Sustainability of Agro-Food and Natural Resource Systems in the Mediterranean Basin. Springer, Cham.

Pollinator Paths. (2021). A Path to a Better Future. Retrieved from: pollinatorpaths.com/ April, 2023.

Predator Free Wellington. (2023) Our Project. Retrieved from: pfw.org.nz/our-project/

Prieur, J. (2020). Critical warning! Preventing the multidimensional apocalypse on planet Earth. Ecosystem services, 45, 101161.

QEII National Trust. (2008). Magazine of the Queen Elizabeth II National Trust, 72.

Queen Elizabeth the second National Trust Act 1977. legislation.govt.nz/act/public/1977/0102/latest/DLM8801.html

Radford, J., Bennett, A. F., & MacRaild, L. (2004). How much habitat is enough? Planning for wildlife conservation in rural landscapes (pp. 8). Melbourne: Deakin University.

Raihan, A., & Tuspekova, A. (2023). Towards net zero emissions by 2050: the role of renewable energy, technological innovations, and forests in New Zealand. Journal of Environmental Science and Economics, 2(1), 1-16.

Randerson, T., and Resource Management Review Panel (2020). New Directions for Resource Management in New Zealand. Resource Management Review Panel, Wellington.

Rayne, A., Byrnes, G., Collier-Robinson, L., Hollows, J., McIntosh, A., Ramsden, M., ... & Steeves, T. (2020). Centring Indigenous knowledge systems to re-imagine conservation translocations.

Razzaghmanesh, M., Beecham, S., & Salemi, T. (2016). The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia. Urban Forestry & Urban Greening, 15, 89-102.

Reserves Act 1977. legislation.govt.nz/act/public/1977/0066/latest/DLM444305.html

Resource Management Act 1991. legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html

Resource Management (Natural and Built Environment and Spatial Planning Repeal and Interim Fast-track Consenting) Bill. legislation.govt.nz/bill/government/2023/0008/latest/d162906e2.html

Richardson, M, Passmore, H, Barbett, L, Lumber, R, Thomas, R and Hunt, R. 2020. The green care code: How nature connectedness and simple activities help explain pro-nature conservation behaviours. People and Nature, 2(3): 821–839. DOI: doi.org/10.1002/pan3.10117

Ricklefs, R., Naveh, Z. & Turner, R. (1984) Conservation of ecological processes, IUCN: International Union for Conservation of Nature. The Environmentalist, Volume 4, Supplement 8.

Rodríguez-Rodríguez, D., & Martínez-Vega, J. (2022). Human Impact on the Biosphere: A Contemporary Ecocide. In Effectiveness of Protected Areas in Conserving Biodiversity: A Worldwide Review (pp. 1-10). Cham: Springer International Publishing.

Rogers, G. M., Courtney, S. P., & Heenan, P. B. (2018). The calcicolous vascular flora of New Zealand. Science for Conservation Report (331), Department of Conservation, Wellington, New Zealand.

Roper-Lindsay, J., Fuller S.A., Hooson, S., Sanders, M.D., Ussher, G.T. (2018). Ecological impact assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.

Ruru, J., O'Lyver, P. B., Scott, N., & Edmunds, D. (2017). Reversing the decline in New Zealand's biodiversity: empowering Māori within reformed conservation law. Policy Quarterly, 13(2).

Russell, J. C., Innes, J. G., Brown, P. H., & Byrom, A. E. (2015). Predator-free New Zealand: conservation country. BioScience, 65(5), 520-525.

Salata, F., Golasi, I., de Lieto Vollaro, A., & de Lieto Vollaro, R. (2015). How high albedo and traditional buildings' materials and vegetation affect the quality of urban microclimate. A case study. Energy and Buildings, 99, 32-49.

Sandbrook, C., Gómez-Baggethun, E., & Adams, W. M. (2022). Biodiversity conservation in a post-COVID-19 economy. Oryx, 56(2), 277-283.

Saunders, A., Towns, D., Broome, K., Horn, S., Neureuter, S., Conomos, K., ... & Bryant, S. (2021). Social dimensions in island restoration: some case studies from Aotearoa–New Zealand. Pacific Conservation Biology.

Scarsbrook, M. R., Barquín, J., & Gray, D. P. (2007). New Zealand coldwater springs and their biodiversity (Vol. 278). Wellington: Department of Conservation.

Seabrook-Davidson, M. N., & Brunton, D. H. (2014). Public attitude towards conservation in New Zealand and awareness of threatened species. Pacific Conservation Biology, 20(3), 286-295.

Seddon, N., Turner, B., Berry, P., Chausson, A., & Girardin, C. A. J. (2019). Grounding nature-based climate solutions in sound biodiversity science. Nature Climate Change, 9, 84–87. doi.org/10.1038/s41558-019-0405-0

Shahmohamadi, P., Che-Ani, A. I., Etessam, I., Maulud, K. N. A., & Tawil, N. M. (2011). Healthy environment: the need to mitigate urban heat island effects on human health. Procedia Engineering, 20, 61-70.

Sills, M. J., & Carrow, R. N. (1983). Turfgrass Growth, N Use, and Water Use under Soil Compaction and N Fertilization 1. Agronomy Journal, 75(3), 488-492.

Soulé, M. E., & Terborgh, J. (Eds.). (1999). Continental Conservation: Scientific Foundations of Regional Reserve Networks. Washington D.C. & Covelo, California: Island Press.

Sparrow, M (2015) Canterbury Water Management Strategy: Waimakariri Zone Socio-Economic Profile. Environment Canterbury and Waimakariri District Council.

Sparrow, M., Taylor, N. (2019) Waimakariri Land and Water Solutions Programme: Options and Solutions Assessment. Technical Report to Environment Canterbury.

Spatial Planning Act 2023. legislation.govt.nz/act/public/2023/0047/latest/LMS545761.html

Standish, R. J., Robertson, A. W., & Williams, P. A. (2001). The impact of an invasive weed Tradescantia fluminensis on native forest regeneration. Journal of Applied Ecology, 38(6), 1253-1263.

Stats NZ Tatauranga Aotearoa (2021). Agricultural and horticultural land use. Retrieved from: stats.govt.nz/indicators/agricultural-and-horticultural-land-use

Stats NZ Tatauranga Aotearoa (2021a). New Report Shows Impact of Demands on Land in New Zealand. Retrieved from: stats.govt.nz/news/new-report-shows-impact-of-demands-on-land-in-new-zealand/

Stats NZ Tatauranga Aotearoa, (2023). Waimakariri District. Retrieved from: stats.govt.nz/tools/2018-census-place-summaries/waimakariri-district#more-data-and-information

Stein, A., Gerstner, K., & Kreft, H. (2014). Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. Ecology letters, 17(7), 866-880.

Stewart, G. H., Ignatieva, M. E., Meurk, C. D., Buckley, H., Horne, B., & Braddick, T. (2009). Urban biotopes of Aoteroa New Zealand (URBANZ) (I): Composition and diversity of temperate urban lawns in Christchurch. Urban Ecosystems, 12, 233–248

Stewart, G. H., Ignatieva, M. E., & Meurk, C. D. (2010). Multivariate approaches to the study of urban biodiversity and vegetation: An example from a southern temperate colonial city, Christchurch, New Zealand. In N. Müller, P. Werner, & J. Kelcey (Eds.), Urban biodiversity & design (pp. 291–307). Hoboken: Wiley-Blackwell.

Stronge, D. C., Greenaway, A., Kannemeyer, R. L., & Howard, C. (2023). Reframing well-being: Lessons from Aotearoa New Zealand's first wave COVID-19 response. Asia Pacific Viewpoint.

Sullivan, J. J., Meurk, C., Whaley, K. J., & Simcock, R. (2009). Restoring native ecosystems in urban Auckland: urban soils, isolation, and weeds as impediments to forest establishment. New Zealand Journal of Ecology, 60-71.

Taormina, B. (2019). Potential impacts of submarine power cables from marine renewable energy projects on benthic communities (Doctoral dissertation, Brest).

Taituarā (2023). Incoming Government Coalition Agreements. Taituarā, Wellington, NZ.

Tapper, N. J., Tyson, P. D., Owens, I. F., & Hastie, W. J. (1981). Modeling the winter urban heat island over Christchurch, New Zealand. Journal of Applied Meteorology and Climatology, 20(4), 365-376.

Te Ahukaramū Charles Royal. (2005). Māori-Pre-European society. Te Ara-the Encyclopaedia of New Zealand.

Te Ara Kakariki (2023) Greendots. Accessed February 2023 from: kakariki.org.nz/greendots/

Te Rūnanaga o Ngāi Tahu. (2024). Ngāi Tūāhuriri. Retrieved January 2024 from: ngaitahu.iwi.nz/ngai-tahu/papatipu-runanga/ngai-tuahuriri/

ten Kate K, Bishop J, Bayon R (2004) Biodiversity offsets: views, experience and the business case. IUCN, Gland, Switzerland and Insight Investment, London, UK

Timoti, P., Lyver, P. O. B., Matamua, R., Jones, C. J., & Tahi, B. L. (2017). A representation of a Tuawhenua worldview guides environmental conservation. Ecology and Society, 22(4).

Tischendorf, L., Grez, A., Zaviezo, T., & Fahrig, L. (2005). Mechanisms affecting population density in fragmented habitat. Ecology and Society, 10(1).

Townsend, A. J., de Lange, P. J., Duffy, C. A., Miskelly, C. M., Molloy, J., & Norton, D. A. (2008). New Zealand threat classification system manual. Department of Conservation, Wellington, 16, 2008-11.

Trade in Endangered Species Act 1989. legislation.govt.nz/act/public/1989/0018/latest/DLM145966.html

Treweek, J., & Thompson, S. (1997). A review of ecological mitigation measures in UK environmental statements with respect to sustainable development. The International Journal of Sustainable Development & World Ecology, 4(1), 40-50.

Trussell, P., Brandt, A., & Knapp, S. (1981). Science as a way of knowing. Journal of Nursing Administration, 37-40.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2005). Landscape perspectives on agricultural intensification and biodiversity–ecosystem service management. Ecology letters, 8(8), 857-874.

UNESCO (2021). Local and Indigenous Knowledge Systems (LINKS). Retrieved January 2024 from: en.unesco.org/links#:~:text=Local%20and%20indigenous%20knowledge%20refers,day%2Dto%2Dday%20life

van der Plas, F. (2019). Biodiversity and ecosystem functioning in naturally assembled communities. Biological Reviews, doi.org/10.1111/brv.12499

von Hase, A., & ten Kate, K. (2017). Correct framing of biodiversity offsets and conservation: A response to Apostolopoulou & Adams. Oryx, 51, 32–34. doi:10.1017/S0030605316001022

Walker S, Price R, Rutledge D, Stephens R T T and Lee W G. (2006). Recent loss of indigenous cover in New Zealand. New Zealand Journal of Ecology 30, 169-177.

Walker, S., Bellingham, P. J., Kaine, G., Richardson, S., Greenhalgh, S., Simcock, R., ... & Lee, W. G. (2021). What effects must be avoided, remediated or mitigated to maintain indigenous biodiversity?. New Zealand Journal of Ecology, 45(2), 1-12.

Wardle, P. (1991) Vegetation of New Zealand. Cambridge University Press, UK.

Waimakariri District Council (2015). Neighbourhood Reserves Management Plan 2015. Retrieved February 2024 from: waimakariri.govt.nz/__data/assets/pdf_file/0026/14759/WaimakaririDistrictCouncilNeighburhoodReservesManagementPlanFebruary2015.pdf

Waimakariri District Council (2021) 2018 Waimakariri District Profile. Waimakariri District Council, Canterbury NZ.

Waimakariri District Council (2021). Partnering for Environmental Action: Notes from the Natural Environmental Forum. Waimakariri District Council, Rangiora.

Waimakariri District Council (2023) Proposed Waimakariri District Plan. Retrieved February 2024 from: waimakariri.isoplan.co.nz/draft/0/226#

Waimakariri Water Zone Committee. (2018). Zone Implementation Programme Addendum. Waimakariri Water Zone Committee.

Waimakariri Zone Committee (n.d.) Waimakariri Zone Implementation Programme. Environment Canterbury, Christchurch.

Wallace, P. (2015). The reduced effect of international conservation agreements: A New Zealand case study. Journal of Environmental Law, 27(3), 489-516.

Wallace, K. J., & Clarkson, B. D. (2019). Urban forest restoration ecology: a review from Hamilton, New Zealand. Journal of the Royal Society of New Zealand, 49(3), 347-369.

Wallace, P., & Fluker, S. (2015). Protection of threatened species in New Zealand. New Zealand Journal of Environmental Law, 19, 179-205.

Waters J. M., and Craw D. (2006) Goodbye Gondwana? New Zealand biogeography, geology, and the problem of circularity. Systematic Biology 55, 351-356.

Watson, C. J., Carignan-Guillemette, L., Turcotte, C., Maire, V., & Proulx, R. (2020). Ecological and economic benefits of low-intensity urban lawn management. Journal of Applied Ecology, 57(2), 436-446.

Watts, S. (2023) COP28 National Statement for New Zealand. Retrieved February 2024 from: beehive.govt.nz/speech/cop28-national-statement-new-zealand

Wehi, P. M., Beggs, J. R., & McAllister, T. G. (2019). Ka mua, ka muri. New Zealand Journal of Ecology, 43(3), 1-8.

Weidong, G., Heikkila, R. and Hanski, I. (2002). Estimating the consequences of habitat fragmentation on extinction risk in dynamic landscapes. Landscape Ecol. 17: 699-710.

Wild Animal Control Act 1977 legislation.govt.nz/act/public/1977/0111/40.0/DLM16623.html

Wildlife Act 1953. legislation.govt.nz/act/public/1953/0031/latest/whole.html

Willis., T. J., Handley., S. J., Chang., F. H., Law., C. H., Morrisey., D. J., Mullan., A. B., Pinkerton., M., Rodgers., K.L., Sutton., P. J.H., Tait., A. (2007). Climate Change and the New Zealand marine environment. NIWA, Nelson, New Zealand.

Wells, J. E., Oakley Browne, M. A., Scott, K. M., McGee, M. A., Baxter, J., Kokaua, J., &Team, N. Z. M. H. S. R. (2006). Te Rau Hinengaro: The New Zealand mental health survey: Overview of methods and findings. Australian and New Zealand Journal of Psychiatry, 40(10), 835-844

Whitau, K., Kelly, D., Galloway, T. N., MacFarlane, A. E., van Vianen, J. C., Rossignaud, L., & Doherty, K. J. (2023). Effects of altitude, seedfall and control operations on rat abundance in South Island Nothofagus forests 1998–2016. New Zealand Journal of Ecology, 47(1), 3502.

Whitburn, J., Linklater, W., & Abrahamse, W. (2020). Meta-analysis of human connection to nature and proenvironmental behavior. Conservation biology, 34(1), 180-193.

Williams, P. A. (2006). The role of blackbirds (Turdus merula) in weed invasion in New Zealand. New Zealand journal of ecology, 285-291.

Williams, N. S., Lundholm, J., & Scott MacIvor, J. (2014). Do green roofs help urban biodiversity conservation?. Journal of applied ecology, 51(6), 1643-1649.

Winterbourn M, Knox G, Burrows C and Marsden I. (2008). The natural history of Canterbury. Canterbury University Press, Christchurch.

Wiser, S.K.; Buxton, R.P.; Clarkson, B.R.; Hoare, R.J.B.; Holdaway, R.J.; Richardson, S.J.; Smale, M.C.; West, C.; Williams, P.A. (2013). New Zealand's naturally uncommon ecosystems. In Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand. Pp. 49-61.

Xu, Q., Yang, X., Yan, Y., Wang, S., Loreau, M., & Jiang, L. (2021). Consistently positive effect of species diversity on ecosystem, but not population, temporal stability. Ecology Letters, 24(10), 2256-2266

Young, R. (2014) Farmer 'destroyed' protected bush. Stuff Online - stuff.co.nz/the-press/news/north-canterbury/9781362/Farmer-destroyed-protected-bush

REFERENCES

Appendix A

Glossary

Aquatic habitats - freshwater habitats like lakes, rivers, streams, wetlands, and coastal estuaries etc.

Ara tawhito - ancestral trails (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Biodiversity - the diversity found within species, between species and of ecosystems (Pascual *et al.,* 2021).

Climate - informally, the average weather over a period ranging from months to thousands or millions of years. In more formal terms, a statistical description of the mean and variability of quantities, usually of surface variables such as temperature, precipitation and wind, averaged over a period (typically 30 years, as defined by the World Meteorological Organisation). More broadly, climate is the state, including a statistical description, of the climate system (MfE, 2022b).

Climate Change - a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (RMA, 1991).

Climate Resilience - the ability to anticipate, prepare for and respond to the impacts of a changing climate, including the impacts that we can anticipate and the impacts of extreme events. It involves planning now for sea-level rise and more frequent flooding. It is also about being ready to respond to extreme events such as forest fires or extreme floods, and to trends in precipitation and temperature that emerge over time such as droughts (MfE, 2022b).

Ecological District – a geographical area which is distinct from others in New Zealand on the basis of the ecological factors including climate, soils, topography, geology, fauna and flora.

Ecological integrity – the extent to which an ecosystem can maintain its composition, structure and functioning.

Ecological function – the psychical, chemical, biological and ecological flows within an ecosystem that help to maintain the integrity.

Ecosystem – the complete composition of biological organisms and their interactions with their abiotic environment.

Ecosystem services - the key provisions gained from ecosystems which can be divided into four: provisioning which includes the supply of consumables such as mahinga kai, food, timber, biochemicals; regulating relating to services such as climate, air quality and water regulation as well as pest and disease; supporting indicating primary production, soil formation and nutrient cycling; and cultural services which provide a sense of place, spirituality, recreation and aesthetic values.

Environment - the surroundings or conditions in which a person, animal or plant lives or operates (Oxford Dictionary).

Exotic/Introduced/Non-indigenous species - species that have been brought to New Zealand by humans, whether intentionally or unintentionally. (Department of Conservation, 2020).

Fragmentation – the loss of habitat which leads to a loss of connection and a disjoint between species populations.

Green Infrastructure - means a natural or semi-natural area, feature or process, including engineered systems that mimic natural processes, which are planned or managed to:

- provide for aspects of ecosystem health or resilience, such as maintaining or improving the quality of water, air or soil, and habitats to promote biodiversity; and
- provide services to people and communities, such as stormwater or flood management or climate change adaptation.

(National Planning Standard definition, found in Waimakariri Proposed District Plan, 2023).

Habitat – the physical place where a species population or community resides for part or all of its life cycle or utilises for certain functional needs such as breeding or feeding.

Hapū - sub-tribe (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Indigenous biodiversity - all plants and animals that occur naturally in New Zealand and have evolved without any assistance from humans and includes the variability among these organisms and the ecological complexes of which they are part. It includes diversity within species, between species, and of ecosystems, and includes their related indigenous biodiversity values (Waimakariri Proposed District Plan, 2023).

Indigenous Species – a species that occurs naturally in Aotearoa New Zealand (Department of Conservation, 2020).

Iwi -tribe (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Kaitiaki - iwi, hapū or whānau group with the responsibility of kaitiakitanga (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Kaupapa - theme, policy (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Kōrero pūrākau - oral traditions (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Mahinga kai - food and other resources, and the areas they are sourced from (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Mana - respect, dignity, influence (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Manaakitanga - hospitality, kindness (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Mana whenua - customary authority, those who have customary authority (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Mātauranga - knowledge (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Mauri - the essential life force of all things, spiritual essence (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Montane habitat – ecosystems found on the sides of mountains.

Natural environment - nature is a holistic term that encompasses the living environment (te taiao), which includes all living organisms and the ecological processes that sustain them. By this definition, people are a key part of nature (Department of Conservation, 2020).

Nature-based Solutions - solutions that are inspired and supported by nature, cost effective and simultaneously provide environmental, social and economic benefits and help build resilience (Department for Conservation, 2020).

Pā - fortified settlement site (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Papatipu Rūnanga - marae based councils, administering the affairs of the hapū (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Remnant - vegetation or animal populations or communities which are diminished from their former size because of the influence of man (McEwan, 1987).

Resilience – the ability of an ecosystem to withstand or recover from disturbances maintaining a strong degree of ecosystem integrity.

Restoration – active intervention to assist with the recovery of a degraded, disturbed or modified area in order to retain a more natural state. Restoration can be applied to composition, processes or functions.

Riparian – any vegetated strip of land which extends along streams, rivers and the banks of lakes and wetlands and is therefore the interface between terrestrial and aquatic ecosystems (Waimakariri Proposed District Plan, 2023).

Rongoā - medicinal plants (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Scenic Reserve - as defined in the Reserves Act 1977, an area protected for the scenic interest, beauty and intrinsic worth.

SNA (Significant Natural Area) – land which has been identified through assessment outlined in section 6 of the Resource Management Act 1991 to contain significant indigenous vegetation, habitat or species populations and composition.

Sustainable Development - the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

APPENDIX A

TāngataWhenua - a people of the land; the iwi or hapū who hold manawhenua over an area (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Takiwā - region, tribal or hapū traditional territory (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Taonga - treasures (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Terrestrial – land above the mean high-water springs but excluding land covered by water or wetlands as described by the NPSFW.

Threatened species – species listed on the New Zealand Threat Classification System Manual (Andrew J Townsend, Peter J de Lange, Clinton A J Duffy, Colin Miskelly, Janice Molloy and David A Norton, 2008, Science & Technical Publishing, Department of Conservation, Wellington), available at: doc.govt.nz/globalassets/documents/science-and-technical/sap244.pdf, or its current successor publication.

Tikanga - customary values and practices (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Tohunga - experts (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Trophic Level Index - An indication of the level of nutrient enrichment (excessive amounts of nutrients) of a lake, based on the growth of plants and algae (MfE & Stats NZ, 2019).

Tūpuna - ancestors (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Tūrangawaewae - a person's right to stand on particular land and be heard on matters affecting that place and their relationship to it (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Wāhi taonga - places and things that are treasured and valued (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Wāhi tapu - places and things that are sacred (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Whakapapa - genealogy, cultural identity (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Whakataukī - proverb (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

Whenua - land (Jolly & Ngā Papatipu Rūnanga Working Group, 2013).

APPENDIX A

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