SUSTAINABLE FUTURES 30|50
WHANGAREI DISTRICT

Whangarei District
Ecosystem Services Background Report

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1st December 2009

10/12260

Executive Summary

Ecosystem services refer to the many goods and services emanating from the functioning of the local environment. People benefit from many different ecological functions, from water purification services within water bodies to wild pollination. Many of these services are simply by-products of natural processes and functions happening within ecosystems, but as environmental pressures increase, greater cognisance is been taken globally of the benefits derived from these historically 'free' services. Planning for ecosystem service delivery tries to ensure that the tradeoffs between the provision of different ecosystem services are worthwhile, in that oversupply of one service does not lead to the undersupply of another. Taking an ecosystem services delivery approach expands the focus beyond understanding how development *affects* ecosystems, but also includes understanding how development is *dependant* on ecosystem services.

The delivery of many ecosystem services requires well-functioning ecosystems, and this includes major contributions from biological diversity. Some ecosystem functions and subsequent services are produced by single species, whereas others are the result of a larger number of species such as in the case of freshwater quality. Ecosystem services are sourced from a variety of landscapes, including both rural and urban lands, developed or undeveloped. However, the way the resources are managed has an impact on the delivery and quality of those ecosystem services.

The key areas of interest in terms of ecosystem services and future development would be: provisioning services such as food (dairying, pastoral, horticulture), fibre (timber), freshwater (drinking and potential irrigation), air quality regulation (around urban areas), local climate regulation (especially in urban areas), global climate regulation, water regulation (especially run-off, flooding, and aquifer recharge), erosion regulation, water purification and waste treatment (especially around settlements), pest regulation, pollination, natural hazard regulation (reducing damage from natural hazard events such as storms, or retaining enough moisture to avoid fire risk), recreation and ecotourism elements, nutrient cycling (efficiency of soil micro-organisms in processing and making available nutrients), and soil formation.

In general terms, habitats of larger sizes will supply more ecosystem services than modified landscapes of a similar size. However, modified landscapes will supply ecosystem services as well, irrespective of whether it is forestry, pastoral landscape or dairying, and these areas will often supply more than urban areas. The supply of ecosystem services from lifestyle blocks is heavily dependant upon their management, and cannot easily be generalised Therefore fragmentation of these areas is especially important to understand how ecosystem services may be impacted by future development, especially within catchments.

Few significant natural areas are directly located within the projected areas for growth under any of the Three Futures. However, some significant natural areas are generally located with settlement catchment boundaries, and these will be supplying a range of ecosystem services that settlements are dependand upon.

The main concern in terms of Future One is that ongoing popularity of versatile soils for lifestyle blocks does put pressure on ecosystem services. As these areas are developed, pressure for food production, and reverse sensitivity in remaining productive blocks close to the lifestyle property owners, will mean that present marginal areas will come under pressure.

Future Two is the most neutral in regards to the overall delivery of ecosystem services, due to less pressure for lifestyle opportunities in rural areas, and a smaller distributed population in coastal areas compared with Future One. However, Future Two, with its very large focus on Ruakaka/Marsden, is the future most reliant on restoring and maintaining ecosystem services, especially in terms of the upper catchments serving Ruakaka/Marsden Point.

Future Three has the least impact on the delivery of ecosystem services over a wide range of services. However, compared with Future One, it may not necessarily provide the delivery of services reliant on restoration of indigenous vegetation. More concentrated settlement patterns will mean that more attention is required within these catchments to ensure that the requisite delivery of ecosystem services is available and does not impact on individual's and community's well-being.

1.0 Introduction

The ecosystem services framework is emerging as a powerful lens for better integration of decision-making with people's impact on the biophysical environment (Millennium Ecosystem Assessment (MEA) 2005, Department of Environment, Food, and Regional Affairs (DEFRA) 2007). It has much promise as a platform for decision-making that can identify and illustrate the trade-offs required during landuse changes, especially those changes from relatively less 'developed' to more 'developed' states (MEA 2005). In the last couple of years, the earliest promoters of ES have increasingly turned away from pure research towards calling for the incorporation of ES into actual decision-making, bridging the gap from science to policy (e.g. Daily et al 2009, Tallis et al 2009).

Put simply, ecosystem services refer to the many goods and services emanating from the functioning of the local environment. People benefit from many different ecological functions, from water purification services within water bodies to wild pollination and onwards through to soil formation that builds fertility in productive fields (MEA 2005). People are essentially dependant of the flow of these services, although some elements can be augmented by technology in limited quantities (MEA 2005). The purpose of this background report is to better explain the concept of ecosystem services, why they are important, and outline the ways that the protection and maintenance of ecosystem services may impact on decision-making within the Whangarei District, and the wider region, over the next 50 years. In the Sustainable Futures 30/50 brochure, under Sustainable Environment, ecosystem services has been explicitly mentioned as it is a concept that specifically connects the environment with the economy. It is also a critical ingredient in the development of a 'sense of place' (Raymond et al 2009) or identity for different locations such as Whangarei District.

The identification, and use, of ecosystem services delivery as a framework to promote better environmental management is increasingly finding favour within the research community and policy makers in many parts of the world (Daily et al 2009, Tallis et al 2009). Taking an ecosystem services delivery approach expands the focus beyond understanding how development *affects* ecosystems, but also includes understanding how development is *dependant* on ecosystem services. In other worlds, the relationships between development and environment are not uni-directional but, in fact, are bi-directional. Development is dependant on the environment just as the environment is affected by development - the two are intimately related.

Figure 1: Connections between Development and Ecosystem Services (Sourced from Ranganathan et al 2008, World Resources Institute, 2008, p 3)

Many of these services are simply by-products of natural processes and functions happening within ecosystems, but as environmental pressures increase, greater cognisance is been taken globally of the benefits derived from these historically 'free[1]' services. This wide range of benefits, sometime portrayed as goods and services, has been termed either ecosystem services or environmental services in the literature. It has emerged, in part, from the field of sustainability, and integrates ecology, economics, law and many other fields of study (Ruhl et al 2007). It is increasingly seen as an important conceptual bridge between economic development and the environment, especially in times of increasing resource scarcity and increase environmental degradation, enabling decision-makers to make more holistic decisions, especially when more than one ecosystem service will be affected by a decision.

Planning for ecosystem service delivery tries to ensure that the tradeoffs between the provision of different ecosystem services are worthwhile, in that oversupply of one service does not lead to the undersupply of another. The production of certain amounts of a particular service, e.g. food or fuel production, is generally beneficial or efficient to a certain point or threshold, but further production of the service beyond this threshold may not be worthwhile individually, locally, or globally (DEFRA 2007). In some cases extra costs associated with its provision outweigh returns, especially if high levels of inputs are required to produce the service.

[1] Few ecosystem services have been the subject of market exchange or economic value until recently, because they were either public goods, difficult to establish property rights, public or private, or were very common.

Using ecosystem services as a framework can aid the identification of the wider set of beneficiaries of high environmental quality across communities (Ruhl et al 2007). For example, settlements downstream of farmlands may benefit from the flood attenuation effect of vegetation located on up-river farms or reserves (Ruhl et al 2007, Braumann et al 2007). The farms themselves may benefit from upper bush-clad catchments in terms of their available water quality or quantity for irrigation, or, in some cases, benefit from wild pollination of some crops or forage material like clover. Local fisheries will benefit from riparian vegetation within a catchment intended to reduce sedimentation of the river.

Given this increasing interest in ecosystem services, and what is suspected to be a trend towards increased public demand for high quality environments due to increased population, it is prudent to think about ecosystem services and what this means in the development of Whangarei District. We expect that the trend of using ecosystem services as a key ingredient of environmental management is likely to be strengthened over the next 50 years, if international experiences are any indication, and as such, ecosystem services is worth exploring in terms of Sustainable Futures 30/50. The newness of the topic has also meant that this document also includes elements that are more 'think piece' than simple reporting. This consideration is timely as government seeks to better align legislation that pertain to development and environment. The Resource Management Act, Conservation Act, Building Act, Forests Act, and Wildlife Act are all subject of research for possible alignment, and ecosystem services may provide a useful role in this process of alignment[2].

2.0 Basics of Ecosystem Services

Like many concepts in the environmental field, there are multiple definitions of ecosystem services (ES). For the purposes of this report, the definition used in MEA 2005 will be used, as currently it is the most widespread: "the benefits people obtain from ecosystems". The provision of ES is dependent on a complex interplay of biological and physical processes. These include geological, biogeochemical, geomorphological and hydro-geomorphic processes in terms of abiotic factors, but also include biotic factors and the relationship of people with their environment. For example, forested or tussock catchments' water yield that is important to people in locations such as Dunedin depend on ecological patterns such as vegetation cover, canopy, and roots (Marks et al 2008).

Keen gardeners may have already noticed that a wide variety of insects, birds, and lizards pollinate their vegetable or flower plants, irrespective of whether they are introduced or indigenous plant species. When people think of pollinators, they generally think of honeybees

[2] http://www.mfe.govt.nz/cabinet-papers/cab-min-09-34-6a.html

and bumblebees, but if you spend a little time in the vegetable garden, you might notice a wide variety of insects, including hoverflies and beetles are busy within the flowers, taking advantage of nectar resources. Some keen gardeners also participate in companion planting, where the attributes of one plant can either enhance growth in another, or have deliberately planted species that keep away insect pests, such as marigolds or aromatic plants. Different plant species, flowering at the right time, can provide important habitat for predatory invertebrate species that feed on garden pests, whether directly in terms of providing housing space or indirectly as shade, etc.

Some products of ecosystem services, commodities like timber, food production, and fibre, are actively traded, and provide the foundation to much of New Zealand's original and ongoing wealth. Some ecosystem services are less widely known or not actively traded, such as flood attenuation properties of riparian vegetation, nutrient cycling within soils, and water purification, although they are reasonably well-known within technical circles. Some ecosystem services are not very well-known at all and have only really emerged as topics of interest recently, including pollination services provided by birds, lizards and invertebrates, pest control services provided by predatory insects, and even the existence of invertebrates deep in the soils that help purify groundwater (Kremen et al 2007, Boulton et al 2008).

This hasn't gone unnoticed by scientists and growers, with research being undertaken within the Waipara wine region just north of Christchurch and in Marlborough (Berndt et al 2006). Specific inter-planting of both native and exotic plant species between grape vines is being used to provide appropriate habitat and food for species of predatory insects that subsequently feed on various pests of grapevines (Cullen et al 2008, Wade et al 2008). The purpose of this is to boost the level of predatory species to a level in which pests are reduced to economically viable levels[3]. Whilst Whangarei District doesn't have extensive vineyards, there is a strong possibility that enhanced opportunities in horticulture will emerge as different sub-tropical crop species more suited to warmer climates become possible in Northland. Similar approaches to pest control and environmental management to those in the Waipara vineyards may be appropriate here.

Ecosystem services are produced in all landscapes, whether indigenous or modified, but the types and range of services provided can differ markedly, even within the same industry, e.g. kiwifruit, as different forms of land management can increase or decrease different levels of service delivery. Research in Canterbury New Zealand is seeking to understand the different provisions of ecosystem services between conventional arable and organic arable land (Sandhu

[3] Earlier this year, the worlds first "biodiversity trails", which embeds the importance of biodiversity and ecosystem services into the wider wine experience was inaugurated around the Waipara area. www.bioprotection.org.nz/system/files/Greening+Waipara+No+6.pdf

et al 2008)[4], and whilst both types of management provide various ecosystem services, the organic management approach provided more services, both in terms of quality and variety.

The sources, and delivery, of ecosystem services are not limited to rural areas or bush, but also occur within cities and other urban areas (Bolund & Hunhammar 1999, Colding 2007). In the city, ecosystem services such as the water infiltration[5] properties of vegetation that reduce run-off, the presence of invertebrates in people's gardens that pollinate plants or remove waste, or the air purification properties of trees are all examples of ecosystem services important to urban living (Bolund & Hunhammar 1999). Research has shown that the presence of vegetation within urban areas provides mental and physical health benefits and can even enhance productivity (Hannsmann et al 2007, Boarnet et al 2008, and Velarde et al 2007).

Even the transfer of nutrients through bird or invertebrate excrement from lowland feeding spots to upland roosting and nesting spots can be considered an example of an ecosystem service[6], as they move nutrients around. It must be also pointed out that some ecosystem services are reasonably easily replaceable through alternative means, whereas many others are difficult to replace because of costs, or, on many occasions, ultimately irreplaceable. Examples of the former include the development of Pinus Radiata plantations to replace native vegetation for forestry and artificially constructed wetlands for water purification, whereas examples of the latter include cultural significant services, such as the call of a special bird over the coffee in the morning. The form of replacement will not be an exact fit, and may lead to a different suite of service delivery, in terms of both time and place. Taking the example of Pinus Radiata, plantation forest can be the source of high quality water, and it can also provide habitat for a wide range of indigenous flora and fauna (Brockerhoff et al 2003), albeit less that indigenous habitat, but more when compared with pastoral areas.

The following tables, sourced from the MEA (2005), outline many of the key ecosystem services of interest to decision-makers around the world. Whilst all of these services are of importance to Whangarei District, some are of higher importance in terms of Sustainable Futures 30/50, because of the particular characteristics of the area. These would include climate regulation at a global level, provisioning services such as food, fibre, and freshwater and regulating services like air quality regulation, water regulation, erosion regulation, and natural hazard regulation at regional and district levels; pest regulation and pollination at localised levels, and nutrient

[4] Mean total economic value for organic arable land was $US 4600 per ha ($US 3120 per ha for marketable provisioning services and $US 1480 per ha for other ecosystem services). Mean total economic value for conventional arable land was $US 3680 per ha ($US 3010 per ha for marketable provisioning services and $US 670 per ha other ecosystem services). This was based on assessment of: biological control of pests; mineralisation of plant nutrients, soil formation, food production, raw materials, carbon accumulation, nitrogen fixation, soil fertility, hydrological flow, aesthetic values, pollination services, and shelterbelts.

[5] The process of permeation or cause to permeate by filtration.

[6] Such a transfer of nutrients has been very important in New Zealand ecosystems, such as seabirds feeding at sea but roosting high in mountains and hills around the country (Flannery 1994, Holdaway et al 2007).

cycling and soil formation at both localised and regional levels. Cultural services, such as ethical values, recreation and tourism, and existence values are all of importance to Whangarei District, as various Iwi Management Plans, Community Plan submissions, and local industries would indicate. These issues of importance differ little to those in other parts of the world (e.g. Raymond et al 2009).

The provision of different ecosystem services arises at different scales, as Tables 1 & 2 indicate. The concept of scale is very important to understanding how ecosystem services are provided, but its meaning can be very difficult to define. In environmental management, scale can refer to either spatial dimensions or temporal dimensions of influence. In the first, spatial dimensions can range in size from small local areas to regionally sized area through to global sizes, and all points in between. In the second, timeframes can range from minutes to seasons to centuries. Both types of scale will influence the provision of different ecosystem services, as ecosystem functions operate at different scales. For example, carbon storage is primarily important as a global function, but opportunities for carbon storage will be dependant on local frameworks. Flood attenuation is important within the catchment where flooding occurs (Van Roon 2003); although it may be regionally important if significant regional infrastructure is located within the potential flood areas.

Much landuse planning revolves around the best use of different resources, whether for environmental, financial, efficiency, or other reasons. Some ecosystems can be very far removed from their original state, but are quite capable of providing a range of services, whether agricultural land (Hatfield-Dodds 2006, Sheehan 2009) or urban lands (Tratalos et al 2007, Colding 2007). However, if one activity using a particular suite of ecosystem services is promoted, e.g. horticulture, then another suite of ecosystem services in the same area will decline (Bennett et al 2009). If the ecosystem service that declines is common, easily replaceable, not highly valued, or it does not play a critical role in local well-being, then this can be a worthwhile trade-off for both individuals and their community. However, should this activity expand excessively, and disrupt the delivery of other suites of ecosystem services, all of which are highly critical in one way or another, then this may not necessarily be a worthwhile trade-off for the individual or the community.

As yet, there is no explicit mention of ecosystem services in New Zealand law, although legislation such as the Resource Management Act 1991 uses and applies concepts that fit into an ecosystem services delivery framework. Reports by the Parliamentary Commissioner for the Environment (2002, 2009) do contain references to ecosystem services in the context of agriculture generally and in the high country of the South Island, but little further work has occurred in using ecosystem services in government literature. Research effort is being invested by the Foundation of Research Science and Technology (FORST) for better understanding the

implications of ecosystem services delivery for environmental management, and the science behind it.

The focus of the Local Government Act 2002 on the promotion of well-being is a potential mandate for the use of ecosystem services, because all different ecosystem services contribute directly to human well-being. However, people have widely diverging views on the value of biodiversity, dependant on experiences, and varying knowledge sets will produce divergent preferences. For example, a tree located in a field can elicit different responses from different viewers, according to their worldview. Some may think of livestock shading, others focus on the trees aesthetic qualities, whereas a third may connect it to wider environmental processes through the animal life that lives on it. The context of the tree itself also has a bearing on values, e.g. if the tree was located in a street rather than the field, or if the field is located within an urban area (Spash 2008).

Table 2.1 List of Ecosystem Services

Service	Sub-category	Definition	Examples
Provisioning services - the goods or products obtained from ecosystems			
Food	Crops	Cultivated plants or agricultural produce which are harvested by people for human or animal consumption	• Grains • Vegetables • Fruits
	Livestock	Animals raised for domestic or commercial consumption or use	• Chicken • Pigs • Cattle
	Capture fisheries	Wild fish captured through trawling and other non-farming methods	• Cod • Shrimp • Tuna
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for purposes of harvesting	• Clams • Oysters • Salmon
	Wild foods	Edible plant and animal species gathered or captured in the wild	• Fruits and nuts • Fungi • Bushmeat
Fiber	Timber and wood fibers	Products made from trees harvested from natural forest ecosystems, plantations, or non-forested lands	• Industrial roundwood • Wood pulp • Paper
	Other fibers (e.g., cotton, hemp, silk)	Non-wood and non-fuel based fibers extracted from the natural environment for a variety of uses	• Textiles (clothing, linen, accessories) • Cordage (twine, rope)
Biomass fuel		Biological material derived from living or recently living organisms – both plant and animal – that serves as a source of energy	• Fuelwood • Grain for ethanol production • Dung
Freshwater		Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses	• Freshwater for drinking, cleaning, cooling, industrial processes, electricity generation, or mode of transportation
Genetic resources		Genes and genetic information used for animal breeding, plant improvement, and biotechnology	• Genes used to increase crop resistance
Biochemicals, natural medicines, and pharmaceuticals		Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use	• Echinacea, ginseng, garlic • Paclitaxel as basis for cancer drugs • Tree extracts used for pest control
Regulating services - the benefits obtained from an ecosystem's control of natural processes			
Air quality regulation		Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e., serving as a "source") or extracting chemicals from the atmosphere (i.e., serving as a "sink")	• Lakes serve as a sink for industrial emissions of sulfur compounds • Vegetation fires emit particulates, ground-level ozone, and volatile organic compounds
Climate regulation	Global	Influence ecosystems have on the global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere	• Forests capture and store carbon dioxide • Cattle and rice paddies emit methane
	Regional and local	Influence ecosystems have on local or regional temperature, precipitation and other climatic factors	• Forests can impact regional rainfall levels

Table 1: List of Ecosystem Services (Part 1). Sourced from Ranganathan et al 2008, World Resources Institute, p 23.

Table 2.1 List of Ecosystem Services (continued)

Service	Definition	Examples
Regulating services - the benefits obtained from the regulation of ecosystem processes (continued)		
Water regulation	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape	• Permeable soil facilitates aquifer recharge • River floodplains and wetlands retain water, which can decrease flooding during runoff peaks, reducing need for engineered flood control infrastructure
Erosion regulation	Role vegetative cover plays in soil retention	• Vegetation such as grass and trees prevents soil loss and siltation of water ways due to wind and rain • Forests on slopes hold soil in place thereby preventing landslides
Water purification and waste treatment	Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water, assimilation and detoxification of compounds through soil and subsoil processes	• Wetlands remove harmful pollutants from water by trapping metals and organic materials • Soil microbes degrade organic waste rendering it less harmful
Disease regulation	Influence that ecosystems have on the incidence and abundance of human pathogens	• Some intact forests reduce occurrence of standing water, a breeding area for mosquitoes, which can reduce the prevalence of malaria
Pest regulation	Influence ecosystems have on the prevalence of crop and livestock pests and diseases	• Predators from nearby forest, such as bats, toads, snakes, consume crop pests
Pollination	Animal-assisted pollen transfer between plants, without which many plants cannot reproduce	• Bees from nearby forests pollinate crops
Natural hazard regulation	Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes and tsunamis and to maintain natural fire frequency and intensity	• Mangrove forests and coral reefs protect coastlines from storm surges • Biological decomposition processes reduce potential fuel for wildfire
Cultural services - the nonmaterial benefits people obtain from ecosystem services		
Ethical values	Spiritual, religious, aesthetic, intrinsic or other values people attach to ecosystems, landscapes, or species	• Spiritual fulfillment derived from sacred lands and rivers
Existence values	The value that individuals place on knowing that a resource exists, even if they never use that resource	• Belief that all species are worth protecting regardless of their utility to human beings – biodiversity for biodiversity's sake
Recreation and ecotourism	Recreational pleasure people derive from natural or cultivated ecosystems	• Hiking, camping and bird watching • Going on safari
Supporting services - the underlying processes that are necessary for the production of all other ecosystem services		
Nutrient cycling	Process by which nutrients – such as phosphorus, sulfur and nitrogen – are extracted from their mineral, aquatic, or atmospheric sources or recycle from their organic forms and ultimately return to the atmosphere, water, or soil	
Soil formation	Process by which organic material is decomposed to form soil	
Primary production	Formation of biological material through assimilation or accumulation of energy and nutrients by organisms	
Photosynthesis	Process by which carbon dioxide, water, and sunlight combine to form sugar and oxygen	
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms	

Source: Adapted from Millennium Ecosystem Assessment

Table 2 List of Ecosystem services (Part 2) Sourced from Ranganathan et al 2008, World Resources Institute. p 24.

Most people will tend to connect their knowledge of environmental issues with the benefits or disadvantages it may provide (Agbenyega et al, 2009). It is this lack of understanding and undervaluation of ecosystem services that has led to their ongoing loss. Ecosystem services delivery provides a platform for understanding the wide range of responses that people and communities may have, but is more grounded in the contribution of the subject to wider environmental processes.

Broad examples of how ecosystem services are connected to people's well-being are found in Figure 2 Below. Despite this lack of explicit recognition in New Zealand law, the increasing use of incentives to enhance carbon storage in forestry, and payments to retire highly eroding hill country on the East Coast, are examples of payments explicitly being made for the provision of ecosystem services.

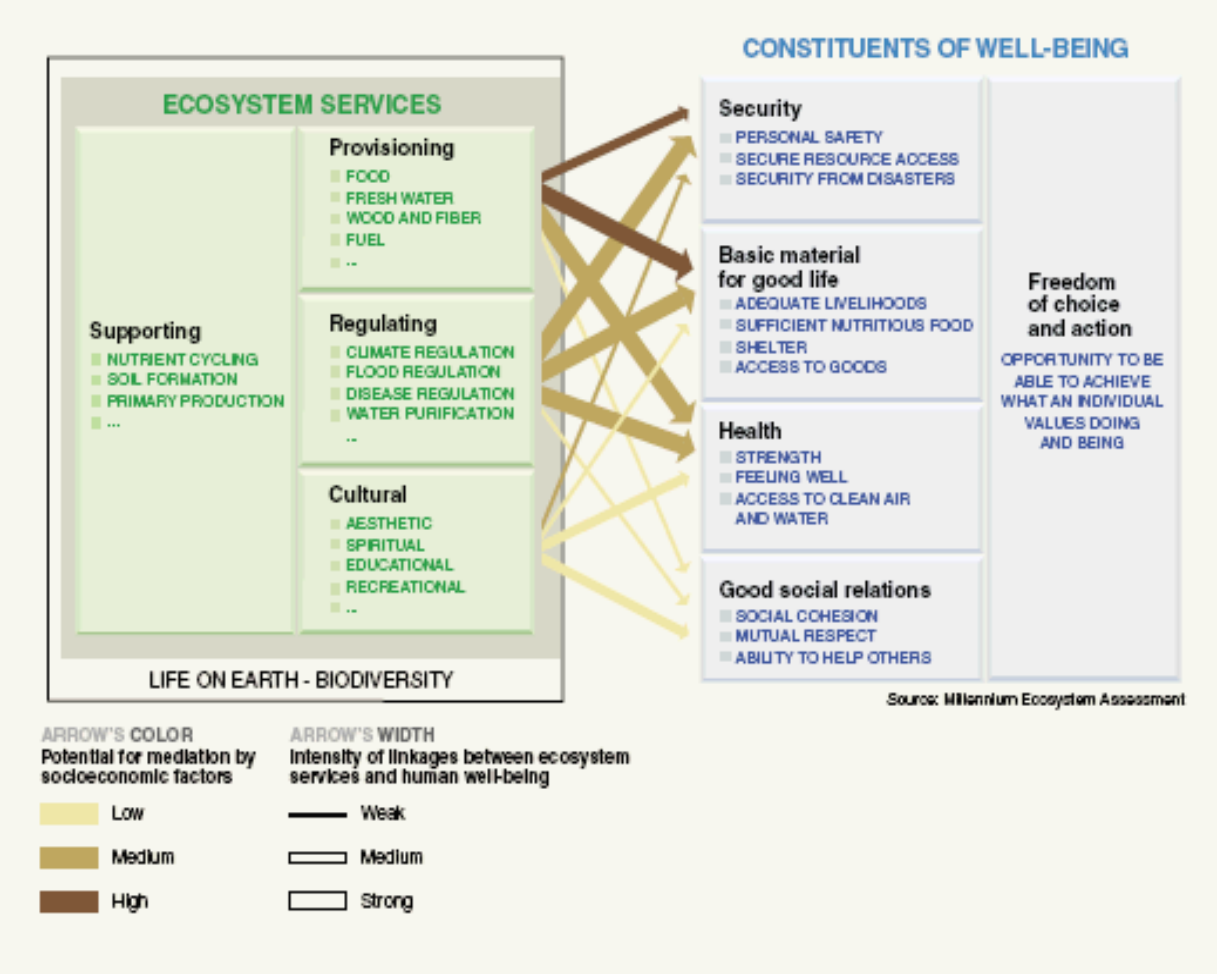

Figure 2: Connections Between Wellbeing and Ecosystem Services. Ranganathan et al 2008. World Resource Institute, p 16

In the United Kingdom, one government ministry (Department for Environment, Food and Regional Affairs) recently produced a guide called *"An Introductory Guide to Valuing Ecosystem Services (2007)"* It begins with the following *"Environmental assets –like other assets – provide benefits that enhance economic performance, offer new opportunities for investment and*

employment, and improve living standards and quality of life. And – like other assets– enhancing or diminishing the condition of environmental assets increases or reduces the stream of benefits we can derive from them in the future." It continues with "… *looks at how the framework for the valuation of the natural environment could be improved by offering a comprehensive and systematic means to ensuring that ecosystems and the services they provide are taken into account in policy appraisal. It builds on traditional valuation approaches by explicitly considering the environment as a whole – bringing together land, water, air, soil and biodiversity – and recognising that their linkages provide a wide variety of services and benefits that are not specific to any one part."* This broader framework allows a shift in emphasis from a focus mainly on valuing environmental damage to highlighting the value of changes in the services provided by the natural environment.

In other words, the call for the increased use of ecosystem services is specifically directed towards decision-makers and seeks to address development in a more strategic manner, including in their preparation of policies and in their development appraisals, similar to the Assessment of Environmental Effects in the Resource Management Act 1991. Of late, the concept, and explicit mention of ecosystem goods and services is finding its way into local resource consent applications and evidence for hearings.

2.1 Connections to Biological Diversity

The delivery of many ecosystem services requires well-functioning ecosystems, and this includes major contributions from biological diversity. Biological diversity is the variety of all life forms; the different plants, animals, and micro-organisms; their genes and the ecosystem of which they are a part. An ecosystem is a natural unit of biological diversity that consists of all plants, animals and micro-organisms (biotic factors) in an area *functioning together* with all of the physical (abiotic) factors of the environment.

Functioning together also relates to the idea that there are relationships between plants, animals, and micro-organisms within an ecosystem. Some are pretty obvious, such as predators feeding on herbivores that, in turn, feed on plants. Some are less obvious, such as plants obtaining their nutrients from the soil, but their ability to access the full range of nutrients being dependent on micro-organisms breaking down soil matter, increasing mineralisation, or fungi obtaining nutrients that plants can skim a little.

The boundaries of an ecosystem are generally blurred, and can often be defined by abiotic physical attributes. Ecosystems can be very simple, e.g. hot water vents and bacteria on the deep ocean floor, through to the very complex, such as the Amazon River Basin. The words functioning together in this definition suggests that there are key processes and interactions going on between the various components, whether biotic-biotic, abiotic-biotic, or abiotic-abiotic (weathering of rock). All such processes can be subject to external or internal changes,

and these can be both positive and negative, which can either increase or reduce interactions and functions. Putting these concepts together with ecosystem services implies that ecosystem services are the wide range of benefits that depend on functions and interaction occurring within different components (abiotic or biotic) of an area.

Research into ecosystem services is a recent field, and one that is still evolving in terms of knowledge, including a full understanding of the contribution of diversity overall. Interactions within the environment can be very complex, and the tools people generally use to assess these interactions may be too limiting, as they can often only focus on limited amount of interactions at one time (Bennett et al 2009). Despite these limitations, there is general agreement within the scientific community over what might be important, or what services can be more readily attributed to high quality biodiversity or habitat (Hooper et al 2005). One of the biggest debates in the field is the role that biological diversity has in the provision and maintenance of ecosystem services; not just specific species, but diversity across the whole system. Examples of such agreement include understanding how high quality soil communities are more productive. Overall it appears that a high level of biological diversity does translate into higher productivity. However, some authors believe that this is more attributable to functional diversity being high.

Species richness is another important concept used in ecology to denote the variety of organisms in an ecosystem, and is sometimes used to indentify the health of an ecosystem, and provide clues over its capacity to provide ecosystem services. However, unqualified use of species richness as an indicator of biological diversity and health can be a little simplistic as some ecosystems are 'simpler' than others to begin with. Present species richness measured and compared against the historical species richness may be more accurate, in determining overall contribution to functionality. Some researchers think that the wider diversity of organisms can lead to more stability over time, as different organisms will do better in different environmental conditions (Walker et al 2004, Weller et al 2008). Systems dependant on singular species for services may be more susceptible to shocks over time, especially if new conditions arise that are not suitable for previously common species. New conditions can include changes in climate, the introduction of a new disease, or increased competition with a new weed species. It is noted that in some systems, especially soils, there can be a massive array of species of micro-organisms and invertebrates, some of them fulfilling very similar roles. Research comparing soil communities beneath forest systems against pastoral systems suggest that there is more diversity of organisms beneath a forest canopy than the pastoral system, but there may be bigger numbers of organisms beneath the pastoral system (Van der Heijden et al 2008). Overall, higher levels of biological diversity are expected to provide more resilience within an ecosystem and act as a form of 'natural insurance', as more species increases the odds of one being able to 'fill the gap' (Balvanera et al 2006).

2.2 Ecosystem Services – Further Connecting Dots

An ecosystem, whether simple or complex, has a variety of organisms holding different functions within its boundaries. Organisms can range from microorganisms, to plants, to herbivores, to carnivores, to those organisms that feed on the dead remains of plants and animals. But within each category, there can be quite different types of herbivore or carnivore, categorised according to their type of feeding, or their preferred prey. Plants can be categorised according to their different functions as well, perhaps by its role in a canopy or its proximity to a feature like a stream. For example, in streams, within the invertebrate community there are four main types, classified according to their main type of feeding[7]. These different types exist to take advantage of different sources of plant materials.

Areas with highest biological diversity are not always the places with the highest ecosystem services value (Eigenbrod et al 2008), and using only ecosystem services for a planning framework can run counter to the outcomes desired by other conservation or environmental practitioners. There is a need to ensure that all interactions are accounted for. A good example of this is the Afforestation Grant Scheme, promoted by the Government which is trying to increase short-term carbon storage. However, it is believed that exotic species are much faster growing and can thus store carbon faster that their indigenous equivalents. Therefore the funding opportunities are weighted in favour of planting exotic species. To mitigate this, the government did reserve some funding for planting projects that provide for other ecosystem services such as water quality and other public goods, and has called for further research (Emissions Trading Scheme Review Committee, 2009, p 67-71).

Some ecosystem functions and subsequent services are produced by singular species, whereas others are the result of a larger number of species such as water quality (Luck et al 2009). For an example of the first, kukupa are the only frugivore birds in New Zealand capable of ingesting the fruits of a couple of trees such as Tairare (Kelly et al 2010). Therefore, any attempt to ensure the maintenance of these high canopy trees in Northern New Zealand needs to ensure the long-term survival of kukupa as seed dispersal agents. Other services provided by individuals would include forms of biological control used in New Zealand that only use a limited number of species for their services such as a particular parasitoid wasp species, or the use of the New Zealand Falcon as a predator within vineyards in Marlborough[8]. If a preferred service requires single species for its dissemination, then programmes to maintain and enhance it are important.

[7] The principal feeding types for freshwater aquatic invertebrates are: Predators (P), Collector-Browsers (C-B), Shredders (S), Filterers (F)

[8] http://www.falconsforgrapes.org/

Most ecosystem services such as flood attenuation or wider pollination services are provided by a wider group of species, at least more efficiently. Most pollination in New Zealand tends to be undertaken by a wider set of invertebrates including introduced honey bees, birds, hoverflies and beetles, although bees are the most commercially favoured (Anderson 2003). Likewise, wider biological control is undertaken by a group of predatory insects, rather than individual species, and erosion regulation is served by a mixture of habitat. In general terms, larger areas of bush tend to be more resistant to pest invasion, although their margins (up to 100 metres) may be impacted by weeds and other pests, affected by high levels of wind and light leading to edge effects. If communities of animals and plants are the primary provider, then habitat maintenance and enhancement is the more appropriate response. In streams, different types of herbivores are food sources for a variety of predatory species, including invertebrates and fish. In turn, bigger fish, or not so big (in the case of whitebait_, provide food for the table or a means of leisure as a cultural service.

Disruptions in different parts of the freshwater system can have impact on the ability of a system to provide benefits. These disruptions could range from the removal of predators from the system that allows prey species numbers to grow to unsustainable levels, through to low levels of sedimentation in particular streams. Sedimentation is seen as a critical issue for New Zealand stream biota, leading to potential smothering of invertebrates, or removal of hiding places for fish. For example, research in the lower North Island has shown fish species sometimes up to a metre below the observable 'bed of the river'[9]. At regional scales sedimentation can have more significant effects that can severely disrupt some types of ecosystem services, such as recreational fishing or water quality. By the time sedimentation is observed, many of these hiding places or habitats are already gone.

Ministry of Fisheries and National Institute for Water and Atmospheric Research recently discovered that the bulk of snapper (around 96-98%) found on the west coast of the North Island originally emerged as juveniles in the Kaipara Harbour (Morrison et al 2009)[10]. The juvenile snapper live mainly within eel grass beds where they find plenty of hiding places. Eel grass beds can be removed or destroyed by a variety of methods, including bottom dredging or smothering by sediment. Sources of sediment can therefore be of risk to the Kaipara eel grass beds, including the Wairoa/Wairua River. Given that several tributary streams and much of Wairoa/Wairua river catchment are found in Whangarei District, landuse in Whangarei can have an impact on the snapper fishery. This could include erosion impacts, or it could be run-off following tillage activities. Erosion regulation as an ecosystem services can therefore have direct impact on the delivery of another ecosystem service, e.g. recreational and/or commercial

[9] http://www.planning.org.nz/Folder?Action=Download&Folder_id=144&File=NZ-Freshwater-Crisis.pdf

[10] http://www.fish.govt.nz/NR/rdonlyres/C6F056C5-6863-4F71-A8D7-2D891D75DFC2/0/MorrisonAEBR37_FINALLR.pdf

values. In many respects, streams and rivers are the most visible connections in the landscape, and can have wide ranging impacts across many communities as they flow. This is why the government is concerned over the declining state of freshwater in New Zealand, and why it is seen as the second highest priority environmental issue after climate change. Of various ecosystem services mentioned in this report, the delivery of quality freshwater has the most significance to everyday lives of communities.

Enhancement of any particular ecosystem service to extreme levels is generally to the detriment of some alternative ecosystem services which may be lost (Bennett et al 2009). For example, increasing food production to extreme levels compared with the relative fertility of the productive land can lead to decline in water quality or loss of habitat for predatory insects. In more developed countries, this loss of other ecosystem services is often buffered by increased dependence on external inputs such as fertilizers for increased soil productivity, chemically based pest control means, or mono-cultural crops for simple harvesting methods. But as evidence mounts over water quality and soil conservation issues even within agricultural systems, concerns have grown over the extent to which agriculture is dependant on external inputs (Wade et al 2008). Table 3 notes some of the broad global trade-offs that are made when this happens.

There is evidence that some environmental changes are proceeding in a non-linear fashion (e.g. the outcomes are more that what are expected over time or for the actual scale of the change) and some may be potentially irreversible[11] (Folke et al 2004). In these cases, 1+1 may not equal 2, and may actually equal 3 or 1. This nonlinearity makes some outcomes very difficult to project. Quite a bit of research is being undertaken into the identification of key resource 'tipping points' and to understand the impact of scale such as the size of a habitat patch and the services provided e.g. is one large wetland or multiple small wetlands better for wider flood attenuation. Nonlinearity can work both ways, positive and negative, but most research does tend to focus on the negative impacts. Already, pollination agreements are being used internationally, and could involve agreements between parties, either within a catchment or locally.

Different ecosystems functions are evident at different time scales as well, whether the length of a forest life, regular masting[12] programmes or ephemeral streams. Likewise across a catchment, due to the extensive changes in many of New Zealand's catchments, some ecosystem services have already been lost or replaced by some new services (Sandhu et al 2008). If the production of ecosystem services is a nonlinear exercise, and overuse is difficult to establish with certainty or could result in a larger series of issues, then many decision-

[11] Unable to return to a former environmental state.

[12] Masting refers to a process when all trees of a given species produce their seed at the same time.

makers point to the need for the precautionary principle in making decisions. The use of the precautionary principle is meant to allow some insurance for these potential changes, limiting the possibility of excessive changes. Contemplating, and planning for, the overall impacts of development patterns on the maintenance and supply of different ecosystem services is therefore a potential constraint when looking at the future, but may also reveal good opportunities for individuals and communities as new markets are developed, e.g. the concept of carbon forestry.

Ecosystems are governed more by a continuum between states rather than specific states themselves (Hunter et al 2008), e.g. there is continuous series of states. Despite this idea, ecologists have long sought to define thresholds, using specific states, where an abrupt change in the ecosystem condition can occur, in order to better manage these ecosystems. Likewise, environmental laws often use thresholds, because the law strives for clarity, predictability, and uniformity (Hunter et al 2008). However, ecosystems vary in space and time and may not have easily discernable boundaries. Because of the differences, most catastrophic shifts tend to be discovered retrospectively following change in land uses (Hunter et al 2008). In making future decisions the concept of resilience is important. Resilience is defined as being: the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks (Walker et al. 2004). Like ecosystem services, it also contains an idea about usage e.g. a certain level of use can be sustained, but beyond this level of use the organism can eventually disappear.

Some uses will have temporary impacts that do not have long term consequences for an ecosystem. Other uses can have much more permanent impact, perhaps disrupting a service for a very long period of time. For example, water taken from a relatively high-flow stream may not have longer term consequences for the system. Water taken from a low-flow stream will have more consequences, perhaps a particular invertebrate predator becomes locally extinct, which in turn leads to a profusion of its prey species which causes further problems. Over time, hopefully, invertebrate predators from another system re-enter the system and eventually reduce the numbers of the herbivores. But if all of the water from the system is removed, then most of the stream biotic community is also removed. Even when the water returns there is not a well-functioning biotic community to take advantage of the water's return, unless the stream community is specialised in dealing with such shocks. Whilst it may be colonised, the community may not be able to take advantage or take too long.

The return of a biotic community can happen quickly, but there are occasions where various issues have led to the degradation of an ecosystem, and even when the original issues have been resolved, the ecosystem has not returned to it original situation. Lake ecosystems have been the most studied system in this case (Folke et al 2004). In New Zealand, lake health has

come under scrutiny, and efforts have been made to restore health before the point of possible no–return, especially around Lake Taupo and some of the Rotorua lakes (Edgar 2008).

2.3 Global Concerns

Like many aspects of the global environment, there has been growing concern over the decline in important ecosystem services such as water quality, pollination, soil nutrient cycling, in many parts of the world, illustrated in Table 3 (MEA 2005, Ranganathan 2008). People have always depended on the environment for a wide range of goods and services, whether food, fibre, or shelter, but with global trade and movement of resources, recognising this link has become harder. As the population has grown, and pressures on the environment have increased, more work has gone into understanding the wider benefits of biodiversity and habitat on the quality of life enjoyed by people.

Table 1.2 Ecosystem Services: Global Status and Trends

Ecosystem Service Type	Degraded	Mixed	Enhanced
Provisioning – the goods or products obtained from ecosystems	Capture fisheries Wild foods Wood fuel Genetic resources Biochemicals Freshwater	Timber Fiber	Crops Livestock Aquaculture
Regulating – the benefits obtained from an ecosystem's control of natural processes	Air quality regulation Regional and local climate regulation Erosion regulation Water purification Pest regulation Pollination Natural hazard regulation	Water regulation (for example, flood protection) Disease regulation	Carbon sequestration
Cultural – the nonmaterial benefits people obtain from ecosystem services	Spiritual and religious values Aesthetic values	Recreation and ecotourism	

Source: Adapted from MA 2005a.

Table 3 Ecosystem Services: Global Status and Trends (Sourced from Ranganathan et al 2008 World Resources Institute, 2008, p .7)

This global concern led to the establishment of the Millennium Ecosystem Assessment, an inter-governmental panel whose purpose was to prepare a global State of the Environment Report (MEA 2005). The MEA was set up through various international agreements that New Zealand has signed up to, such as the Convention on Biological Diversity. This report and wider programme explicitly looked at the decline in services that people receive from the environment, broken into the four broad categories mentioned previously in Table 1. These include provisioning services, such as food, water, timber and fibre; regulating services that affect climate, flood, disease, wastes, and water quality; cultural services that provide

recreational, aesthetic and spiritual benefits, and supporting services such as soil formation, photosynthesis, and nutrient cycling.

The final report of MEA was published in 2005 and provided a reasonably thorough picture of ecosystem services at the global scale. Table 2 shows the main types of ecosystem services that are already being compromised at the global level, as well as pointing out some of the services whose provision has increased. It hasn't been as controversial as the Inter-governmental Panel of Climate Change reports, but it hasn't necessarily been as noticed or publicised in the media either.

Overall, the general view was that approximately 60% of key ecosystem services were either degraded or being used unsustainably, including freshwater, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards and pests. New Zealand, whilst being in a comparatively better position than most countries, is not immune to this concern, with the declining state of freshwater resources being the most publicised concern in New Zealand.

2.3.1 Rural Lands

Good crop lands, those without large-scale problems, are generally the first to be utilised (Farley 2009). Over time lesser quality land gets developed but this results in larger areas or higher inputs being required for producing equivalent levels of food per ha. Ideally, this use of more marginal lands should stop when the costs, economic or environmental, of inputs exceed the benefits, whether these are provisioning services or other ecosystem services (Farley 2009). Expansion of farming land and intensification of use within existing farmland are both major drivers of global environmental change.

Agriculture production tends to simplify landscapes (Wade et al 2008). There is now much research into building more complexity into the agricultural ecosystem, with the ultimate goal of creating multi-functional landscapes (Wade et al 2008). Much of New Zealand's agricultural system is based upon approximately 140 species, most of which are exotic in origin (Williams & Timmins 2002). Even the way that habitat is managed can have an impact on the provision of ecosystem services (Fiedler et al 2008). Generic methods of increasing complexity for multifunctional systems include the reduction of pesticide use, increasing indigenous habitat size and building connections within and beyond the farm boundaries to form a 'matrix landscape[13]', increases in the non-cultivable land at any one period, increasing numbers of fields rather than reducing field numbers, diversification of crops, fencing off streams and staggering timing of husbandry (Bewsell et al 2007, Valentine et al 2007, Blackwell et al 2008, Wade et al 2008).

[13] Where a 'patchwork' of different types of habitat exist – whether within a field or across a farm.

Present research includes work on learning how to manipulate biotic interactions to provide desired services with the pay-off of reducing or eliminating need for some external inputs, all of which is fundamental to the practice of ecologically sound agriculture (Kean et al 2003, Wade et al 2008, Sheehan 2008). This approach requires better knowledge of biotic interactions, and how these can be managed in agricultural ecosystems (Kareiva et al 2007, Wade et al 2008). At the very local level biological species richness is probably less important than the presence of functional groups, and some consideration should be given to soil food webs beneath the ground surface which can also be very important to overall productivity and resilience of an agricultural ecosystem (Shennan 2008).

Ecological restoration is being contemplated, and undertaken, as a serious option to restore some services to some landscapes to reduce the risk from reliance on mono-cultural systems. Various indigenous and exotic species may have qualities suitable for farmland restoration, and are the subject of sustainable land management programmes undertaken by regional councils. In New Zealand, indigenous species of interest include kowhai as a leguminous species, along with kanuka, and totara (Dehlin et al 2008, Wade et al 2008). Increases in beneficial arthropod numbers can be highly useful, especially in crop pollination and pest control (Isaacs et al 2009). In some horticultural areas, the use of beetle banks as extra habitat is also increasing. Maximising the survival of preferred predatory species requires provision of pollen and nectar resources in particular seasons.

The goal of riparian planting is seen also as very important in the context of adapting to climate change, providing habitat for fauna, and for connecting landscapes (Seavey et al 2009). However, restoration is an expensive option, and even a field of manuka can cost between $5000 and $10,000 per ha to establish (including planting labour, suppressive weed control, and the plants themselves). In addition, if the planting is done for a specific purpose, it can be a long time before the benefits are realised, e.g. getting shading effects and full canopies from riparian planting can take decades or more to emerge (Davies-Colley et al 2009). In terms of good planning practice, it is therefore often more cost-effective and ecological appropriate to retain existing vegetation or add to it, rather than rebuilding from scratch.

Overall, as spatial and temporal scales increase more biotic diversity is needed to sustain wider ecosystem functions. Some habitat retention is considered a requirement, as is the need to produce and maintain more woody refugia in agricultural landscapes that build up invertebrate communities (Blackwell et al 2008). Large scale screening processes for identifying these arthropods and preferred plants are being undertaken in the United States (Isaacs et al 2009), and also in New Zealand.

2.3.1.1 Example – Pest Control

Invasive alien species (IAS) is defined by Pejchar & Mooney (2009) as "*those non-native species, that threaten ecosystems, habitats, or species"* are heralded as the second greatest agent of species endangerment and extinction after habitat destruction, especially on islands. Some of these IAS are inflicting serious impacts on the ecosystem processes and functions that are fundamental to human well-being. They regard the impacts of invasive alien species as an invisible tax that is not necessarily taken into account as part of wider environmental decision-making (Pejchar & Mooney 2009). In New Zealand, the cost of invasive weeds and pests was estimated at approximately $400 million per year in 2002, as well as spending $440 million per year on controlling and removing pests[14].

Much of New Zealand's and Northland's economy is based on introduced species for agriculture and horticulture, although Northland's economy was initially founded on indigenous ecosystem provisioning services such as kauri timber and gum. Most food crops in New Zealand have their origins elsewhere, with most terrestrial indigenous species being mainly used for flavouring, small amounts of freshwater fisheries, or for foraging wild foods like mutton-bird. All introduced species have an impact on wider ecosystem functioning (Williams et al 2003) across the landscape, but this impact is especially noticeable in the case of introduced weed species and pest fauna such as possums and rats. In 2002, it was estimated that there are approximately 500 introduced weed species in New Zealand already posing economic and environmental problems, with an estimated 12 more become problems every year (Williams & Timmins 2002). Invasive species are having a major impact on ecosystems throughout the world, and climate change is expected to exacerbate this impact.

Invasive alien species can impact on hydrological services, and can change the flow of water for drinking and irrigation compared with native species. In New Zealand some invasive alien species can influence the increase or decrease erosion processes; via changing soil properties, root structure of Invasive plants, and other species can also consume roots of plants. Invasive species, such as willow, can change the water systems, and can change flooding patterns as a result of this e.g. some species will enclose channels. Many can also spread disease (e.g. brushtail possum and bovine tuberculosis).

In marine systems, invasive alien species has changed fisheries conditions in many harbours in New Zealand and abroad. The protection of bush catchments for drinking water in New Zealand often requires possum control. Possum browse can reduce the ability of the forested catchment to undertake water purification functions as browse directly impacts on vegetation, impeding

[14] A notable recent success story is the control of possum numbers, down from 60-70 million in the 1980's to an estimated 30 million today. http://www.stuff.co.nz/environment/3099539/Possum-numbers-down-by-more-than-half

normal living functions. This is why the Water Services Division of Whangarei District Council is involved with possum control efforts in Pukenui Forest, above the Whau Valley Dam. Controlling possums in this catchment would also improve pollination services (through less consumption by possums of potential pollinating invertebrates and vertebrates). Invasive alien species can also directly impact on cultural or aesthetic elements, especially iconic species. Invasive pests have had a substantial impact on bird life in New Zealand impacting on the 'dawn chorus', a phytophora species is impacting on Kauri, and wilding pines invading the South Island High country that plays an important role in New Zealand culture.

However, invasive alien species can also form important alternative food species for native birds, lizards, and invertebrates. It is well known that species such as loquats, guavas, and Taiwanese cherry are popular with Kukupa that have contributed to quick spread of these species. Some highly beneficial species such as the honey bee or the bumblebee, used across New Zealand for both pollination of important exotic crops such as red clover, or, the collection of honey, have also been known to disrupt specialist plant-pollinator relationship internationally, But less is known in regards to their impact in New Zealand (Brockerhoff et al 2010). However, as befits their generalist nature, honey bees will also pollinate many of the problem weed species as well.

Invasive weed management is a long-term commitment which will require many different tactics over time, in so-called integrated weed management. Over time, rather than simply relying on herbicide for weed suppression; crop species may be developed that have better weed suppression traits than current species that are primarily bred for yield. Perennial plants, as opposed to annuals, may become a preferred forage species, as there is less ongoing disturbance that creates advantageous conditions for weeds. Use of weed suppressive mulches may become more commonplace, along with more mediation of nutrient availability between cropping seasons for some managed landscapes by the use of intercrops (Sheehan 2008).

Increasing the numbers of particular insect or bird species to feed on introduced weed seeds is another option being researched. In this process, more weed species often occur at first, but over time reductions through weed seed eating may occur. Adjacent non-crop habitat has an impact in the potential grazers, especially weed seed predation in autumn. Seed loss of more than 50% is seen as necessary to reduce weed species to economically viable levels. So this approach, by itself, won't be a standalone magic bullet, but form a part of a range of efforts (Navntoft 2008).

Increased organic farming may be a key future management process for advancing these approaches for pest control, but they are likely to across in many farming systems in time and the knowledge about their use improves.

2.3.1.2 Example - Pollination

Pollination and the decline of pollinator species numbers around the world is seen as a major global issue (FAO 2008, Gallai et al 2009). Pollination is of growing concern in New Zealand, in regards to both food crops but also in the longer term resilience of native forests (Kelly et al 2010). For example, mistletoe species in New Zealand are dependant on native bees and tui for specialist feeding that can twist their buds for the release of their pollen (FAO 2008). Not all food crops are dependant on pollinators for production, especially cereal crops, but the production of many tasty foods such as coffee, cocoa, nuts, fruits, edible oils, and vegetables are at risk due to their heavy dependence on pollinators. Ricketts et al (2008) notes that pollination efforts increase size, quality or stability for 70 major global crops whilst FAO notes that animal pollinators increase the output for 87 leading crops (FAO 2008). Many of these are dependent on wild native pollinators for their pollination. An economic valuation of pollination worldwide has been estimated at $153 billion euro or around NZ $300 billion, for crops such as fruit, edible oils, vegetables, stimulants, nuts and spices (Gallai et al 2009). Oceania, as a region, is regarded as one of the lesser risk locations for pollinator decline, based on our main crop types (Gallai et al 2009), but there is increased concern of late for various reasons.

The direct contribution of honey bees[15] to the New Zealand economy has been estimated at $ NZ 3 billion, with indirect effects (e.g. clover production) also being high. The recent release of the Trees for Bees regional guides by Landcare Research and Federated Farmers in November 2009 illustrates the concerns in New Zealand over the potential loss of the ecosystem services provided by honey bees[16], and advocates for the planting of various trees and shrubs for bees to ensure food availability on a year-round basis. The preferred tree species are a mix of indigenous and exotic species, and in essence they are used to introduce complexity into farming landscapes.

Relationships between pollinator species and plants are expected to be under further pressure from climate change beyond those experienced at present (Hegland et al 2008). Insect pollinated plants are expected to react more strongly to changes than wind pollinated plants. There is expected to be changes in onset of flowering times and also in dates when potential pollinator insects emerge or hatch (Hegland et al 2008). It has already been noted that bumblebees have increase spring flight times around the world. If flowering occurs at a different time to insect emergence, then pollination will not occur. Most pollinators are insects (Losey & Vaughan 2006), and due to their size, are more likely to be affected by temperature changes affecting their metabolism. Whilst this is expected to impact more on flowers

[15] Apis mellifera

[16] http://www.fedfarm.org.nz/treesforbees

dependant on more specialised pollinators than generalist species, climate change is expected to have a wide impact on most species.

One of the responses to bee decline around the world has been to better understand the contribution of wild pollinators to pollination, as opposed to honey bees (FAO 2008). Such research has revealed that wild pollination plays a highly significant role internationally in pollinating food crops. This research has also revealed the importance of habitat in providing additional food resources, and building more complex, resilient landscapes.

In research by Ricketts et al (2008), distance from habitat was a key determinant for ensuring ongoing wild pollination from invertebrates, in terms of visits per plant by individuals within a species as well as the variety of species that are involved in pollination. In general terms, wider varieties of pollinators are found close to natural habitat, with longer distance reducing the number of potential species involved. Species richness drops steeply at about 1500m from native habitat to 50% of the maximum near the native habitat. Visitation rates drop steeply at about 670m from native habitat, with the number of visits being 50% of their maximum, with visitation rates dropping more steeply in tropical than temperate climates. Around 590m was the average distance in tropical areas where visits were 50% of those found in immediate proximity to natural habitat, and 1308m in temperate climates. This material was used to enable better planning of the maintenance of pollination ecosystem services. Research into the effects of wild pollinators in New Zealand is still ongoing (e.g. Anderson 2003) and no direct research in sub-tropical climes in New Zealand has occurred.

2.3.2 Urban Ecosystems

Urban areas rely on a variety of ecosystem services, some produced outside the area and some within urban boundaries (Bolund & Hunhammar 1999, Colding 1999). In terms of the production of ecosystem services, the city is a very different location to rural areas but many services within the city are no less important than those produced elsewhere. The types and variety of weeds, people's influence on the soils, patch isolation, and soil compaction are common issues in urban areas, and can differ markedly when compared with their surrounding rural landscapes (Sullivan et al 2009). Urban trees play a role in this ongoing provision of ecosystem services, whether through increased infiltration into the soil during rainfall, provision of way-stations between larger patches of bush, shading effects (which, in the face of increase global temperatures is an important ingredient for future urban fabrics), and air pollution. In larger urban centres, such as Auckland, the value of an individual tree can be very high in terms of both air quality regulation and aesthetics. (Cavanagh & Clemons 2006, Veseley 2007). Many cities, including New Zealand, are dependant on the protection and maintenance of forest catchments or tussock lands for their water supply, e.g. Dunedin (Mark & Dickinson 2008).

Management of both indigenous and exotic habitat within a city can be used to encourage or discourage other types of ecosystem services. Many New Zealand cities are located in highly productive locations, e.g. soils, and as such can be good locations for habitat restoration and building some level of self-sufficiency in terms of ecosystem services delivery. Park grounds, in this respect, can be seen as providers of multiple ecosystem services, where the primary use is for recreational and health benefits/services (whether physical, spiritual and mental), but subsidiary uses such as flood attenuation, temperature smoothing, carbon storage could also be highlighted and enhanced. In addition, waterways, roadside berms, and cemeteries also play a role in the production of ecosystem services across urban areas (Colding 2007).

No singular urban settlement pattern is a magic bullet in terms of lessening the impact on ecosystem services. A good example of this is infill housing. If infill is simply taken to mean subdivision into two sections, this will see an overall reduction in section size, an increase in the area of hard surface, and reduction of area for vegetation and trees. International research, including in Australia, has indicated the wider values of larger section sizes in suburbia for the provision of biodiversity (Moroney & Jones 2006). On the other hand, higher density locations enable more efficient provision of infrastructure, a larger catchment population to support funding the improvement and management of parks in the vicinity and wider environmental management capacity.

In terms of future planning, it may well be necessary to adopt a policy portfolio approach to enable the retention of urban ecosystem services, with a mixture of high and low intensity settlement areas being created, with lower intensity blocks being used to build transport corridors for wildlife along stream-sides and between larger fragments of bush, and using higher intensity settlements in other areas to enable the provision of larger scale ecosystem services areas such as parks. Such an approach could be built around encouraging private landowners to plant a wide variety of shrubs in their back gardens that provide food resources.

3 Valuation and Payment for Ecosystem Services (PES)

Valuation is seen as a critical component to managing ecosystem services, as often monetising their value seems to be an indicator that decision makers can better understand and make comparisons. This can also aid public realization of how much high quality biodiversity values contribute to clean waters, healthy air, house values, and economic development, and what the wider cost implication may be if those ecosystem services are lost. Valuation can range from attributing community value or conservation values, but also includes monetary valuation. Monetary valuation of ecosystem services is regarded as very controversial as it tries to put a value on things that either have no easily identifiable market, or are very difficult to quantify, or historically have not been valued due to perceived commonness, but this is being worked on. Especially noticeable in research is the growth in academic literature trying to understand the

real economic costs of biodiversity loss in many parts of the world, and correspondingly, the real benefits in addressing biodiversity issues as part of best practice.

Several attempts at valuation of the contribution of ecosystem services to the global economy and national economies have been made. The most well-known of these was in 1997, when Costanza et al (1997) put a value on global ecosystem services of $US33 trillion in 1994, which was approximately a third larger (in value) than the monetary economy at that time ($US 25 trillion). In New Zealand, Patterson and Cole estimated that biodiversity contributed approximately $NZ 48 billlion value to the New Zealand economy in 1994, with ecosystem services emanating from agricultural lands and forests being the main contributors. As well as these broad spectrum analyses, valuations of specific ecosystem services within set areas have occurred. For example, Sandhu et al (2008) have estimated the value of ecosystem services to the Canterbury Region from arable farming, both conventional and organic, to be approximately $NZ332 million from 125000 ha of modified landscape, of which $NZ71 million was attributed to non-market ecosystem services.

There are valid concerns that the identification of monetary values for ecosystem services, or the use of payments, may lead to over-emphasis on some services to the detriment of others. The most relevant recent example of this in New Zealand at present is that of carbon storage within forests, exotic and indigenous. The emphasis of schemes such as the Afforestation Grant Scheme and the Permanent Forest Sink Initiative is the storage of as much carbon in forests as possible. Exotic trees like Pinus Radiata tend to be faster growing than indigenous trees (MAF 2008). Even though it is intended that these trees are treated as permanent forests, the emphasis on carbon storage policy tends to be towards more permanent pine forests. Whilst it is recognised that pine forests can develop high biodiversity values over time, through extensive indigenous undergrowth and wildlife habitat, their biodiversity values are likely to be less than that of indigenous forest. This was recognised in later policy, to a certain extent, and a portion of the funds available for these has been "ring-fenced" for planting forests that provide a wider suite of benefits including water purification and biodiversity values. In addition, further research into growth rates of indigenous species in optimum conditions and their final carbon storage figures are being re-examined to ensure that these indigenous species are not being overlooked.

Another danger is that ecosystem services policy will result in an increased focus on managing ecosystem services that can be relatively easily measured, generally to the detriment of other services that are not easily measured. A recent example of this is, once again, carbon storage which can be reasonably well measured through existing techniques or modelling, or the economic effects of recreational use of habitat, which has a well-established suite of techniques available for its use. This contrasts with nutrient cycling (or indeed many things to do with

invertebrates) where the historic research doesn't enable easy measurement or the baseline information is not available about the soil fauna.

In addition, values placed on individual types of ecosystem services themselves are context dependant. For example, whilst carbon storage, through tree planting, may have a similar value around the world due to present global needs, the ability of different locations to provide this particular service will be variable. If fast growth of vegetation is needed, then warmer localities can do better than cold localities in terms of carbon storage. But warmer localities may not have the space available for the tree planting, resulting in some level of compromise. Valuing carbon storage potential may result in different values. Likewise, pollination or pest control services may only be valued if there are those around that benefit from it, and this can be easily determined, perhaps by crop and orchard owners. In locations where there is little such demand, perhaps due to low populations, pollination services may not be highly valued but other services may be, e.g. bush impacts on down-stream water availability.

Thus, there are some noticeable dangers involved in promoting the ecosystem services concept at the expense of other resource values, especially in terms of the 'benefits to people' approach. Focussing solely on the services that ecosystems provide can be to the detriment of other ecosystem functions which do not have a direct or easily discernable benefit for people, but are nevertheless important overall in terms of wider ecosystem functions. The use of ecosystem services does not adequately account for the intrinsic values of ecosystem services or ethical and moral arguments for the protection and enhancement of biodiversity and habitat. As such, focussing on delivery of ecosystem services will likely remain but one of several approaches to the protection and maintenance of biological diversity. But it is one that is appropriate to local government which needs to address conservation and development issues every day. Despite these issues, many of which can be addressed over time, using ecosystem services can allow for more progress in understanding the implications of decisions on future generations, which is a core component of sustainable development.

Once some level of valuation has been made, then a new environmental management approaches using incentives to specifically maintain and enhance some ecosystem services is available. One of the key differences in this approach, when compared with simply traditional environmental funding, is that it can provide an explicit set of preferred outcomes within which participants can clearly understand and commit to providing for within any agreement. Payment schemes are now often being used to help protect those ecosystem services that are not generally valued by the private market, but are regarded as critical to the well-being of local communities. In the European Union, farmers are paid a subsidy for the production of ecosystem services such as hedgerow protection and enhancement, or their role in producing aesthetically pleasing rural landscapes. In the United States, farmers are paid to leave land fallow or set aside for the production of other ecosystem services such as the production of

water. In Australia, the distribution of financial rewards to landowners has been more explicitly linked to the production of ecosystem services in various states (Bennett et al 2008, Toovey 2008). Many studies on valuing different types of ecosystem services have been undertaken in New Zealand and abroad[17] and these can increasingly been used to form a baseline for future decisions that evaluate costs and benefits of different development paths.

3.1 International Programmes

Internationally, the uptake of an ecosystem services delivery approach for environmental management has emerged in several countries and regions such as the United States, the European Union, Latin America, and Australia. Various international development programmes are focussed on the retention of various ecosystem services, and much work has gone into the development of simple tools that can aid the identification of key ecosystem services as constraints. For example, the Natural Capital Project based at Stanford University is preparing a simple Geographical Information Services (GIS) application called INVEST as a free package that allows users to mesh this information into local GIS systems to identify key services, and make a broad assessment on their value (Tallis & Polasky 2009). Most of these programmes are based around promoting the provision of single preferred services, whether these are provided by individual species or by a community of species.

In Costa Rica, owners of forested land near coffee plantations have been paid by the government to leave the forest standing, to ensure that the coffee plants are pollinated by wild bees and so on. In Ecuador and Mexico, conservation of cloud forest is seen as important for the continuation of water resources, and communities are being paid for the retention of forest. In the European Union, some of the farm subsidies made available to landowners have quite stringent criteria before any payment is made that includes outcomes such as the provision of a preferred ecosystem service. Likewise, in the United States, various users of river catchments have developed agreements to provide, maintain and allocate water, with some landowners being paid to let forest remain. Increasingly, many of the federal lands in the United States are being recognised for their important contribution to downstream quality of life and their provision of ecosystem services such as water distribution, flood attenuation, cultural values, etc.

Closer to home, in Australia, the states of Victoria and New South Wales have both prepared guidelines on ecosystem services, and there has been recent calls for the preparation of a

[17] http://www2.lincoln.ac.nz/nonmarketvaluation/QuerySearch.asp; http://ecovalue.uvm.edu/evp/modules/nz/; http://www.evri.ca/english/default.htm

National Ecosystem Services Strategy that can help deal with the many environmental issues facing Australia in terms of water, salt-infiltration and so on (Toovey 2008).

4 New Zealand Context

New Zealand has some of the most modified landscapes in the world, in which much of the forest existing before human settlement having been changed to agricultural landscapes. Early periods of development in New Zealand saw the conversion of other land-uses into production based land uses. In some locations, almost complete replacement of native species has occurred, with an overall general trend for intensification (in terms of present production land) (Moller et al 2008). The result of this has been a perceived separation between conservation and development. As well as landscape changes, New Zealand has seen approximately 25,000 plants introduced, which is more than double the number of recorded indigenous species. New Zealand, by virtue of a low population base, good soils, and access to fertilizers produces large food surpluses, leading to it being one the world's most efficient food exporters. However, the last couple of decades have seen an increase in environmental problems such as soil erosion, water quality, and biodiversity loss recorded in State of the Environment Reports nationally and regionally. It is evident in many quarters that this trajectory is clearly not sustainable in the longer term, but conflicting views over the best means of addressing these issues remain.

Agriculture extends over half of New Zealand's terrestrial land area, dominating the land use of most middle and lower catchments of freshwater systems. Production land across New Zealand covers approximately 58% of the land area, whilst in Whangarei District it is closer to 74%, with a further 9.7% classified as lifestyle (WDC 2009). Agriculture has been, and continues to be, of high importance to New Zealand's economy and culture. Dairying is the largest industry in New Zealand, accounting for approximately 20% of NZ export income, but it isn't the only substantial agricultural industry. New Zealand's rural communities are very diverse, as are the different rural land uses undertaken throughout the country. Different approaches to agriculture, horticulture and forestry tend to have different scales of impact, a component that is sometimes lost in media reports.

However, some recent landuse changes are associated with higher intensities of agricultural development in order to increase yields (Edgar 2009). Intensification includes a shift away from pasture-based systems to systems more highly dependant on inputs from outside the farm area, such as supplemental feed, synthetic fertilizers, and irrigated water (Moller et al 2008). For example, since 1990, nitrogen based fertilizer rates have soared in New Zealand[18]. A portion

[18] Urea Fertiliser use in New Zealand has expanded greatly, with only 18000 tonnes across the whole of New Zealand in 1990, 122000 in 1996, and 433000 tonnes in 2007 (MAF 2008). http://www.maf.govt.nz/statistics/fertiliser/

of these additional nutrients have not been taken up in pasture growth, and are leached into waterways, which has implications for environmental health, and the marketing image of 'clean and green'. McDowell & Wilcock (2008) note that water quality in agricultural catchments tends to be worse than forested catchments, but also that different types of pastoral animals have different relative impacts on water quality. As noted in a recent address made by the Minister of Trade, continued environmental impacts resulting from the intensification of agriculture in many locations pose significant risks in terms of marketing products[19].

Despite the large area of land utilised in production, Mackay et al (2008) notes that 65% of NZ soils have physical limitations and that intensification of use has resulted in small farm scale issues. Broad symptoms of degradation within agricultural systems include algal blooms in waterways, regular plant disease epidemics, regular livestock epidemics, loss of topsoil, and impact of pugging on earthworm communities. Some pastures in New Zealand have lost much organic matter whilst the level of contaminants increases within the soils. With landuse intensification, the soil biological community becomes dominated by species with shorter generation times, smaller body sizes, rapid dispersal that can cope with very regular shocks. Intensification generally removes variety in the landscape and uses larger scale infrastructure and machinery. Increased urbanization also poses a threat to these soils, with the loss of elite and versatile soils to urban sprawl and lifestyle blocks (estimated to be 140,000 lots covering around 753000ha of land) New Zealand wide (McKay et al 2008).

New Zealand's response to biodiversity loss tends to be developed around creating a network of protected lands for the sole purpose of conservation, similar to countries such as Australia, United States and Canada. Thus, New Zealand's main actions in regard to biological diversity have revolved around placing substantial amounts of land into the Conservation Estate, which is formally protected land (McCleave et al 2006). Much of the Conservation Estate is located in more marginal areas such as mountainous areas. Realisation has grown that this is not sufficient for the wider protection of indigenous biodiversity in New Zealand, with lowland areas being of real concern (Wren & Green 2006). Before human arrival, these lowland areas, with wetlands, forests, and estuaries were highly productive, and considerable levels of indigenous biodiversity were found in these areas.

The focal points of this kind of effort has been two-fold – conservation planning focussing on mitigating the decline of critically threatened species from threats such as invasive pests and land clearance, and the avoidance of habitat modification wherever possible. This approach has seen significant areas (approximately 30% of New Zealand's terrestrial land) placed in the Conservation Estate, with a purpose of protecting the many intrinsic values of indigenous

[19] Speech by Minister of Trade, Tim Groser to Federated Farmers on 4th November 2009. http://www.beehive.govt.nz/speech/climate+change+trade+and+agriculture+address+federated+farmers

biodiversity and habitat (Macleod et al 2008). The other side of this coin is that virtually all land outside the conservation estate is seen as production landscape, and often considered, or seen to be devoid, of biodiversity value. Whilst the Resource Management Act 1991 and the advocacy role of the Department of Conservation did have some influence over the state of biodiversity on private land, this remained subsidiary to managing biodiversity on public land However, the recent interest in multifunctional landscapes (Argent et al 2007) and ecosystem services represents more of an integrative approach, resulting in much research in Australia and New Zealand's research communities.

The recent inception of the Land and Water Forum[20] in New Zealand is perhaps a signal of new approaches to environmental management in New Zealand which will increasingly focus on ecosystem services. In New Zealand, Manaaki Whenua Landcare Research, the New Zealand Centre for Ecological Economics in Palmerston North, Massey University, Lincoln University and others are all undertaking work on ecosystem services. Iwi ecosystem services are a particular research stream unique to New Zealand but does mirror work carried out overseas. Further complications to the mix include issues relating to the Treaty of Waitangi between the Crown and Maori. A brief perusal of plans and policies produced by Maori representatives, such as Iwi Management Plans, makes it quite clear that environmental issues need to be better considered than has been the case in the past. However, comment has been made within the Maori Land Court that there is the danger that Maori land will be treated as the backdrop to the lowlands, and the ability to receive an income from this will be curtailed.

These drivers and how they may influence the environment towards using ecosystem services as a basis for management is illustrated by the next two excerpts from New Zealand Government legislation and agreements.

4.1 New Start for Freshwater

Recent moves over the management of water in New Zealand reflect views of tradeoffs between uses, the present state of the system, and the prospects for recovery. Some freshwater systems are not expected to return to health, and that pumping in resources may not resolve the issues at play. Alternatively, some freshwater systems have received less degradation, and improvement may well be expected. The main problem is that many systems are highly complex and not predictable in regard to their outcome (New Zealand Government Cabinet Minutes 2009). Announcements by the New Zealand government suggest that new environmental management alternatives are being considered, especially in regard to water. On the 8th of June 2009, the New Zealand Government outlined its new strategy in regard to water issues in New Zealand. The key points of this were:

[20] http://www.mfe.govt.nz/issues/water/freshwater/new-start-for-fresh-water-qa.html

- *ensure that water contributes to New Zealand's economic growth and environmental integrity*
- *provide stronger central government direction and leadership*
- *set some resource limits to shape the actions taken on managing water quality and allocation*
- *develop an allocation regime that provides for ecological and public purposes (including Treaty considerations), and then maximises the return from the remaining water available for consumptive use*
- *identify the contribution water infrastructure (including storage) could make to improve water use, and address the barriers to achieving this*
- *address some of the scientific, technical, information and capability gaps that hold back improved management*
- *establish supplementary measures to address the impacts of land use intensification on water quality, and manage urban and rural demand*
- *maintain Treaty-based engagement with Māori on water management options.*

Whilst the basic concern underlying this approach is better allocation, this new approach to water essentially looks to manage trade-offs relating to water on a catchment basis. This type of approach was signalled in the Freshwater National Policy statement, in which different catchments will be treated differently, according to their individual needs. The Cabinet Note suggests that few streams will eventually end up as pristine, but a few freshwater systems may be regarded as moving to a different state that it is very difficult from which to return. Between the two extremes, mixed quality freshwater systems will probably be governed by agreement between stakeholders.

4.2 Waikato-Tainui River Settlement

Recent settlements between the Crown and various Iwi make it clear that new governance arrangements will be required, such as the Tainui-Waikato River Deed of Settlement. Examples of provisions in this document include:

The Waikato-Tainui objectives for the Waikato River are[21]:

5.1.1. The restoration and protection of the health and wellbeing of the Waikato River.

[21] http://www.nz01.2day.terabyte.co.nz/ots/DocumentLibrary/WaikatoRiverDOSDec09.pdf

5.1.2 The restoration and protection of the relationship of Waikato-Tainui, with the Waikato River, including their economic, social, cultural, and spiritual relationships.

5.1.3 The integrated, holistic and co-ordinated approach to management of the natural, physical, cultural and historic resources of the Waikato River.

5.1.4 The adoption of a precautionary approach towards decisions that may result in significant adverse effects on the Waikato River, and in particular those effects that threaten serious or irreversible damage to the Waikato River.

5.1.5 The recognition and avoidance of adverse cumulative effects, and potential cumulative effects, of activities undertaken both on the Waikato River and within its catchments on the health and wellbeing of the Waikato River.

5.1.6 The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities.

5.1.7 The protection and enhancement of significant sites, fisheries, flora and fauna.

5.1.8 The application to the above of both maatauranga Maaori and latest available scientific methods.

Whilst this agreement is particular to the Waikato River, and is under review, it has been held up as an example of appropriate approach for settling Treaty of Waitangi claims around waterways, and may be used as a model for future agreements in Northland, such as that recently announced for Ninety-mile Beach.

5.0 Potential Management Approaches to Ecosystem Services

Transitioning to approaches that fully account for wider ecosystem services approaches will be a long and ongoing process, but one that can fit within lifetimes of central and local government plans and policy documents. Like environmental policy approaches in general, little material about policy development for ecosystem services delivery is new, but it instead builds on knowledge developed across many research fields. Already different aspects of the ecosystem services delivery framework is being used at different levels or paths of decision-making around the world, especially in the more recent use of economics for environmental decision-making when evaluating merits of different development paths (Ranganathan et al 2008). Making policy choices depends on a minimum of two judgements and sources of uncertainty, these being scientific assessments that generate recommendations, and the political process which eventually results in a decision.

To manage these trade-offs, whether at a district or regional level or on a catchment basis will require a platform capable of incorporating a whole host of information from ecology, economics, legislation, etc. This is where the concept of ecosystem services may begin to see real traction. Whilst the use of incentives to conserve biodiversity values has been contemplated in New Zealand (Clough 2005), and funding for different environmental projects is available at various governance levels in an ad hoc manner, formal connections between the provision of specified ecosystem services and incentives are only just emerging with the carbon market, but has been used in Australia (Toovey 2008).

Incorporating this research into New Zealand institutions will be a process that occurs over time, especially as no environmental management approach operates within a vacuum. Existing policy tools need to be taken into account when incorporating ecosystem services into New Zealand's environmental policy framework. The most important legislation and institutions in New Zealand are the Resource Management Act 1991 and the various arms of government, central and local.

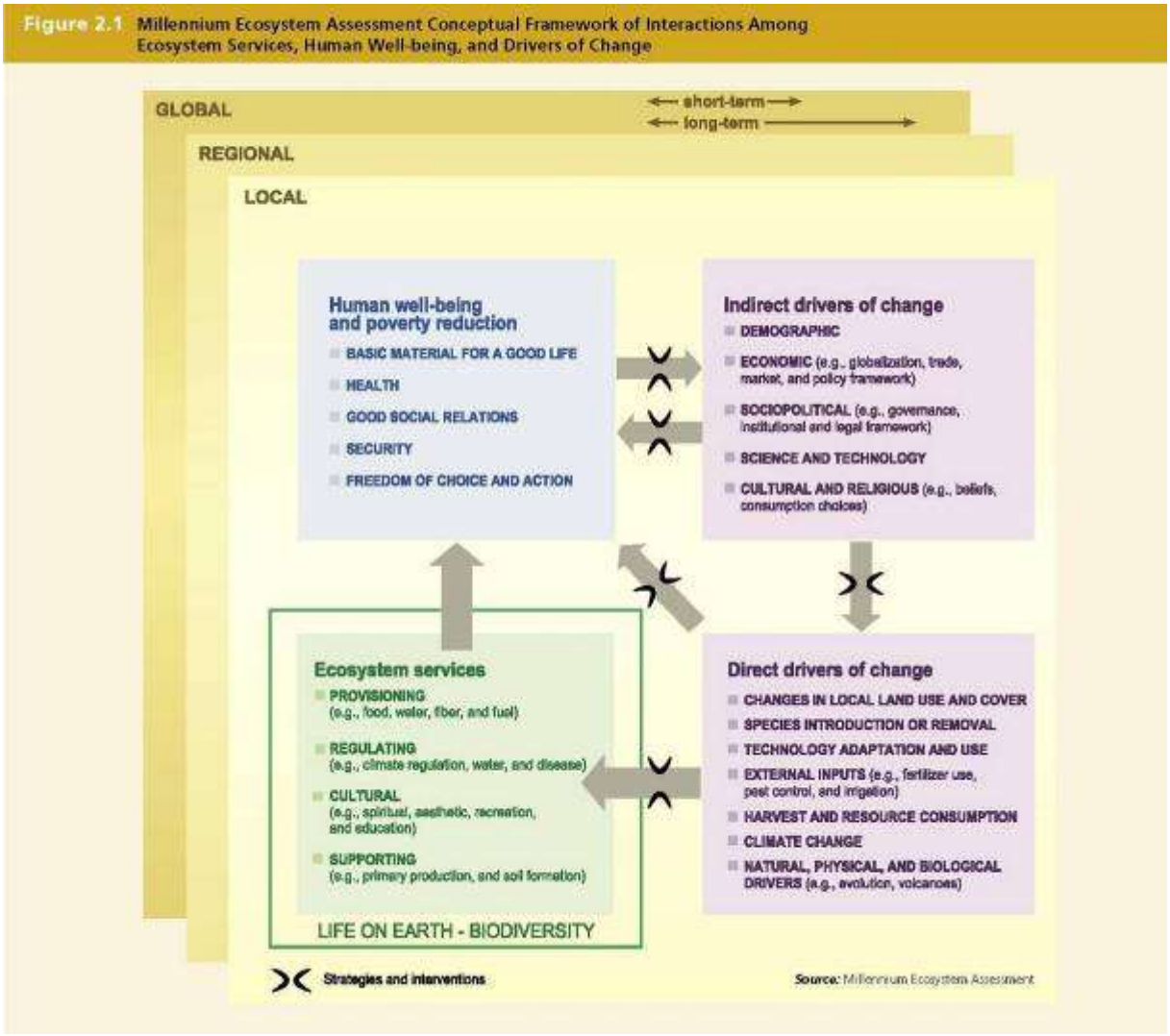

Figure 3 Conceptual Framework of Interactions. Sourced from Ranganathan et al 2008, World Resource Institute, p. 14

The Resource Management Act has, as a matter of national importance, a provision relating to the protection and enhancement of significant ecological areas which may be provided for by various governance institutions noted in the Act (Voigt 2003). It also recognises that there are intrinsic values of ecosystems that need to be protected (Curran 2005). The genesis of these provisions has been built around an acknowledgement that biodiversity is important for many different reasons, some outlined in international agreements such as the Convention of Biological Diversity, and some in national strategies such as the New Zealand Biodiversity Strategy (MFE 2000). Government institutions include regional authorities and territorial authorities, which are both arms of local government in New Zealand. However, defining what is significant has been fraught with much difficulty for these institutions. Scaling international or national significance down to regional or district levels for the purposes of local planning can be a difficult exercise for these institutions.

A critical issue in resource management is to better understand what biodiversity values are worth protecting, what values are not at risk, and what values need to be enhanced, all of

which can help prioritise resource management decisions. At present, legislation such as the Resource Management Act gives guidance on what is considered important, whether through provisions in the Act, or through the provision of National Policy Statements. But there are difficulties in translating this guidance into real actions. The aforementioned Land and Water Forum is likely to produce guidance on what ecosystem services are at critically low levels or are important to future development, which will also give some strong clues for prioritisation. As noted previously, one major advantage of the ecosystem services delivery framework is that it can be used to more clearly define the providers and main beneficiaries of given ecosystem services, better identify what is significant for critical ecosystem functions, and what may be still accessible for exchange in a form of trade-offs as part of development.

Much work is being undertaken nationally and internationally to better understand how landuse changes can impact on biodiversity, and whether there are preferred tools that can be utilised that reduce this impact, or, indeed, enhance biodiversity in some areas. In 2002, The Parliamentary Commissioner for the Environment released a report called "Weaving Resilience into Productive Lands" that started to consider these aspects in terms of agricultural land (PCE 2002). As an emerging science, ecosystem services has still got a wide range of uncertainties (and possibilities) in the way it will be used over time, and new knowledge is being generated on a regular basis. For example, it is now known that biotic communities play a role in water quality emanating from ground water resources (Boulton et al 2008).

New Zealand legislation tends towards an approach that recognises that some resources such as land and vegetation are best managed by private interests, within specified guidelines, whereas other resources such as air, water, and fauna are managed through public interests. However, as the pollination and seed dispersal examples illustrate, different elements of resources cannot exist without the other, e.g. vegetation relies on fauna, and fauna depends on vegetation. Both, of course, rely on water as a limiting factor, which is owned by the Crown. Therefore interactions are more blurred than simple private or public approaches.

Key future issues include understanding the characteristics of ecosystem services that make some types more responsive or easily accommodated into planning documents. Using a framework of ecosystem services also allows for a much wider variety of policy tools to be used, each one selected for a different purpose and outcome, depending on the critical nature of each resource, or its relative scarcity. Policies may include education, regulation, incentives and disincentives, and is not dissimilar to various approaches already evident in district plans. For example, some critical services may be best protected by legislative processes, others may require incentives, whereas other might need to be purchased outright. No one tool will fit all options and each will be used for different outcomes or targets.

In carrying out wider programmes of ecosystem restoration to help deliver ecosystem services in the future, consideration must be given to a suite of methods that promote ecosystem

changes at different scales, spatially and temporally. For example, research undertaken suggests that the full benefits of streamside planting in terms of temperature and shade, will not be realised for many years (Davies-Colley et al 2009). Therefore, whilst restoration is useful and is sometime necessary, the retention of remaining riparian vegetation may be more important in the short to medium term and policy can reflect this. With this changes and a need for flexibility in mind, highly defined rules or regulations within governmental planning documents may not be appropriate, due to their lack of flexibility, especially at the beginning of the process of integrating ecosystem services into a policy framework. Some of these tools are specifically concerned with subdivision, and includes tools such as different forms of subdivision development spatial patterns, incentives to get landowners to work with one another, and so on. Some of these tools are increasingly being investigated in New Zealand, whether in Whangarei or elsewhere. Please note that the following sections are simply suggestions of possible policy options and are not final recommendations.

5.1 Ecosystem Services and the Local Government Act 2002

The concept of ecosystem services has links with the concept of well-being, referring to both individuals and communities, and notes that a person or communities well-being is dependant on a range of factors from social, cultural, economic, and environmental fields. Human well-being, in the view of the MEA (2005), includes access to basic material for a good life, good social relations, security, and freedom of choice and action. This is paralleled in the Local Government Act 2002 Section 10:

> *"The purpose of local government is -….*
>
> *b) to promote the social, economics, environmental, and cultural wellbeing of communities, in the present and for the future"*

Given that ecosystem services underpin all components of well-being, ecosystem services are important for local government, whether regional or territorial. Whilst the functions and responsibilities of regional councils more closely align with maintenance and enhancement of wider ecosystem services such as water quality and quantity, the functions and responsibilities of territorial authorities like Whangarei District Council suggest local action as well, especially in terms of urban environments where development pressure is highest. Several provisions in local LTCCP's point to the need for ecosystem services being considered and valued across the district and in the region. These include

Whangarei Community Plan 2009-2019 key outcomes:

> *A sustainable, environmentally responsible District which values its natural uniqueness*
>
> *A District which is safe and crime free*

A community which is healthy and educated

A vibrant and growing local economy

A community which values its culture and heritage

Northland Regional Plan 2009-2019 key outcomes:

Northland residents are safe and healthy

The region's infrastructure is developed in a sustainable way

Northland's natural environment is sustainably managed

The region is prosperous

Our residents are educated and skilled

We have cohesive communities

Northland retains and enhances its regional identity

The region's residents have access to recreational and leisure opportunities

Ecosystem services fits strongly into the context of community's social, economic, and cultural wellbeing in both plans. Concerns over the loss of indigenous biodiversity feature in many submissions to the Annual Plan and Community Plan process, and within local and national media. The ongoing popularity of organisations such as the Friends of Limestone Island, Bream Head Trust, and multiple landcare groups are all testament to our communities desire to be involved in biodiversity maintenance and enhancement. Many schools in the district now have programs on environmental issues, and Kamo High School has been nationally recognised for its instrumental achievements in instigating a local marine reserve.

5.2 Resource Management Act 1991

This Act is the primary tool for managing the environment in New Zealand and has as its primary purpose:

5 Purpose (1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

(2) In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—

(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

The Resource Management Act does emphasis the protection and maintenance of significant biodiversity as a matter of national priority. The Act also makes it clear that both regional and territorial authorities have explicit functions relating to the protection of indigenous biodiversity (Sections 30 (1) (ga) and 31 (1) (b) (iii) respectively). These functions are additional to Councils requirements under Part II of the Act 1 requiring recognition and providing for preservation of natural character near water bodies, protection of outstanding natural features and landscapes, and the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna.

Determining significance in terms of biodiversity has always been an area of much debate and research (e.g. Norton & Roper-Lindsay 2004). Question that have arisen include: is significance determined in terms of its contribution to local ecosystem functioning, or is it significant in terms of people's perceptions, or is something significant nationally due to conservation status but not necessarily be in decline locally. Different scales, times, and space have been important for the assessment of significance. These questions have proven to be controversial since the inception of the Resource Management Act. For example, large tracts of native habitat and important sites, or environmentally sensitive sites along the coast, perhaps, should continue to be primarily maintained for their conservation value. But they may also be important in the provision of certain services, such as clean water, coastal fisheries, or carbon storage as secondary outcomes.

Significance of indigenous biological diversity, in terms of the functions of district councils, could be more focussed on enhancing the delivery of ecosystem services, which is more in keeping with their functions than conservation planning. In this model, contribution to ecosystem services delivery becomes the primary objective for biodiversity on private land, and conservation remains the focus of public land, and the policy and rules flow from this. Various parts of the Resource Management Act processes presently have the capacity to incorporate the ecosystem services framework.

5.2.1 Objectives & Policies

A key component of resource management in New Zealand is the use of objectives and policies to guide environmental decision-making. The use of objectives and policies in relation to the maintenance and delivery of ecosystem services could be appropriate in National Policy

Statements, Regional Policy Statements, Regional Plans, or District Plans. These objectives and policies may not necessarily be prescriptive, but could provide strong enabling approaches for different landuse approaches.

For example, objectives and policies could be crafted for the purposes of giving development more credit for maintaining and enhancing ecosystem services. In any complex subdivision or landuse application, a wide range of issues are generally balanced in the decision-making process. If an applicant meets such crafted 'objectives and policies' then it could increase the opportunities for their proposal being accepted.

This approach could also allow for better 'sense of place' planning, with the possibility of promoting different ecosystem services within different catchments, or enable decision-making that takes advantage of the latest available science or maatauranga Maori[22]. These differences in focus for each catchment could be based on the lack of a particular critical ecosystem service that impedes future development or it could be to promote the delivery of services that meet particular, identifiable community aspirations that develop their 'sense of place'.

5.2.2 Resource Consent Applications

Under the Resource Management Act, applicants are expected to prepare an assessment of the environmental effects of their proposed activities should the activity require a consent. Whilst this assessment is undertaken, it is often carried out on a piece-meal basis, e.g. the values of a specified particular location or site. It is not always clear as to the wider significance that the activity has on surrounding areas, although cumulative effects is a resource management term that tries to incorporate the significance of a development within the wider environment.

Environmental effects are relatively easy to evaluate (albeit on a technical basis) on a site by site basis in terms of the built environment and according to the rules in a plan, whether regional or territorial, but it is much more difficult to understand the impact of the activities on the functioning of the wider ecosystem, including any possible trade-offs required to evaluate the proposed development. Whilst the removal of a piece of bush may not seem significant on the site itself, it may have consequences for the surrounding pasture, such as clover production, horticulture output, and urban gardens which may rely on water or pollination services. Use of an ecosystem services delivery framework can use structure methods to understand wider implications of the activity, both negative and positive.

Likewise, when understanding the impacts from resource consent applications under the Resource Management Act, the concept of ecosystem services can help establish the wider understanding of who may be affected by a development proposal. One of the key ideas of

[22] See Chapter 4.2 Waikato-Tainui Rvier Settlement for an example of an objective used in the Deeds of Settlement of a Treaty of Waitangi clai that mentions maatauranga Maori and latest available science.

ecosystem services analysis is that it widens knowledge of the identifiable beneficiaries or stakeholders that benefit from continued provision and intactness of habitat. For example, surrounding orchardists do benefit from native pollination coming from a patch of bush. Previously, in environmental policy making, the range of potential stakeholders would be limited to immediately proximate stakeholders, and some public interest criterion. But given that the location of the actual patch of habitat may not be immediate to its service provision (pollination locally, downstream water impacts regionally, carbon mitigation globally), the patch of habitat may be seen to have a much wider significance and this is important when understanding cumulative events.

Conversely, the specific introduction of ecosystem services as a mitigation measure for subdivision applicants could also be useful in terms of promoting positive development. At present some developers will offer particular trade-offs in exchange for development. But often these offers are simply seen as an additional patch of bush. Recognising wider values may enhance the value of the offer. The context of the offered mitigation will be important, in that patches that significantly enhance lowland areas, or provide habitat to pollinators and seed dispersers may be more important than a larger patch in an area that already has ecosystem services. Likewise, it may be that any proffered incentive may need to be undertaken within the originating catchment. This includes understanding what are the actions that are useful immediately, as well as actions that are presently small in scale, but over time will have larger payoffs over time in terms of providing ecosystem services. Understanding this significance over the longer term is important in building resilience.

The "environmental benefit" rule already provided in the Whangarei District Plan does not presently take wider values into account, but this approach would be appropriate should changes to that rule eventuate. The use of agglomeration bonuses to help protect wider tracts of land is a distinct possibility in the longer term (Shogren et al 2003, Parkhurst & Shogren 2007). This is where two or more landowners that share a wider environmental feature can benefit from bonus payments or lots for subdivision if they are both enrolled in a local scheme. This process could also include the development of an ecosystem services district, where all landowners in the district pool their efforts to enhance some services. Prime examples of this approach internationally include water catchment bodies in the United States (Goldman et al 2007), or cloud forest in Ecuador that are paid by the urban area downstream to maintain the forest.

Overall, different scales of impact from development, both positive and negative, on the provision of ecosystem services will need to be understood in terms of developing an appropriate mitigation response for development. The concept of ecosystem services has already begun to be used in resource consent evidence, but in an ad hoc way, and there needs

to be acceptance that it will be used more regularly in evidence and local government needs to be prepared.

5.2.3 Section 32

Every plan or policy plan change undertaken by local government requires an assessment of the costs and benefits of a project under S.32 of the RMA 1991, and these require an evaluation against matters raised in Part II of the Resource Management Act. These matters include *the preservation of the natural character of the coastal environment, wetlands, rivers and lakes and their margins*; and *the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna*, the development of any plan changes to meet Part II of the Act can be very controversial and are dependant on professional opinion for their resolution, as much of the debate can be academic in nature. As such, the benefits of their protection or enhancement on *"safeguarding the life-supporting capacity of air, water, soil and ecosystems"* have been difficult to quantify, and even more difficult to understand by the wider public.

When dealing with issues that emerge from Section II of the Act, evaluating trade-offs can be a difficult process The use of the ecosystem services framework lends itself quite well to better understanding of the trade-offs involved in complex decision-making, as it shines a light on aspects that were not contemplated. Focussing on the benefits or costs in terms of ecosystem services delivery would allow a more practical or pragmatic focus for explaining why a certain action is required by the local council.

Many of the attributes outlined in Section 5.2.2 are also relevant to the preparation of plan changes, with the role of territorial authority as applicant.

5.3 Priorities

New Zealand's landscape has experienced large-scale changes in the last couple of centuries, and in 2007, central government released a series of National Priorities that are to be addressed by regional and district councils when developing policy to protect biodiversity. The most important one for an area like Whangarei District, due to the extensive removal of much indigenous vegetation is:

> *National Priority 1 - To protect indigenous vegetation associated with land environments, (defined by Land Environments of New Zealand at Level IV), that have 20 percent or less remaining in indigenous cover*[23].

This national priority uses Land Environments of New Zealand (LENZ), the Land Cover Database (LCDB) and a national database of land protection status to identify what type of vegetation

[23] http://www.mfe.govt.nz/issues/biodiversity/rare/

occurs in each land environment and the broad pattern of formal protection that each location has. LENZ is a national environment-based classification of ecosystems mapped across New Zealand's landscape, and is used as a surrogate for the likely past (pre-human) pattern of terrestrial ecosystems and their associated biodiversity.

The threshold of 20% of remaining original indigenous cover is viewed as the minimum required for conservation values. This information is then layered against the actual levels of formally protected land in order to understand which area are underprotected in a formal sense, in the Threatened Environments Programme.

From this information, local government is then expected to develop polices that promote the maintenance, enhancement and restoration of locations to meet the 20% threshold. To implement this would require large investments in a location like Whangarei District which has many locations which would be considered threatened in status. Some locations have been so heavily modified that much restoration will be required over time to meet these conservation objectives.

Prioritising key areas will be necessary over time, given that only a small pool of resources would be available for this purpose. The ecosystem service approach may be beneficial in identifying key localities for further work programmes, as they can connect local conservation actions with wider benefits and identify the different scales for each project or elements of ecosystem services that are important. This is useful as it may be a more efficient means of allocating scarce financial resources, whether by investing in services that are critical and yet in danger of disappearing, or protecting those locations in which many different services are required, and thus providing multiple benefits for each action.

5.4 Strategic Alignment of Resources

There are many organisations involved in environmental management, including regional council, landcare groups, large forestry companies, Iwi, smaller landowners, Department of Conservation and district and regional councils. But despite work being undertaken, decline is continuing. The forthcoming Biodiversity Background Report points to ongoing decline of biodiversity values within Whangarei District, but also notes the many efforts being undertaken by landowners across the district. The objective of each organisation in terms of biodiversity tends to be different in focus, especially in regard to private land. Each of these stakeholders has different access to resources, but also different preferred outcomes in terms of biodiversity values. This can often lead to fragmentation in overall management. Many of these objectives can fit into the framework of ecosystem services delivery compared with conservation values approaches.

The framework of ecosystem services may be useful in better aligning resources between different land managers to get more efficient bang for their collective bucks. For example, some

catchments may require too much work at the present time to be effective, whereas other catchments may be more appropriate for management in the short time. Shifting funding programmes that build coalitions to support the use of soft infrastructure, such as the aforementioned stakeholder groups, and their differing priorities. Developing better linkages between public and private outcomes may be a more beneficial outcome.

5.5 Public Assets

The Crown's or Whangarei District Council's own assets may be viewed in a different light by the public, if the ecosystem services framework was applied. Much recent literature in asset management and engineering points to increased use of soft infrastructure approaches as an appropriate means of flood attenuation, water quality filtration, or cleansing sewerage. In this view, parks and reserves are not regarded just simply as places to take a walk, but play an important role in providing habitat for pollinators, provide water quality functions, soil and nutrient cycling, carbon storage, and can play a role in the wider health and wellbeing of citizens. This is especially important in contexts where urban areas have reasonably high levels of density of population, and have less green space. They can also play a role in building and maintaining productivity in urban work environments.

Council environmental management in the urban areas could shift, using parks, reserves, and streams as the main ecosystem services providers within an urban environment, but Council could also provide incentives for the maintenance of larger urban trees, promote riparian planting, or encourage the planting of indigenous shrubs on private property (these would provide additional food for birds and insects, but may not result in as many neighbourhood disputes over larger trees). Likewise, golf courses, community gardens, and even cemeteries have importance beyond their boundaries in terms of the ecosystem services delivery framework. In Australia, Brisbane City Council has starting developing an Environmental Asset Management Plan which identifies indigenous habitat, wetlands, and parks, and picks up their value to the surrounding neighbourhood and city (Pearson et al 2008). When understanding the role of parks, they hold significance for their immediate localities, but networks can be significant across a region, or to wider beneficiaries in the urban area.

Such views or approaches are not limited to local government. Headwaters of many streams and river in New Zealand are under the management of the Department of Conservation or other Crown Agencies. Fully functioning ecosystems in these upper catchments provide good water quality downstream, and, in times of dry weather, continue to allow for moderate low flows. Trees and vegetation capture much water from precipitation, and provide infiltration of water into the soil. It also provides carbon storage. However, in setting up management programmes or budgets for the Department of Conservation in New Zealand, this wider set of benefits is often not taken into account in governmental priorities. Use of the ecosystem

services delivery framework could add impetus to maintaining and enhancing DOC land as critical to the ongoing welfare of New Zealand.

5.6 Community Catchments

Much environmental planning in New Zealand is based around producing generalised rules that apply across whole regions or districts, albeit some differentiation into broad zones. It is increasingly recognised that such generalised approaches do not allow for the special characteristics of particular areas within a district or region. Some locations could, arguably, cope with increased development, whereas other areas may not have a high level of resilience due to past changes in the catchment. Catchments may be an appropriate management unit for the ecosystem services policy, as it can help recognise the trade-offs that may be available in an area and can focus on key connections in the landscape that allow for potential development. Some international literature, and some work in New Zealand, has proposed using catchments as an appropriate environmental management unit. Programmes such as Integrated Catchment Management have emerged in places like Tasman District Council.

One of the longer term programmes could be the development of ecosystem service districts, in partnership and with the local community. These ecosystem services districts would be particular catchments where the landowners agree to certain actions around the protection or maintenance of some determined ecosystem services in return for incentives (Goldman et al 2008). Looking at the Government's plans for water, it would be expected that water-based ecosystem services district will be used as an approach in key catchments of New Zealand with multiple large competing demands.

Whilst many catchment approaches like these are most likely to be led by local and regional government, at times community themselves can take the lead in promoting indigenous habitat. Whilst most regulation has been top down in approach, there have been instances, albeit incredibly rare, where local communities have either put together private agreements on conservation over an entire landscape, and then advocated to the local government for their inclusion into the local regulation and planning documents. For example, in Victoria, Australia, a group of landowners voluntarily agreed to enhance and maintain local biodiversity and produced private covenants. Later, they then successfully lobbied the state government for their inclusion into state agreements (Nelson 2001). Similar agreements have occurred in the development of community forestry in many parts of the world (Nelson 2005).

Through the identification of particular thresholds of different services preferred locally, it may be possible to undertake activities to ensure the maintenance of different ecosystem services. For example, if insectivorous birds such as fantails were a preferred species for pest control, then small patches of habitat such as half a hectare may be sufficient. However, if flood attenuation is required, then the retention or restoration of wetlands may be necessary.

Whilst this approach may at first seem a little controlled, a similar type of approach has been used in land-use planning elsewhere, such as in the United States, in which size distributions or foraging areas for birds and mammals have been used to identify more significant habitat. This was for those species protected by the Endangered Species Act in the United States. Whilst the legislation in the United States is different, there will be lessons for planning in New Zealand in terms of providing for ecosystem services in identification of key threats for the delivery of preferred services.

The concept could be extended to a group of landowners pushing for organic farming in a given locality, and then lobbying local government to include this in their planning. In some locations, such a scheme could be used to allow for particular catchments to become organic in focus, or specifically develop cross boundary schemes for indigenous forestry or other types of agricultural activity. Likewise, landowners with predominantly dairy catchment could agree to produce certain outcomes that benefit themselves and their neighbours, similar to some landowners in the Aorere River catchment in the Tasman District that connected community well-being, coastal water quality, and river water quality with their environmental efforts[24].

Alternatively, the purchase and use of easements for critical ecosystem services could also be an option, for public groups and local government as well. However, community groups, under New Zealand legislation, may not have as much protection for their interests, e.g. should they prefer to purchase specialised services from providers such as landowners, they may not have strong recourse to the law if something goes wrong in the agreement or relationship (Ewing 2006). Whilst use of conservation easements has been a regular approach in the United States, this approach may not be as strong here (Ewing 2006), although The Queen Elizabeth the Second Trust is an organisation of this type. Outright purchases of locations have occurred by various trusts in New Zealand[25], but there have been fewer agreements either between conservation organisations (in the form of easements) or between private parties for certain ecosystem services outcomes. Private covenants between parties may play a role in providing a continued flow of ecosystem services in return for development right, as a means for reducing reverse sensitivity.

5.7 Ecosystem Services and Iwi Management Plans

Many of the principles behind planning for the delivery of ecosystem services can be similar to the approaches of resource management undertaken by Iwi and Hapu. Iwi Management plans emphasise the holistic nature of environment management and the deep connections and

[24] http://www.nzarm.org.nz/Brown_Aorere_2009.pdf. This type of project is parallelled by many other catchment projects undertaken by other landcare groups across the country but went further in understanding connections.

[25] E.g. NZ Native Forest Restoration Trust

relationships between people and the place within which they live. However, one major difference between planning for ecosystem service delivery and Maori approaches to resource management is that the ecosystem services approach does involve some prioritisation of values, and tries to determine significance, whereas Maori approaches emphasis that there should not be any hierarchical values involved in resource management. The following sections outline key objectives and policies of relevance to an ecosystem services framework from Iwi Management Plans that have been lodged with Whangarei District Council:

Ngatiwai Trust Board[26]

Air Quality Objectives for Ngatiwai rohe

The life supporting capacity of air enables optimum health and wellness for all Tāngata Whenua; those they host within their rohe; their plants, animals and other whanaunga; and their waterways and moana.

Water Objectives for Ngatiwai rohe

The mauri of water and soil is protected and enhanced in ways which enable Tāngata Whenua to provide for their social, economic and cultural wellbeing; and that of generations as yet unborn.

The life-supporting capacity of creeks, streams, water bodies, wetlands, swamps, springs, aquifers, thermal waters, estuarine waters and coastal waters enables optimum health and wellness for all Tāngata Whenua; those they host within their rohe; their plants, animals and other whanaunga.

The sustainable management of water, soil and air in a collaborative manner considering all flow on effects.

Water use, allocation, and flow will be sustainably managed within Ngatiwai territory.

Water Policies for Ngatiwai rohe

1. Tāngata Whenua promote innovative, sustainable management practices concerning water. All natural water has value and sustains some form of natural life in the environment. Water is a sacred resource to Tāngata Whenua, to be given the highest level of protection.

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[26] Sourced from Ngatiwai Iwi Environmental Management Plan 2008. Available publicly from http://mail.ngatiwai.iwi.nz/downloads.html . The contact details for Ngatiwai Trust Board can be found here: http://mail.ngatiwai.iwi.nz/contactus.html Ngatiwai Trust Board gave Whangarei District Council permission to publish their Iwi Management Plan on the Council Website, and can be found here http://www.wdc.govt.nz/resources/12637/Iwi-Management-Plan-2007.pdf

3. All regional councils will have an integrated catchment riparian management and implementation strategy.

9. Water must be seen and managed in an integrated, holistic way as per its cycle, and as an element of the life supporting natural and physical environment. Water should not be viewed just as a running stream, a lake, or an aquifer, with no relationship to the other resources within its environment.

10. All activities concerning or potentially affecting creeks, streams, water bodies, wetlands, swamps, springs, aquifers, thermal waters, estuarine waters and coastal waters within a water catchment will be managed in an integrated way on a catchment basis.

11. Regional and district plans and strategies will promote and provide incentives for the planting of riparian margins from the headwaters of a catchment through to its outfall into the moana.

12. Regional and district plans and strategies will promote and provide incentives for the rehabilitation, enhancement and protection of existing river banks and riparian margins, and their further extension along the margins and beds of water bodies.

Indigenous Flora Objectives for Ngatiwai rohe

The maintenance and restoration of natural species, habitats and ecosystems.

The enhancement of endemic and endangered indigenous species and habitat.

The mauri of indigenous ecosystems is protected and enhanced in ways which enable Tāngata Whenua to provide for their social, economic and cultural wellbeing; and that of generations as yet unborn.

The life-supporting capacity of indigenous ecosystems enables optimum health and wellness for all Tāngata Whenua; those they host within their rohe; their plants, animals and other whanaunga; and their waterways and moana.

Indigenous Flora Policies for Ngatiwai rohe

2. No hierarchical values will be placed on indigenous flora within any council's planning documents to decide differing levels of protection.

7. Ngatiwai kaitiakitanga will be recognised as a viable management approach with respect to its indigenous flora.

9. Use will be made of all relevant forms of knowledge and practises and information, including Tāngata Whenua traditional environmental knowledge, in assessments and decision-making around indigenous flora.

Indigenous Fauna Objectives for Ngatiwai rohe

The maintenance and restoration of natural species.

The enhancement of endemic and endangered indigenous animals.

Tāngata Whenua are acknowledged as the kaitiaki of all indigenous animals and their associated ecosystems within their rohe.

Tāngata Whenua traditional environmental knowledge in relation to animals is appropriately acknowledged and utilised.

Indigenous Fauna Policies for Ngatiwai rohe

2. No hierarchical values will be placed on indigenous fauna within any council's planning documents to decide differing levels of protection.

7. Ngatiwai kaitiakitanga will be recognised as a viable management approach with respect to its indigenous fauna.

9. Use will be made of all relevant forms of knowledge and practises and information, including Tāngata Whenua traditional environmental knowledge, in assessments and decision-making around indigenous fauna.

Patuharakeke Trust Board[27]

Fewer policies or objectives of relevance to this background report are found in the Patuharakeke Te Iwi Trust Board Environmental Plan 2007, but the ones of relevance include:

Patuharakeke Te Iwi Trust Board recommends:

6. That a stronger enforcement structure to protect the indigenous Māori people, and the flora and fauna in the Takahiwai Hills from business development must be set up. For example, a Joint Management structure consisting of WDC, Patuharakeke Te Iwi Trust Board (Inc), the Department of Conservation and the Bream Action Group must be set up.

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[27] Sourced from Patuharakeke Trust Board. Available from: http://www.wdc.govt.nz/resources/12637/Iwi-Management-Plan-Patuharakeke-Te-Iwi-Trust-Board-Environmental-Management-Plan-2007.pdf

Contact details for the Patuharakeke Trust Board can be found here: http://www.takahiwai.net.nz/takahiwai%20marae_003.htm

7. That a stronger enforcement structure to protect the indigenous Māori people, marine creatures and the foreshore of the waterways known as Takahiwai, Te Hopua, Mangawhati and Te Kopuawaiwaha (on the southern side of the Te Rerenga Parāoa) from recreational sportspeople and tourists must be set up. For example, a Joint Management structure consisting in WDC, the Northland Regional Council, Patuharakeke Te Iwi Trust Board (Inc), and the Department of Conservation must be set up.

Ngati Hine[28]

This document has similar objectives and policies that are important when considering ecosystem services, but have not been reproduced here.

6.0 Whangarei District

Whangarei District contains a wealth of distinctive landscapes that strongly contribute towards the character of the place and its people, also known as its 'sense of place'. From the fertile wetlands, through to the bush shrouded ranges, and down to the eastern coast, the wide range of habitats is essential for the ongoing survival of some of our most endangered species such as pateke, kiwi and kaka. More than that, the environment has played a large role in defining the character of Northland, in other words its sense of place.

The Northland Regional Policy Statement, Regional Plans, and the District Plan all contain provisions for the purposes of protecting remaining stands of indigenous vegetation, ranging from riparian strips, through to protection for blocks of bush that are over 1 ha in size across much of the district. These fragments remain due to the foresight of landowners, or lack of rationale for improvements or for aesthetic purposes. Continued retention of these areas remains important in the face of future population and environmental pressures. However, despite limited supplies of habitat or extensive modifications, many different ecosystem services are evident in the urban area. These range from the water catchments, through to the roles of vegetation in flood attenuation, and water infiltration. Even such things as the humble ant plays a role in the provision of such services, in this case enabling water infiltration into the soils through their tunnels following rain.

Whangarei City is blessed in having significant patches of bush over looking the city, a harbour at its doorstep, a range of coastal habitats in which to live, work and play. These hills provide habitat for species such as pekapeka (long tailed bat), kauri snails and so on (DOC 2001). This

[28] The first chapter of the Ngāti Hine Environmental Plan can be found here http://www.ngatihine.iwi.nz/environmentalplan It is necessary to contact Ngāti Hine for further details about their Iwi Management Plan. http://www.ngatihine.iwi.nz/contacts

natural environment also provides a wealth of ecosystem services that have a key impact on people's wellbeing. From the provision of clean air and water, high levels of soil ecology to help provide food, the pollinators that are needed to provide the food we eat, or the bush for recreational and spiritual value, ecosystem services are a key fundamental of sustainable development of Whangarei District. As most of these services require healthy ecosystems, and high biodiversity values, it is recognised that biodiversity is a key element of sustainability.

The 270,000 hectares of Whangarei District contains 6 ecological districts, or areas where distinct patterns to the landscape can be found, places where the climate, soils, and topography influences the habitat structure. Some of the species found in these areas are found elsewhere in Northland, but some species historically found in Whangarei are not found here anymore. Examples of this include the weka (successfully introduced back into Russell following large scale pest control efforts), and kokako (found in Whangarei District before 1978). It is not to say that there have not been species successes, such as the popularity of kiwi restoration programmes, the development of marine reserves, or the various conservation trusts, but, if the general trends observed across the breadth of New Zealand, and worldwide, are accurate in Northland, then the prognosis for biodiversity values is not good. Overall decline in biological diversity seems to be the order of the day, with some successes in various species following large efforts, but not overall.

Overall, Whangarei city itself is reasonably well-served by the delivery of ecosystem services, although more could be done around the restoration of streams and waterways. However, other parts of the district with growing populations are not so strongly blessed, such as around Ruakaka or Waipu and their associated catchments.

Forested catchments play an important role in the provision of drinking water, with Whangarei being one of the districts in New Zealand most dependant on forested water catchments for clean drinking water, rather than using groundwater or alpine sources. NIWA climate projections point towards more extreme weather events, which will have an impact on biodiversity and therefore ecosystem service values. The best insurance for biodiversity is to maintain, enhance, and, where appropriate, expand the available habitat, and provide connections to the wider areas. In most cases this will mean indigenous biodiversity is the preferred value to be maintained, but, on occasion, non-indigenous biodiversity options may be the more appropriate material to work with.

There are 17 major catchments within the Whangarei District, as illustrated in Figure 4. Noticeably, many of these rivers and streams head westwards; with the Wairua/Wairoa system draining much of the district, and eventually drains into the Kaipara Harbour. Most of the eastern rivers and streams are relatively small catchments. Few patches of indigenous habitat are left in the lower and middle segments of the west-draining catchments, although the upper catchments are often still bush-clad. The east bound rivers, on the other hand, tend to have

more remaining significant indigenous vegetation, but their lower catchments are the focus of ongoing development and subdivision. Being small catchments water levels can rise and fall quickly. Indigenous vegetation retention as part of flood attenuation tends to be more important within small catchments than in larger ones. Land use changes also have a proportionally higher impact within these catchments when compared with activities in a larger catchment such as the Wairoa/Wairua system. This holds for both negative and positive effects but also considerable opportunities for mitigation. This also means that mitigation actions used for development within a small catchment should remain within small catchment, preferably the same catchment, rather than being transferred to a larger catchment. Conversely, however, mitigation action in larger catchments for development could be transferred to smaller catchment, especially where higher populations are evident.

Of additional note is that much of the land designated as erosion prone land in regional council documents, is located in uplands of many catchments, especially on the eastern hills, as figures 4 and 5 indicate. The next map, Figure 6, shows that much of this erosion prone land is covered in significant indigenous vegetation, especially on the eastern hills north of Whangarei and in the uplands above Bream Bay. The eastern hills also have the highest risk of extreme rainfall, as indicated in the Natural Hazard Constraints report (p14). These eastern hills are also important for plantation forests, which were often planted in areas prone to erosion across New Zealand. Most flood susceptible areas are located on the lowlands areas, and have very little significant indigenous vegetation left, and what exists tends to be in small patches. Of note is that very little significant vegetation remains above the Hikurangi Basin, but there is little erosion prone land in the vicinity of the Hikurangi Basin either. This would have meant that there were few barriers to land clearance around this basin, especially in a location with good soils in the vicinity.

The following series of figures are maps illustrating various biophysical attributes and characteristics of Whangarei District. These are important for the process of identifying important major sources of ecosystem services and to help define the likely beneficiaries of ecosystem services. Figure 4 illustrates boundaries of the 17 catchments, as well as the location of major streams in the district. It also helps to illustrate the direction each waterway drains towards, and which settlements are located within a given catchment.

Figure 5 maps the various slopes of the land around Whangarei Harbour. The dark green refers to flat to gently slope locations (0-3 degrees) that help identifying waterways draining into the harbour and valley floors.

Figure 6 maps the main erosion prone areas (often the location of river headwaters) and flood susceptible areas with the district, as well as the catchment boundaries. This helps to identify potential sources of sedimentation and water for many catchments.

Figure 7 is an evolution of Figure 6, with the location of significant natural areas, where available. Of note is that many erosion prone areas are covered or surrounded by bush areas, especially around the eastern hills and above Bream Bay. It also helps identify which significant natural areas are located in the headwaters of rivers that provide water to downstream users.

Figure 8 maps the lowest elevation locations around the harbour. Of note is the relative importance of high points along the coast, especially dunes, which protect lowlands to the west along Bream Bay and parts of Whangarei Heads.

These maps are then used is the evaluation of the three futures.

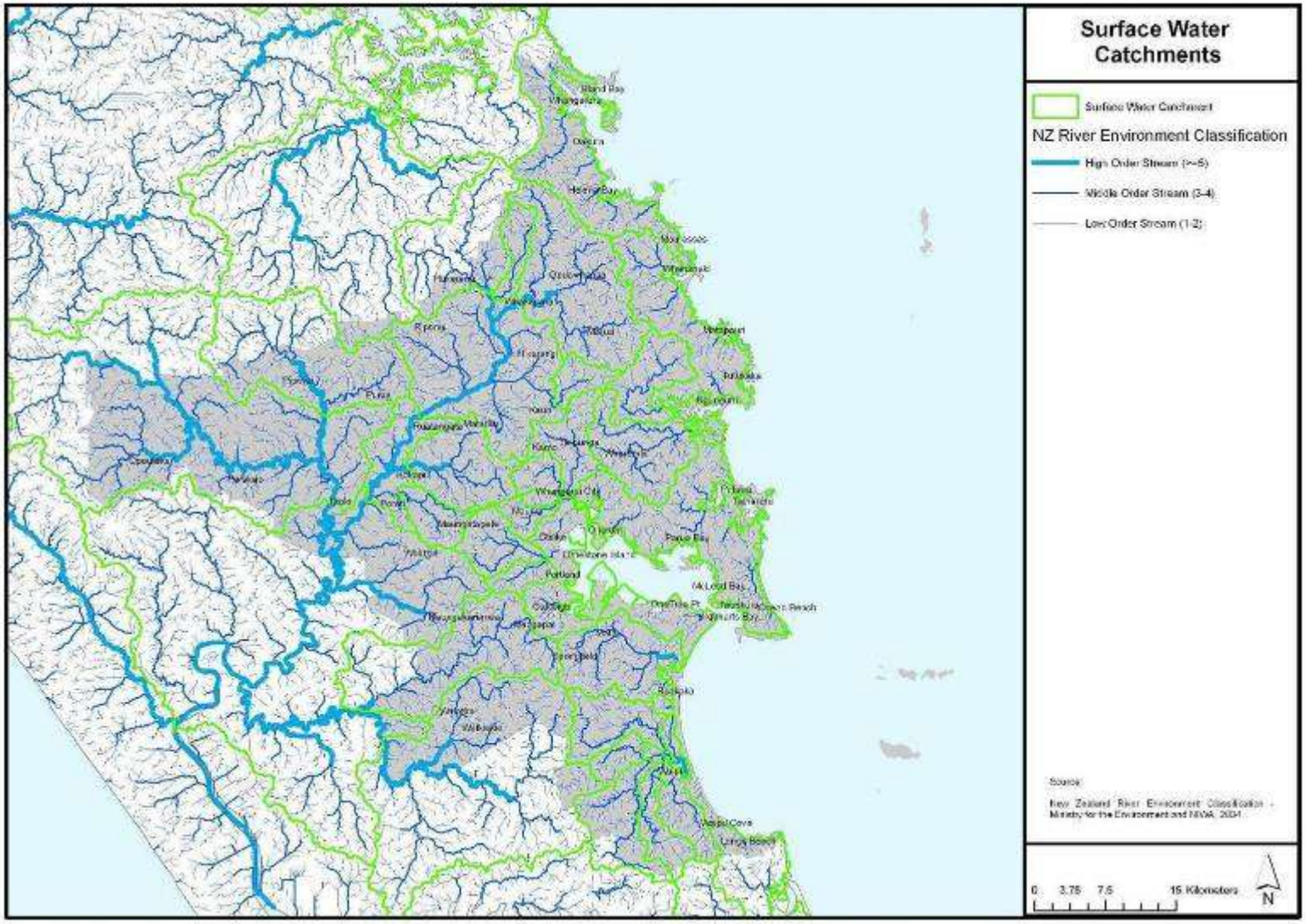

Figure 4: Key waterways and catchments within Whangarei District.

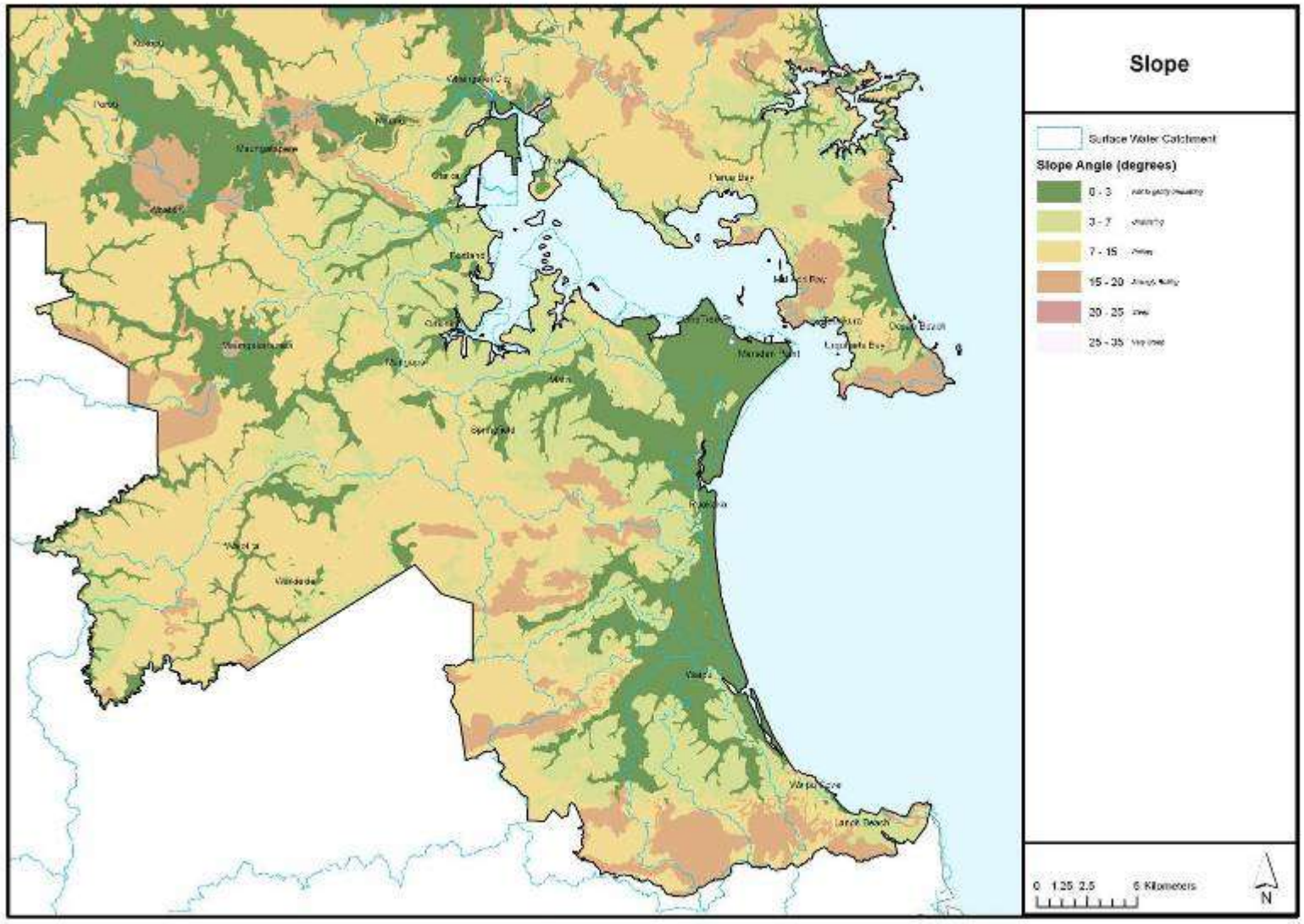

Figure 5: Map of Slope Around Whangarei Harbour and Bream Bay.

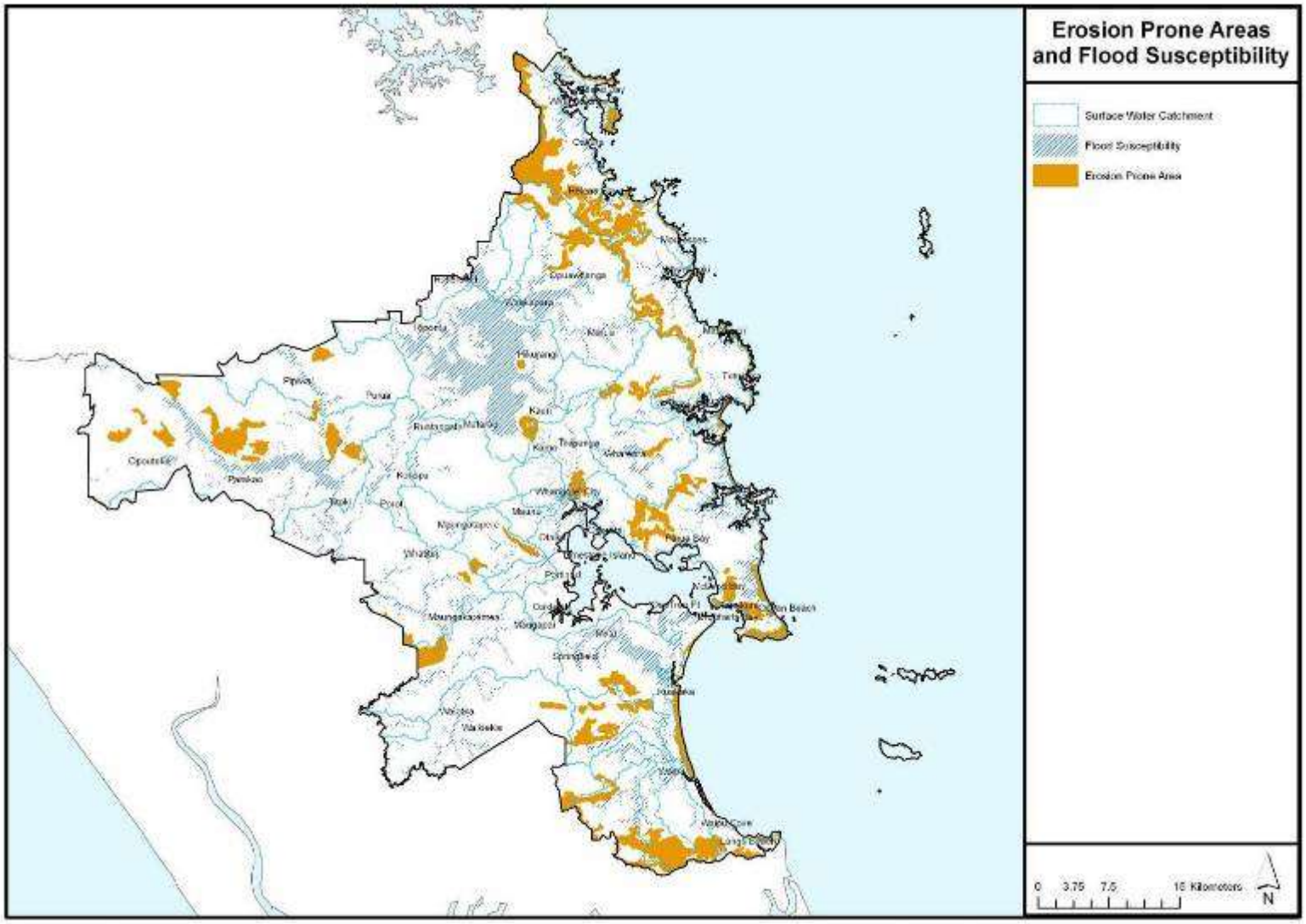

Figure 6: Map of Catchment Boundaries, Erosion Prone Areas and Flood Susceptibility

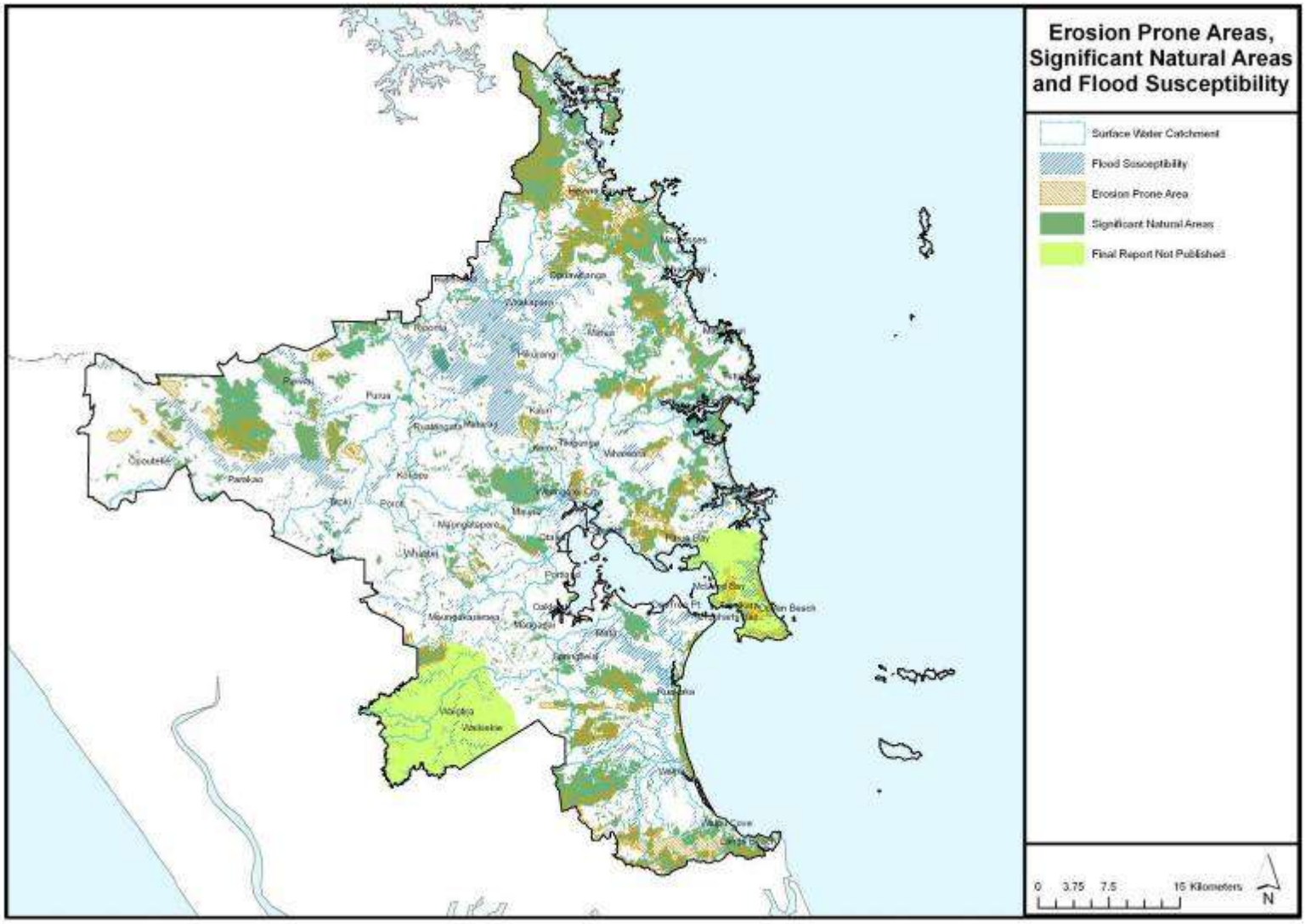

Figure 7: Map of Significant Natural Areas, Catchment Boundaries, Erosion Prone Areas and Flood Susceptibility.

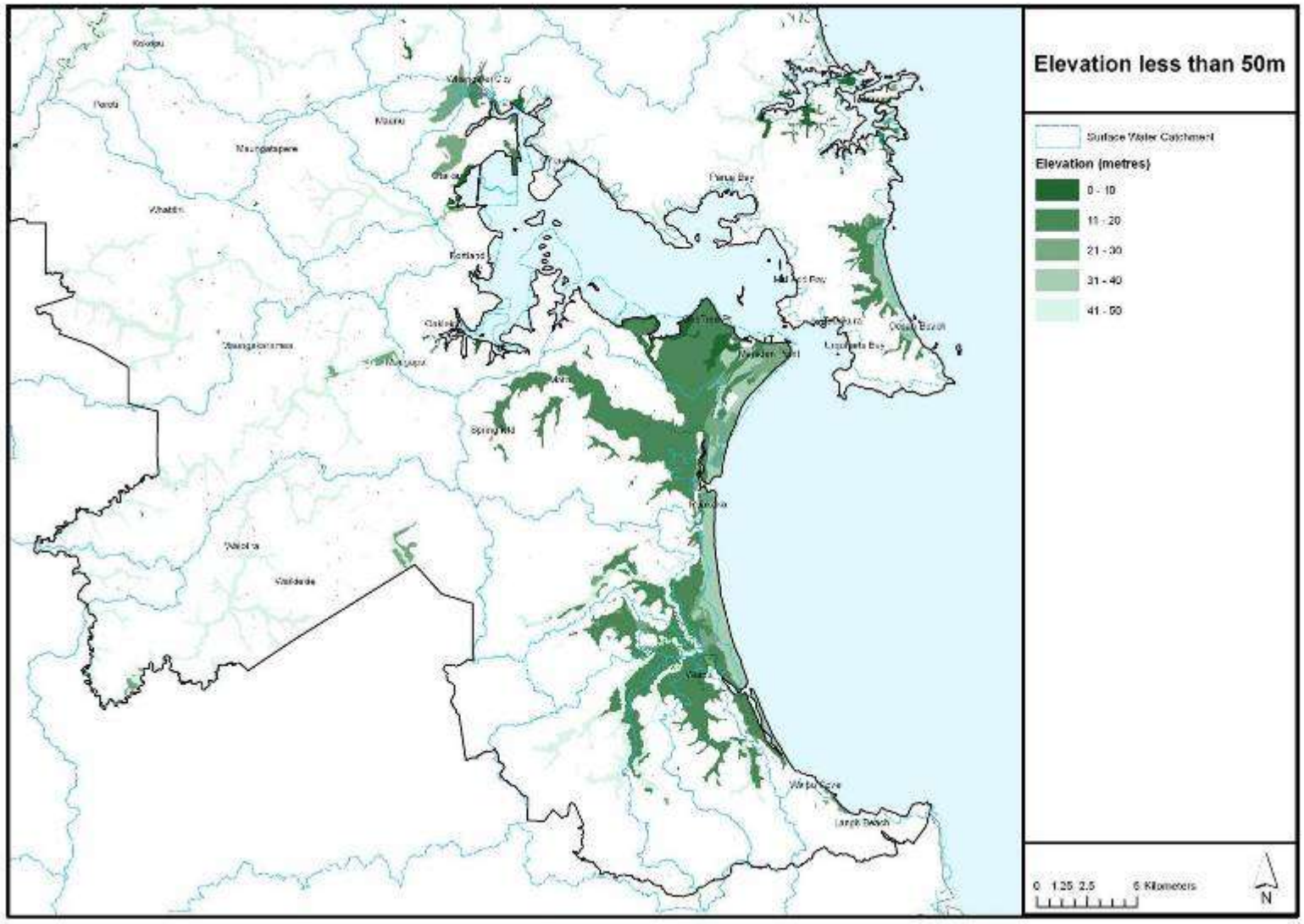

Figure 8 Map of Low-Lying Land Around Whangarei Harbour.

7.0 Comparison of the Three Futures

The Growth Strategy outlines three alternative futures for the district over the next 30/50 years. The Three futures are presented to stimulate debate as to the preferred future settlement pattern for the district over the next 50 years. The following is a brief analysis of the most plausible impacts on the provision of ecosystem services, dependant on the likely spatial patterns of development in the Whangarei District. Once again, it should be reiterated that this assessment is at a broad level and there are high levels of uncertainty in some respects.

Future One represents a lightly regulated, market led approach to development and, in general, reflects land development in the district over the past 10-20 years. It is presented as a continuation of this lightly regulated, largely market driven approach to land development and can be seen as a baseline against which to evaluate the other two options, in addition to being an alternative development path in its own right.

Futures Two is an intermediate position between Futures One and Three. It represents a moderately controlled, less consolidated development path based upon a three tier settlement pattern. These tiers consist of: twin cities at Whangarei and Marsden Point/Ruakaka competing with each other for higher level service provision; urban and coastal settlements with some associated urban sprawl and ribbon development; and rural urban development largely at village level with some sporadic development throughout the rural area.

Future Three represents a managed, consolidated development path based upon a structured five tier settlement pattern. This hierarchical arrangement is as follows: Whangarei City as the primary district and regional urban centre with a strong, protected and enduring CBD; a satellite town at Marsden Point/Ruakaka which complements (but does not compete with) Whangarei City; five urban villages within greater Whangarei; one rural (Hikurangi) and two coastal growth nodes at Parua Bay and Waipu; and two rural villages along with eight coastal villages located along the coastline from Waipu Cove in the south to Oakura in the north.

In general terms, indigenous habitat of larger sizes will supply more ecosystem services than modified landscapes of a similar size. However, modified landscapes will supply ecosystem services as well, irrespective of whether it is forestry, pastoral landscape or dairying. And these areas will often supply more than urban areas. The supply of ecosystem services from lifestyle blocks is heavily dependant upon their management, and cannot easily be generalised Therefore fragmentation of these areas is especially important to understand how ecosystem services may be impacted by future development, especially within catchments.

The key areas of interest in terms of ecosystem services and future development would be:

Provisioning services such as food (dairying, pastoral, horticulture), fibre (timber), freshwater (drinking and potential irrigation), air quality regulation (around urban areas), local climate

regulation (especially in urban areas), global climate regulation, water regulation (especially run-off, flooding, and aquifer recharge), erosion regulation, water purification and waste treatment (especially around settlements), pest regulation, pollination, natural hazard regulation (reducing damage from natural hazard events such as storms, or retaining enough moisture to avoid fire risk), recreation and ecotourism elements, nutrient cycling (efficiency of soil micro-organisms in processing and making available nutrients), and soil formation. Each of these main ecosystem services will be qualitatively addressed for each of the three futures.

7.1 Future One: Lightly Regulated, Market Led Development (Business as Usual)

In this Future, there is continued market led development resulting in a widely dispersed settlement pattern consisting of two discernable trends:

Urban development dispersed throughout the district with concentrations in Whangarei, Marsden Point/Ruakaka, and other urban, rural and coastal locations and along transport corridors.

Widely dispersed, sporadic rural residential development throughout the district including both countryside and coastal countryside environments.

The countryside area has recently seen significant recent growth, and if projected into the future, there is expected to be a substantial population dispersed in the countryside (from 20% to 25% of the total population). Recent population growth at Marsden Point/Ruakaka has not been very strong, and if projected into the future, this area actually decreases its relative percentage of population (from 4% to 3%). Dispersed settlement in the coastal area is also likely, with 13% of the population living in coastal areas. The relative percentage of population found in Whangarei city decreases in this Future, from 66% to 57%. Of the three futures, this is the least urbanised and most dispersed. Table 4 indicates the overall broad impact on both supply of and demand for ecosystem services, based on the overall development pattern.

As suggested in the previous sections, many favoured locations for settlement do not have much significant vegetation in their vicinity, with the notable exception of the coastal catchments. Places like Ruakaka, Waipu and most coastal settlements do have substantial patches of bush in their upper catchments, but Ruakaka and Waipu have little in their middle and lower catchments, impeding flood attenuation. Few patches of protected land are located within the settlement areas, and notably, few protected areas of large size lie within the wider catchments of the largest settlements. Few areas used for forestry are located in popular catchments. The main concern in terms of Future One is that ongoing popularity of versatile soils for lifestyle blocks does put pressure on ecosystem services. As these areas are developed, pressure for food production, and reverse sensitivity in remaining productive blocks close to the lifestyler property owners, will mean that present marginal areas will come under pressure. In terms of cultural ecosystem services, it is likely that the continued growth of lifestyle

opportunities will mean that more indigenous vegetation is planted, and that connections between patches of habitat do occur. Therefore , lifestyle blocks, depending on their individual management, can have advantages and disadvantages for the delivery of ecosystem services across the district.

Few significant natural areas are directly located within the projected areas for settlement under Futures One, however, some significant natural areas are located within their catchment boundaries, and will be supplying a range of ecosystem services downstream. In terms of protected areas, few large formally protected areas of land are located within the main settlement catchments around the district. This would suggest that mechanisms are needed to ensure the ongoing provision of ecosystem services across the district from private land.

Maps illustrating the productive land uses have been included because of their significance to the district, and they are also sources of ecosystem service delivery. Ongoing fragmentation of land around the main settlements does impede the ability for various productive lands to provide a flow of ecosystem services, including the provisioning service of food. This is especially evident around areas like Maungatapere, Maungakaramea, and Ruatangata. Figure 9 illustrates the location of significant natural areas, whilst Figure 10 illustrates the location of formally protected land. Figures 11 & 12 illustrates how present productive land uses could become limited in locations popular for lifestyle properties, despite the quality of their soils, as settlement in these locations increases over time.

Table 4 Qualitative Assessment - Future One & Ecosystem Services

Ecosystem Service Type	Settlement Type	Impact on Supply/Delivery of Ecosystem Service/Delivery	Impact on Demand for Ecosystem Service	Overall Assessment
Food & Fibre	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	Some reduction in production due to loss of agricultural production land to urbanisation (but smallest of three futures).	Some increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	High increase in demand for this ecosystem service with larger population.	
	Rural/Lifestyle	Reductions in overall supply/delivery of this ecosystem service without large increases in external inputs. Reduction in agricultural production capacity due to the conversion or fragmentation of versatile soils to lifestyle properties. Increased use of marginal lands that require larger inputs, and potential increases in negative downstream actions. Most forestry areas are located away from growth nodes, and this settlement pattern will have little impact on the delivery of these services. However, issues for harvesting will occur as more people are exposed to logging trucks in outlying areas.	High increase in demand for this ecosystem service with larger population.	
Freshwater	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service.	
	Coastal Settlements	Reduction in the delivery of this service with increased habitat fragmentation.	Major increase in demand for this ecosystem service as increased population results in more need for high quality freshwater.	

	Rural/Lifestyle	Small increase in the delivery of this service in lifestyle areas with new plantings, but overall a reduction should larger blocks of habitat be fragmented or converted to agricultural production. Whilst the main catchments are little impacted by the spread in population, potential septic tank issues can impact on the delivery of this service. However, small block owners may also restore riparian areas so in some popular areas stream flow and quality is improved.	Major increase in demand for this ecosystem service as increased population results in more need for high quality freshwater.	
Natural Hazard Regulation	City & Margins	Medium impact on the delivery in marginal areas around the city (for both flooding and landslide protection) but least of the three futures.	Some increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery. However, upper catchment vegetation continues to be fragmented through lifestyle blocks.	Some increase in demand for this ecosystem service.	
	Coastal Settlements	Ongoing removal of vegetation along the coastal environment means that less vegetation is available for the delivery of this service. Vegetation above many coastal settlements does remain and the demand for this ecosystem service for their retention will increase as these settlements grow. In other parts of the district, much upland vegetation has already been lost but a spread out population may not enable resources for some restoration effort. High reductions in the delivery as some bush blocks are removed in coastal margins for both houses and views.	Some increase in demand for this ecosystem service.	
	Rural/Lifestyle	Small reduction in the delivery of natural hazard regulation especially if upper catchments continue to be fragmented.	Small increase in demand for this ecosystem service.	
Air Quality Regulation	City & Margins	Small reductions in supply/delivery of this ecosystem service from city margins as vegetation is removed.	Small increase in demand for this ecosystem service. Whilst spread out populations may lead to more traffic in the urban areas and the potential for increased air quality issue, this settlement pattern will not impact on the delivery of this service, but will increase the	±

			demand for this ecosystem service.	
	Marsden/Ruakaka	Small reductions in supply/delivery of this ecosystem service from margins as vegetation is removed.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Reductions in delivery from margins as vegetation is removed for settlement purposes.	Small increase in demand for this ecosystem service.	
	Rural/Lifestyle	Some increase in supply/delivery of this ecosystem service in lifestyle areas as new vegetation is planted.	Small increase in demand for this ecosystem service.	
Local Climate Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but some actions to increase supply/delivery possible during development.	Some increase in demand for this ecosystem service.	
	Coastal Settlements	Reduced supply/delivery of this ecosystem service in coastal settlements.	Increased demand for this ecosystem service in coastal settlements.	
	Rural/Lifestyle	Some improved supply/delivery of this ecosystem service in lifestyle areas due to new plantings.	Some increase in demand for this ecosystem service.	
Water Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Some increase in demand for this ecosystem service for water regulation services.	
	Coastal Settlements	Reductions in water regulation services as coastal vegetation becomes more fragmented with increased settlement.	Increased demand for this ecosystem service for water regulation by growing coastal population.	

	Rural/Lifestyle	Some increase in service delivery through riparian planting by lifestyle owners, but reduction in upper catchments as marginal land converted to agricultural production. Continued intensive use in remaining areas on external input continues to impact on this service. Increase in possibility of septic tank failure with increased numbers of lifestyle properties.	Increased demand for this ecosystem service in some areas due to lifestyle preferences for clean water, beyond what the use of rainwater storage systems	
Erosion Regulation	City & Margins	Reductions in supply/delivery of this ecosystem service in upper catchments that feed into Whangarei Harbour.	Increase in demand for this ecosystem service for reduction in upper catchments for reduced sedimentation that could aid local fisheries.	↓
	Marsden/Ruakaka	Reductions in supply/delivery of this ecosystem service, especially in upper catchment.	Some increased demand for this ecosystem service from the larger population (although smallest of three futures).	
	Coastal Settlements	Major reduction in erosion serves as vegetation removed for building houses and driveways, and for aesthetic purposes.	Increased demand for this ecosystem service in the coastal settlements for both the protection of settlement but also reductions in the impact of sediment on local fisheries.	
	Rural/Lifestyle	Some reduction in erosion services as vegetation removed on marginal lands to increase production when making up for the losses on versatile soils.	Increased demand for this ecosystem service in some locations where settlement is below erosion prone areas, but very little increase in other locations.	
Water Purification and Waste Treatment	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Reduced supply/delivery of this ecosystem service due to fragmentation and removal of habitat, around and between settlements.	Large increase in demand for this ecosystem service as more coastal properties are not	

			connected to reticulation systems (water or sewer).	
	Rural/Lifestyle	Small increase in supply/delivery of this ecosystem service in some lifestyle areas as diverse landscape allows more species, and wetlands are reintroduced. Some reduction in some bush locations as vegetation is removed. However, the distributed population may mean that fewer resources are available to increase delivery of this service in the urban areas.	Large increase in demand for this ecosystem service as more lifestyle properties are not reticulated.	
Pest Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Reduced supply/delivery of this ecosystem service due to fragmentation and removal of habitat, around and between settlements.	Large increase in demand for this ecosystem service as increased fragmentation of habitat allows more opportunities for weeds in some areas as more lifestyle properties are able to be the source of weeds.	
	Rural/Lifestyle	More widely spread populations tend to be main sources of weed species, but increased populations in some area may result in landcare groups that undertaken pest control, so these factors tend to offset each other. However, increased indigenous vegetation planting do provide habitat and nectar resources for species that feed on pest invertebrates. Small increase in supply/delivery in some lifestyle areas as diverse landscape allows more species. Some reduction in some bush locations as vegetation is removed.	Large increase in demand for this ecosystem service as increased fragmentation of habitat allows more opportunities for weeds in some areas as more lifestyle properties can be the source of weeds. Some demand for this ecosystem service for the delivery of this service may occur, especially to avoid reverse sensitivity issues from pesticide use.	
Pollination	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	↑

	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Small decreased supply/delivery of this ecosystem service in coastal belt as land becomes further fragmented. Whilst some planting will occur, this is unlikely to offset the overall loss of vegetation.	Increase in demand for this ecosystem service within coastal settlements.	
	Rural/Lifestyle	Increased supply/delivery of this ecosystem service in lifestyle area due to new plantings, but decreased supply/delivery in other areas, especially when marginal land is converted to agricultural production. Increased lifestyle blocks will generally lead to more vegetation being planted, which enables a better mixed landscape, and allows for more pollinators.	Major increase in demand for this ecosystem service for both lifestyle areas and productive soils, in order to reduce external inputs. Given the loss of pollinators worldwide, demand for this ecosystem service for this service will rise.	
Nutrient Cycling	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Decrease in supply/delivery of this ecosystem service as vegetation removed for new housing.	Small increase in demand for this ecosystem service.	
	Rural/Lifestyle	Increased supply/delivery of this ecosystem service in some areas as new plantings take place by lifestyle block owners. However, decreased supply/delivery in other areas as continued intensive land uses, and their inputs are favoured over landscape processes. More indigenous vegetation planting may lead to more diversity within the soil biotic community, and allow for more diversity of organisms to take advantage of different environmental conditions.	Increased demand for this ecosystem service for the promotion of nutrient cycling as a means of reducing inputs. However, this is relatively small in size.	
Soil formation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	±

	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	
	Coastal Settlements	Little impact on overall supply/delivery of this ecosystem service.	Small increase in demand for this ecosystem service.	
	Rural/Lifestyle	More lifestyle settlement will means that some land is left fallow and more indigenous planting is undertaken. However, removal of versatile soils from production may lead to increased intensity of use on remaining versatile soils and increased usage of marginal land, which removes capacity for soil formation processes.	Some increase in demand for this ecosystem service as smaller lots are used for small gardens. Outside of lifestyle blocks, increased demand for this ecosystem service is likely as use of other quality soils is intensified.	

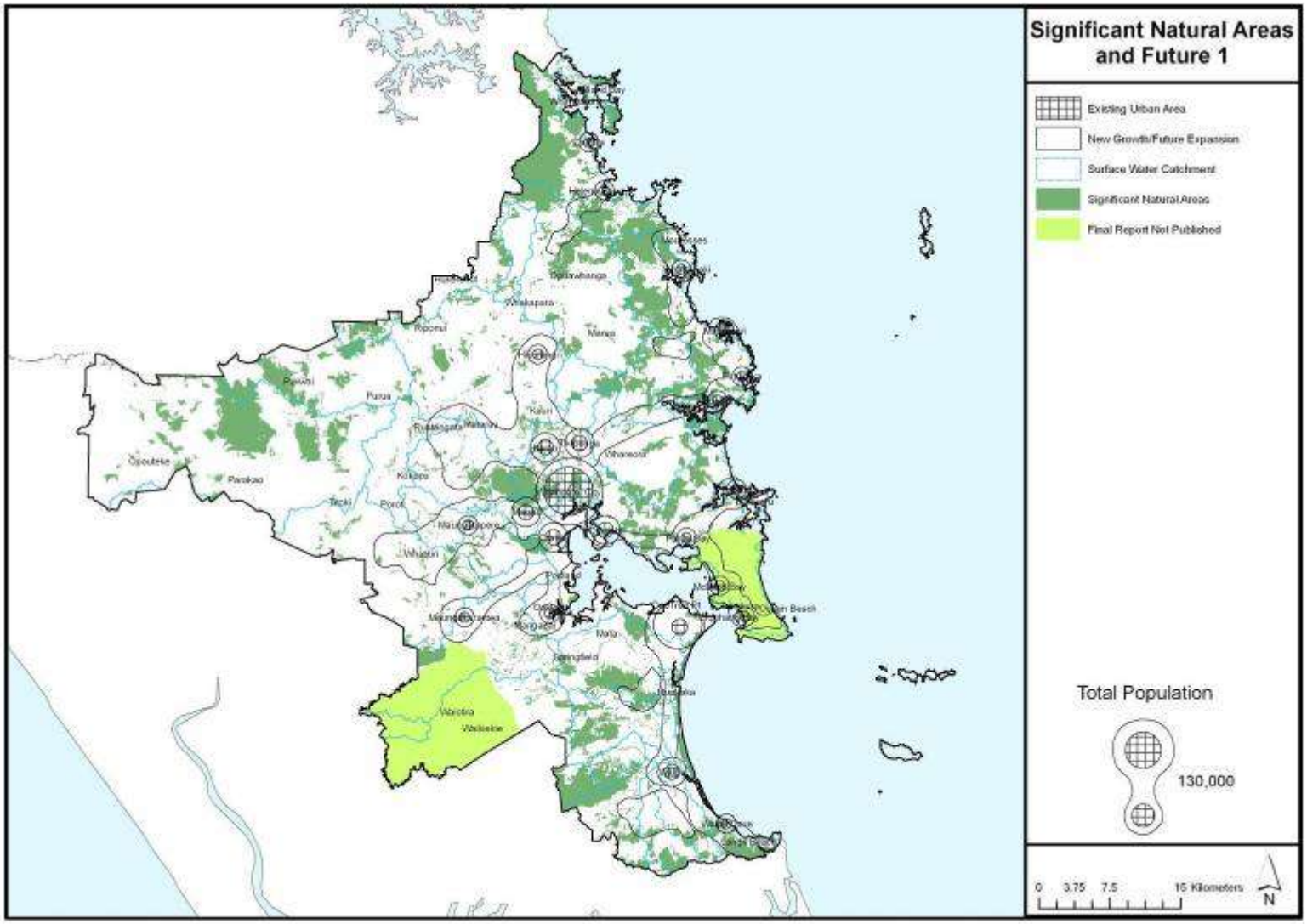

Figure 9: Map of Significant Natural Areas, Catchments, and Future One

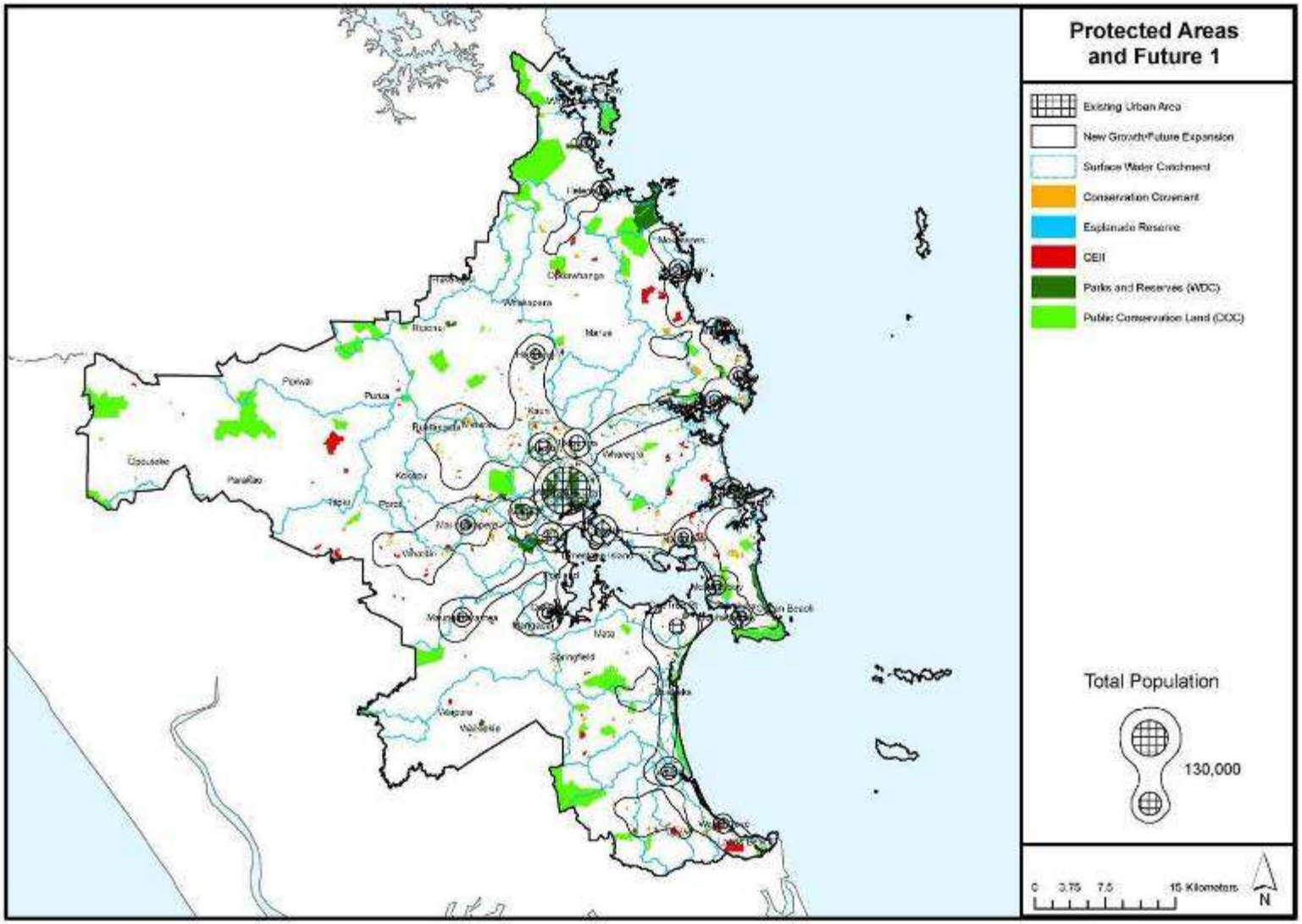

Figure 10: Map of Future One and the Location of Protected Natural Areas

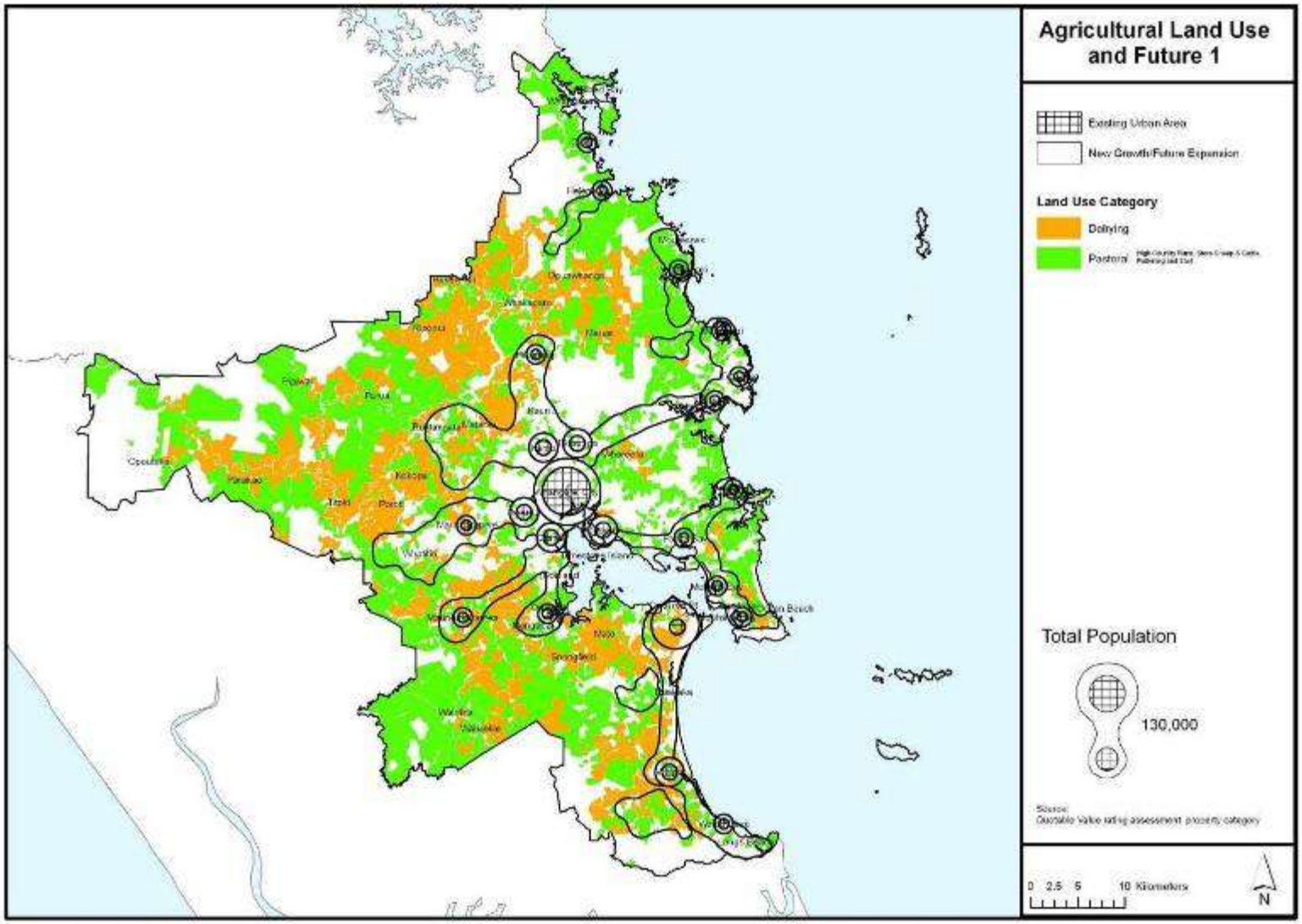

Figure 11: Map of Agricultural Land Use and Future One

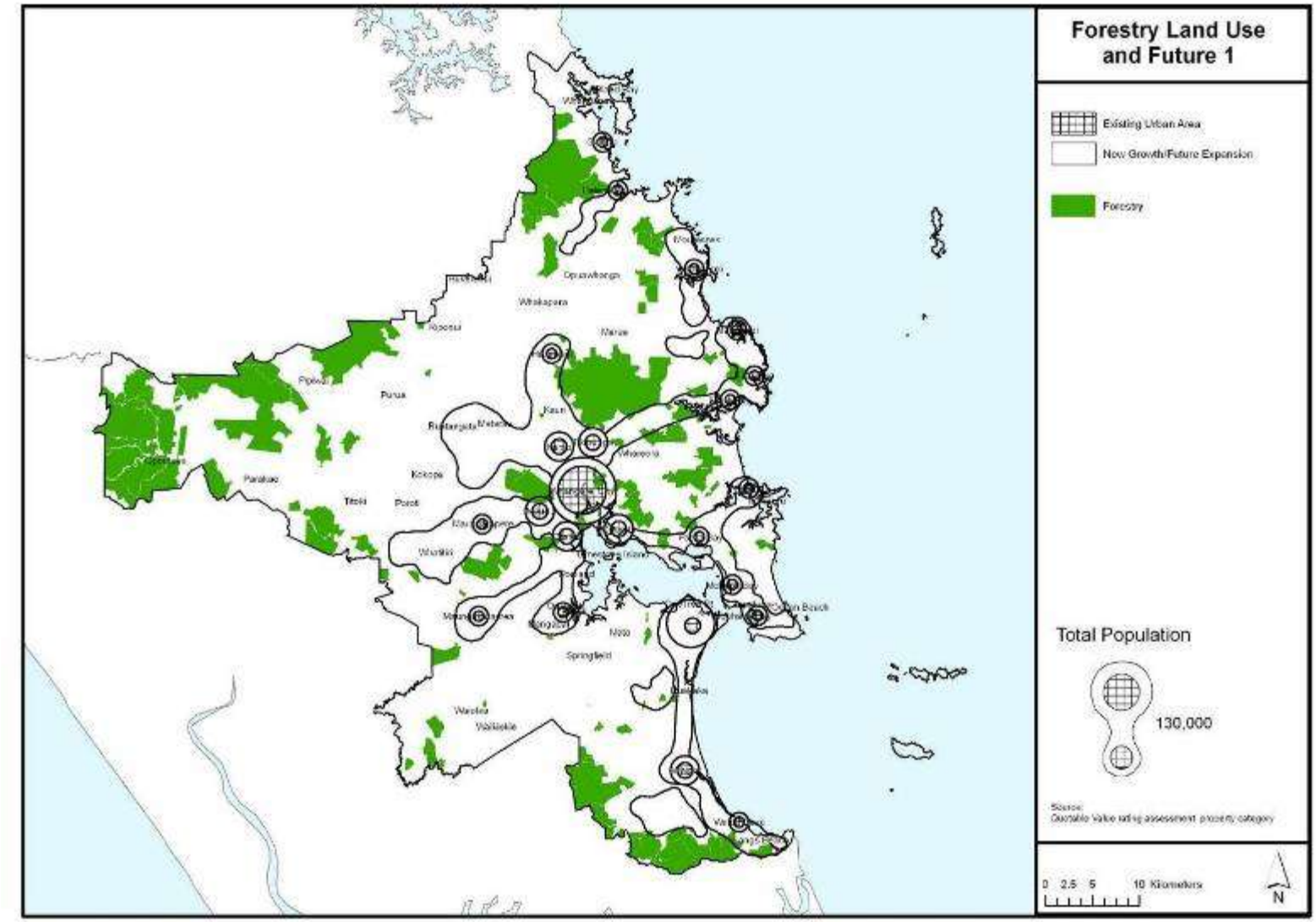

Figure 12: Map of Forestry Land Use and Future One Settlement Pattern

7.2 Future Two: Twin City/Urban and Coastal Spread

Future Two (Figure 20) represents a moderately controlled, partly consolidated development path based upon a three tier settlement pattern. These tiers consist of:

Twin cities at Whangarei and Marsden Point/Ruakaka,

Urban and coastal settlements with some associated urban sprawl and ribbon development,

Rural urban development largely at village level with some sporadic development throughout the rural area.

Under this scenario, the countryside area has seen a substantial decline in its relative population size, from 20 % down to 7% (most likely underestimated), both dispersed and within any larger present rural settlements. Population growth at Marsden Point/Ruakaka has been very high, and the relative population has jumped from 4% to 19% of the population. Settlement in the coastal area has also continued, with an increase in the relative population of 8% to 10% likely. The relative percentage of population found in Whangarei city decreases a little in this Future, at least when compared with the present baseline. However, of the three futures, this is the most concentrated with 80% of the population found in Whangarei and Marsden Point/Ruakaka settlements (See table 5).

Of the three futures, Future 2 is the most neutral in regards to the overall delivery of ecosystem services, due to less pressure for lifestyle opportunities in rural areas, and a smaller distributed population in coastal areas compared with Future One. As noted in table 5, avoidance of distributed settlement in rural and coastal areas reduces pressure on productive uses, but may also reduce opportunities for restoration activities from lifestyle property owners. Conversely, however, Future 2, with its very large focus on Ruakaka/Marsden, is the future most reliant on restoring and maintaining ecosystem services, especially in terms of the upper catchments surrounding Ruakaka/Marsden Point. Certainly in the case of Ruakaka/Marsden Point, given the possibility of flood susceptibility and coastal hazard, care must be taken to ensure that the capacity for natural hazard regulation from natural sources is increased.

Parts of the upper catchment of the Ruakaka river is formally protected, but very little formally protected land is located elsewhere within the catchment for Ruakaka/Marsden (see figure). This future has very little impact on forestry or agriculture services, except in the proximity of Ruakaka/Marsden Point and a few areas with high class soils, so this future does little to impede the flow of these resources. Figure 13 illustrates the importance of significant natural areas in the upper catchment feeding the Ruakaka River, and that a portion of the forest is formally protected. Of note is that there is little forestry or pastoral farming undertaken in this catchment, but significant levels of dairy activity in the middle catchments.

In terms of the coastal settlement areas, the key areas of Ngunguru/Tutukaka and Whangarei Heads have reasonable levels of significant natural areas remaining, but little of this is formally protected in the upper catchments that impact on Ngunguru/Tutukaka, but Whangarei Heads has more formally protected catchments. Like all futures, continued retention of vegetation in the upper catchments for flood attenuation and erosion regulation is required for all coastal settlements outside of these locations.

Table 5 Qualitative Assessment Future Two and Ecosystem Services

Ecosystem Service Type	Settlement Type	Impact on Supply/Delivery of this Ecosystem Service	Impact on Demand for this Ecosystem Service	Overall Assessment
Food & Fibre	City & Margins	Medium decrease in supply.	Medium increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	High decrease in supply as whole area is urbanized.	High increase locally for food provisioning services.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, but some localised reductions of this service around Ngunguru/Tutukaka corridors and Whangarei Heads.	Some increases in demand for this ecosystem service.	
	Rural/Lifestyle	Less reduction on supply/delivery of this ecosystem service than Future One, but reduced supply/delivery options from lifestyle properties. Reduced pressure on marginal land. Less pressure for versatile and other productive soils from lifestyle opportunities, meaning that the delivery of these services in not heavily impeded.	Small increase in demand for this ecosystem service locally, but increased demand for this ecosystem service from urban areas.	
Freshwater	City & Margins	Supply/delivery of this ecosystem service decreased in marginal areas, and little action to increase service delivery.	Small increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	Some impact on overall supply/delivery of this ecosystem service in the area, and, mainly due to urbanisation, only a small capacity to increase supply/delivery of ecosystem service.	Very large increase in demand for this ecosystem service for water services in the upper catchment. Some demand for this ecosystem service for action on the local streams (and some resources are available to meet that demand for this ecosystem service).	
	Coastal	No major impact on overall supply/delivery of this ecosystem service and few	Some increases in demand for this ecosystem	

	Settlements	actions to increase supply/delivery of this ecosystem service, but some localised reductions around Ngunguru/Tutukaka corridors and Whangarei Heads.	service.	
	Rural/Lifestyle	Less reduction on supply/delivery of this ecosystem service than Future One, but reduced supply/delivery options from lifestyle properties. Reduced pressure on marginal land.	Little impact on demand for this ecosystem service.	
Natural Hazard Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service, and few actions to increase supply/delivery.	Small increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	Major reduction in the delivery of service, resources may be available to increase supply/delivery due to large population.	Very large increase in demand for this ecosystem service in the upper catchment. Some demand for this ecosystem service for action on the local streams (and some additional resources are available to meet that demand for this ecosystem service).	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, but some localised reductions around Ngunguru/Tutukaka corridors and Whangarei Heads.	Smaller demand for this ecosystem service than Future One. Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	Less reduction on supply/delivery of this ecosystem service than Future One, but reduced supply/delivery options from lifestyle properties. Reduced pressure on marginal land that provides services to downstream settlements.	Limited increase in demand for this ecosystem service.	
Air Quality Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service as pressure from cars drops in the city centre.	↓
	Marsden/Ruakaka	Major reduction in the delivery of service, resources may be available to increase supply/delivery of this ecosystem service due to large population.	Very large increase in demand for this ecosystem service in the whole catchment.	

	Coastal Settlements	Small reductions in delivery of service.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	Small reduction in the delivery of service.	Limited increase in demand for this ecosystem service.	
Local Climate Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	↓
	Marsden/Ruakaka	No real reduction in the delivery of service compared with present, but increased resources may be available to increase supply/delivery due to large population.	Very large increase in demand for this ecosystem service in the whole catchment.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	
Water Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No real reduction in the delivery of service compared with present, but increased resources may be available to increase supply/delivery of this ecosystem service due to large population.	Very large increase in demand for this ecosystem service for water services in the whole catchment. Some resources are available to meet that demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery apart from Tutukaka/Ngunguru & Whangarei	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru &	

		Heads.	Whangarei Heads.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	
Erosion Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery of this ecosystem service.	Limited increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No real reduction in the delivery of service compared with present, but increased resources may be available to increase supply/delivery of this ecosystem service due to large population.	Very large increase in demand for this ecosystem service in the upper catchment. Some demand for this ecosystem service to avoid sedimentation in local streams that may impact on local fisheries.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery of this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	
Water Purification/ Waste Treatment	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Very large increase in demand for this ecosystem service in the whole catchment.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	

Pest Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No real reduction in the delivery of service compared with present, but increased resources may be available to increase supply/delivery to large population. However, multiple new gardens will emerge as new sources for pests.	Limited increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	Fewer resources are available for conservation pest control. However, lesser numbers of lifestyle blocks will mean fewer opportunities for exotic weed colonisation. Some demand for this ecosystem service for the delivery of this service may occur, especially to avoid reverse sensitivity issues from pesticide use, but this is less than Future One.	Some increase in demand for this ecosystem service.	
Pollination	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	↑
	Marsden/Ruakaka	Increased supply/delivery of this ecosystem service possible as new landscape allows more opportunities for different pollinators. No real decrease in supply/delivery of this ecosystem service compared with present.	Increase in demand for this ecosystem service for wild pollination in home gardens.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service, apart from Tutukaka/Ngunguru & Whangarei Heads.	
	Rural/Lifestyle	Smaller levels of restoration activities in this Future, but smaller amounts of potential fragmentation for properties for bush lifestyle blocks.	Limited increase in demand for this ecosystem service locally, but global concerns lead to international demand.	

Nutrient cycling	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	Due to new plantings, some new nutrient cycling services are likely to be supplied. No real impact on present delivery of services.	Limited increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	
Soil formation	City & Margins	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on present supply/delivery of this ecosystem service, and few opportunities for new delivery.	Limited increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery, apart from Tutukaka/Ngunguru & Whangarei Heads.	Limited increase in demand for this ecosystem service.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Limited increase in demand for this ecosystem service.	

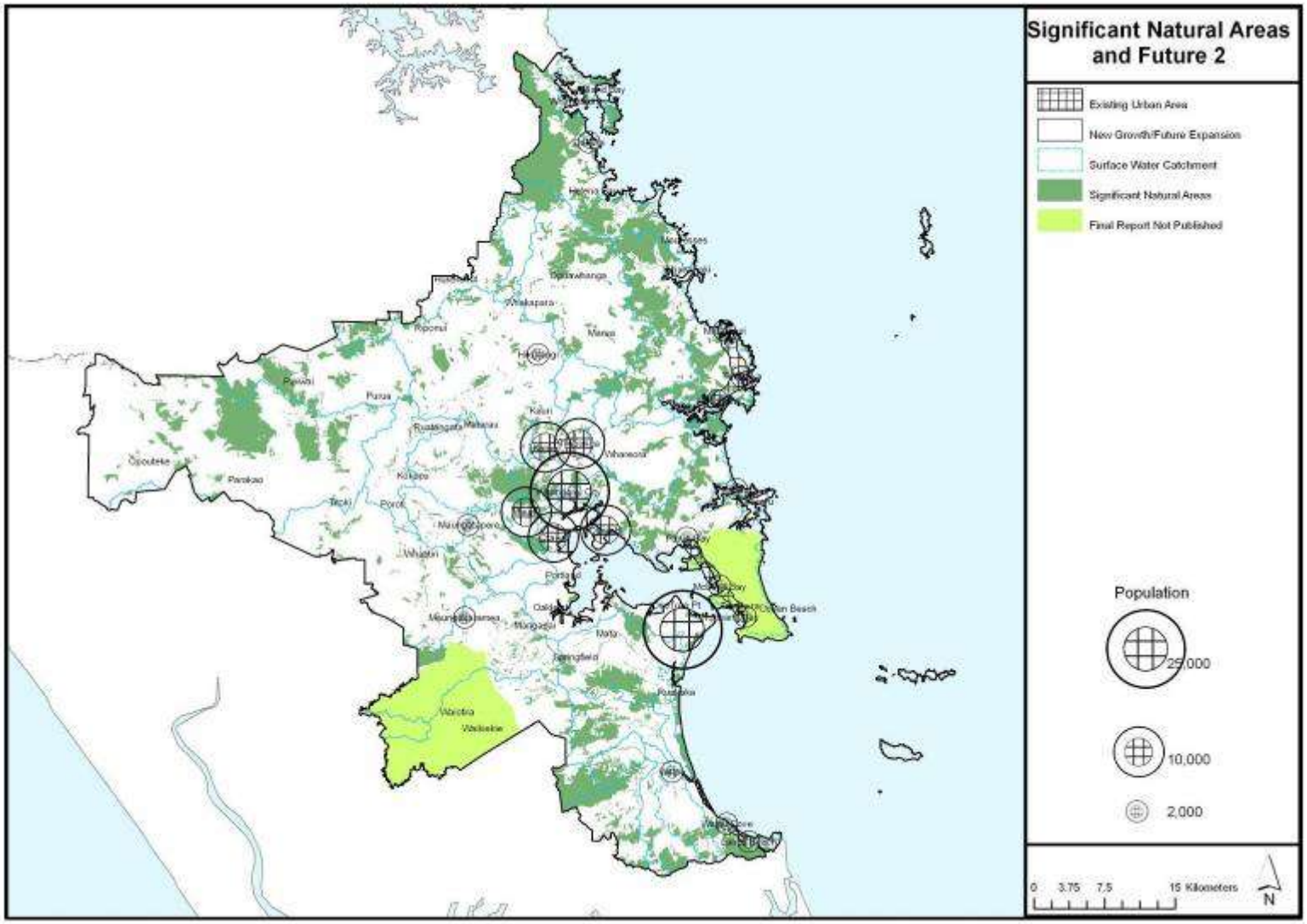

Figure 13: Map of Significant Natural Areas, Catchment Boundaries and Future Two.

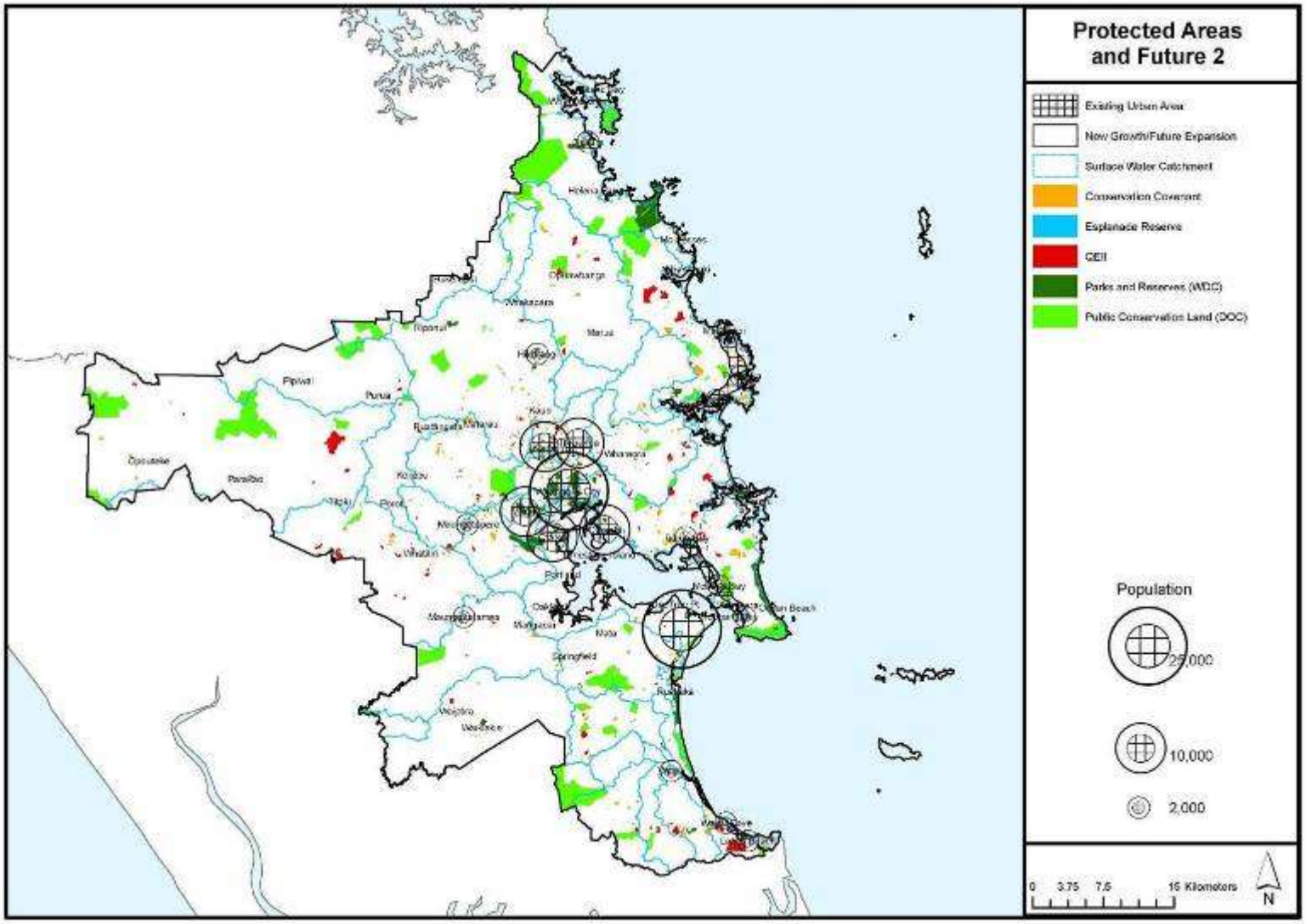

Figure 14: Map of Location of Protected Natural Areas and Future Two.

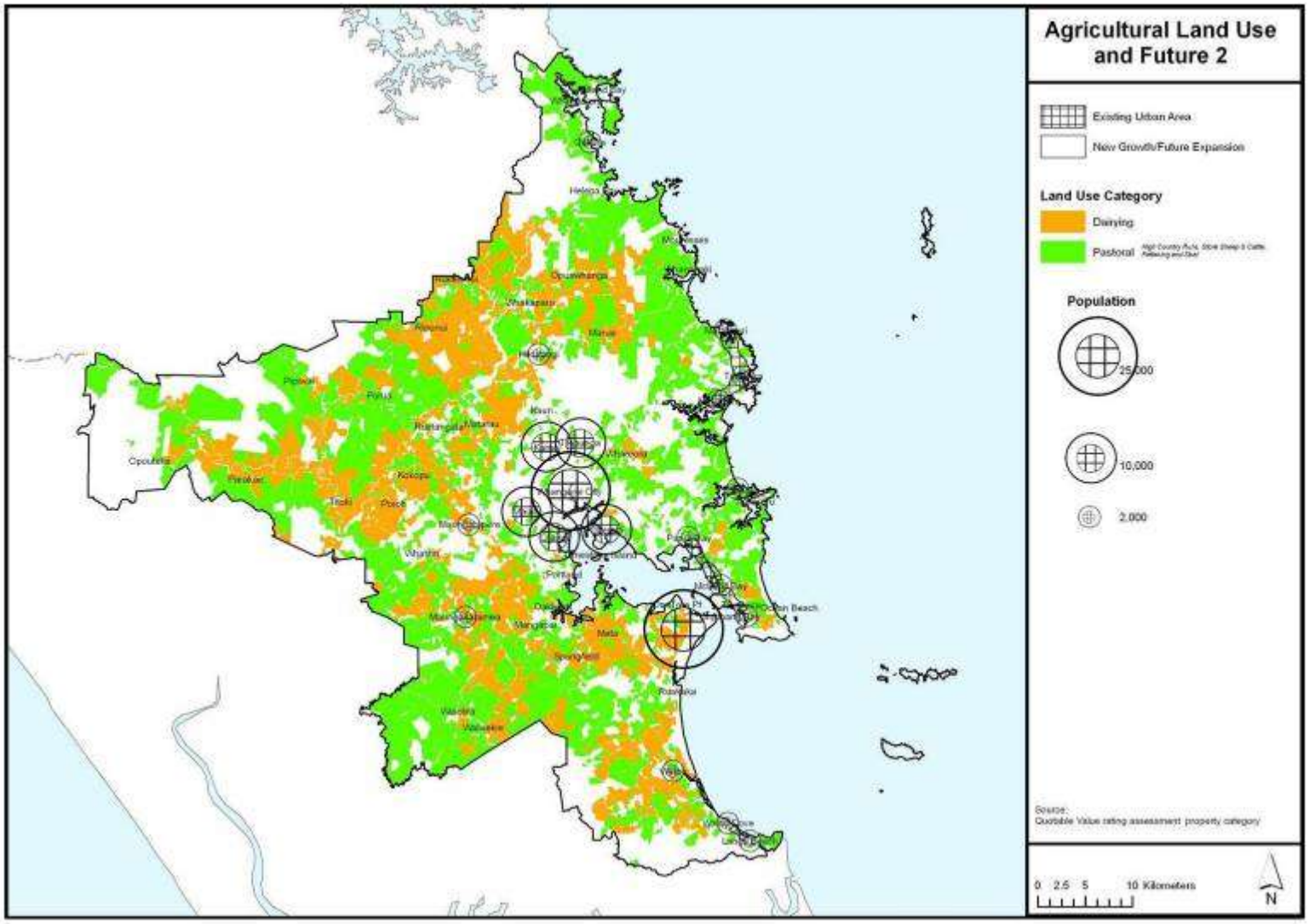

Figure 15 Map of Agricultural Landuses and Future Two

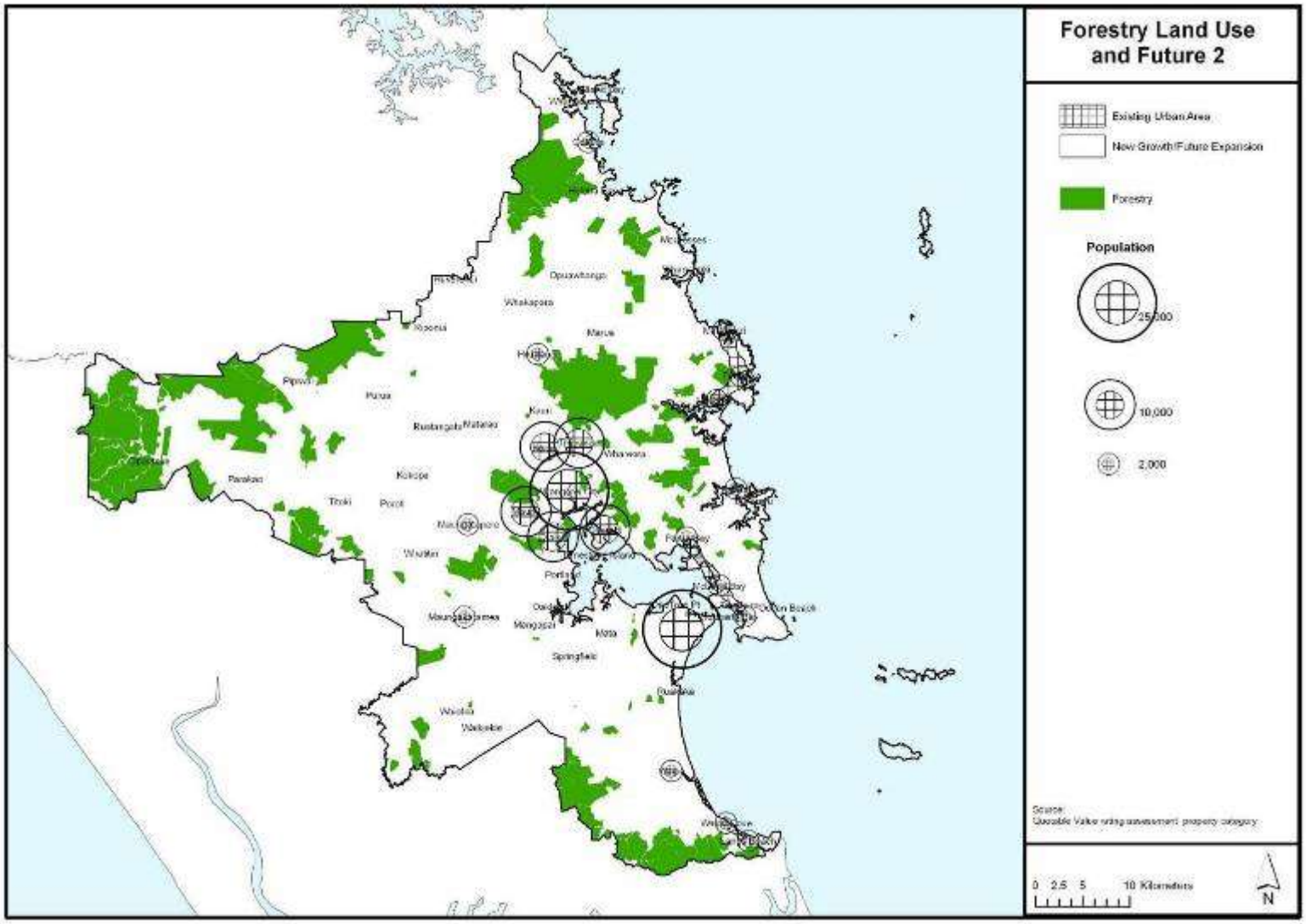

Figure 16: Map of Location of Forestry Land Use and Future Two

7.3 Future Three: Satellite Town/Rural and Coastal Villages

Future Three represents a controlled, consolidated development path based upon a structured five tier settlement pattern. This hierarchical arrangement is as follows:

Whangarei City as the primary district and regional urban centre with a strong, protected and enduring CBD.

A satellite town at Marsden Point/Ruakaka which complements (but does not compete with) Whangarei City.

Five urban villages within greater Whangarei urban area.

One rural and two coastal growth nodes,

Two rural villages along with eight coastal villages.

Under this scenario, the countryside area has still seen a large decline in its relative population size, from 20% down to 11% of the total population. However, most of this is contained within rural settlements such as Hikurangi and Maungatapere. Population growth at Marsden Point/Ruakaka is high, with the population jumping from 4% to 11% of the population. Settlement in the coastal area is also high, with an increase in the relative population percentage of 8% to 14%, which is the highest of the three futures. However, the bulk of this growth is around Parua Bay and Waipu. The relative percentage of population found in Whangarei City decreases somewhat in this Future (from 66% to 61%). Depending on the definition of urban, this is the most urbanised settlement pattern with 84% of the population found in Whangarei, Marsden Point/Ruakaka, Waipu, Hikurangi, and Parua Bay (if we assume that 5,000 and up is an urban population). Otherwise the total for Whangarei City and Marsden Point/Ruakaka is 72% (see Table 3).

Of the three futures, Future Three has the least impact on the delivery of ecosystem services over a wide range of services. However, compared with Future One, it may not necessarily provide the delivery of services reliant on restoration of indigenous vegetation. Through consolidation, it may well remove some pressure on provisioning ecosystem services such as food production or loss to food production of marginal land with subsequent losses of other ecosystem services. In addition, with a slightly large core population size in the city areas, and more defined cores at other settlements, it may provide a wider rating base that increases financial capacity for ecosystem services from the rural areas, and this is useful for habitat restoration and could also be used to build up better quality ecosystem services in the urban areas. Secondly, more people in the cities also allow more opportunities for quality agriculture in the hinterland by providing a market that is based around quality rather than quantity of goods.

More concentrated settlement patterns will mean that more attention is required within these catchments to ensure that the requisite delivery of ecosystem services is available and does not impact on individual's and community's well-being. Figure 17 illustrates the location of significant natural areas and their proximity to the key growth nodes and villages. Figure 18 illustrates the location of protected areas of land, and of note is very few are located in close proximity or within the key catchments of protected areas. Many of these areas are dependent on services supplied by the agriculture and forestry land uses (Figures 19 & 20), and the significant indigenous forests located on private land (Figure 21).

Table 6 Qualitative Assessment Future Three and Ecosystem Services

Ecosystem Service Type	Settlement Type	Impact on Supply/Delivery of Ecosystem Service	Impact on Demand for Ecosystem Service	Overall Assessment
Food & Fibre	City & Margins	Least pressure on this provisioning service from lifestyle blocks. In addition, a larger urban population may lead to higher demand for this ecosystem services for quality food production.	High increase in demand for this ecosystem service.	↑
	Marsden/Ruakaka	Major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service and few actions to increase supply/delivery.	Increase in demand for this ecosystem service.	
	Rural/Lifestyle	Least pressure on this service from the fragmentation of productive farmlands. Capacity to supply/delivery of this ecosystem service is highest of the three futures.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth node.	
Freshwater	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service.	↑
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but some actions to increase supply/delivery in urban areas.	Medium increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Increase in demand for this ecosystem service around key settlements.	
	Rural/Lifestyle	Decreased settlement distribution leading to fewer impacts from septic tanks, and increased urban population enables more resources for ensuring and increasing the delivery of this service. Increased demand for this ecosystem service for this service is likely.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth node.	

Natural Hazard Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Very high increase in demand for this ecosystem service, especially protection in terms of flooding and landslides.	↑
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service, especially protection in terms of flooding and coastal protection.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service, especially protection in terms of flooding and coastal protection.	
	Rural/Lifestyle	Less distributed populations will lead to less indigenous vegetation removal, and overall this future is less likely to impede the delivery of this service.	Low increase in demand for this ecosystem service locally, but high increase in demand for this ecosystem service around villages and growth nodes, potentially leading to more restoration.	
Air Quality Regulation	City & Margins	Major impact on overall supply/delivery of this ecosystem service is possible but capacity and resources available to increase supply/delivery.	Very high demand for this ecosystem service locally for air quality, however less demand for this ecosystem service in terms of offsetting from traffic movements sourced from lifestyle properties.	↓
	Marsden/Ruakaka	Major impact on overall supply/delivery of this ecosystem service is possible but capacity and resources available to increase supply/delivery.	High demand for this ecosystem service locally for air quality, however demand for this ecosystem service in terms of offsetting from traffic movements sourced from other coastal locations.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Low increase in demand for this ecosystem service.	

	Rural/Lifestyle	No major impact on supply/delivery of this ecosystem service, and no real actions to increase supply/delivery.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth nodes.	
Local Climate Regulation	City & Margins	Some impact on overall supply/delivery of this ecosystem service is possible but capacity and resources available to increase supply/delivery.	Very high demand for this ecosystem service locally.	↓
	Marsden/Ruakaka	Major impact on overall supply/delivery of this ecosystem service is possible but capacity and resources available to increase supply/delivery.	High demand for this ecosystem service locally.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Low increase in demand for this ecosystem service.	
	Rural/Lifestyle	No major impact on supply/delivery of this ecosystem service, and no real actions to increase supply/delivery.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth nodes.	
Water Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service. Whilst this Future will not impede the delivery of this service, it will increase the demand for this ecosystem service for this service especially around Whangarei city and the three growth nodes.	↑
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service in coastal growth nodes.	

	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service in villages and growth nodes.	
Erosion Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service in coastal villages and growth nodes.	
	Rural/Lifestyle	No major impact on overall supply/delivery of this ecosystem service but capacity and resources not available to increase supply/delivery.	Whilst this Future will not impede the delivery of this service, it will increase the demand for this ecosystem service for these services, especially around Ruakaka/Marsden Point, but also around Whangarei city and the three growth nodes, especially to ensure development opportunities.	
Water purification and waste treatment	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Whilst this Future will not impede the delivery of this service, it will increase the demand for this ecosystem service, especially around Ruakaka/Marsden Point, but also around Whangarei city and the three growth nodes.	↓
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	High increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on supply/delivery of this ecosystem service, and no real actions to increase supply/delivery.	Low increase in demand for this ecosystem service generally, but high increase in demand for this ecosystem service around villages and	

			growth nodes.	
	Rural/Lifestyle	No major impact on supply/delivery of this ecosystem service, and no real actions to increase supply/delivery.	Low increase in demand for this ecosystem service generally, but high increase in demand for this ecosystem service around villages and growth nodes.	
Pest Regulation	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Some increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Some increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery. Small amounts of restoration activities outside coastal villages.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around coastal villages and growth nodes.	
	Rural/Lifestyle	Major impact on supply/delivery of this ecosystem service (especially with villages and growth node source of new weed species), but increased resources and capacity to increase supply/delivery. Small amounts of restoration activities outside villages, however this may change dependant on land management.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth nodes.	
Pollination	City & Margins	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Some increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on overall supply/delivery of this ecosystem service but capacity and resources available to increase supply/delivery.	Some increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery. Small amounts of restoration activities outside coastal villages.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around	

			coastal villages and growth nodes.	
	Rural/Lifestyle	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery. Small amounts of restoration activities outside villages.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth nodes.	
Nutrient cycling	City & Margins	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery.	Low increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery of this ecosystem service.	Low increase in demand for this ecosystem service.	
	Coastal Settlements	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery. Small amounts of restoration activities outside coastal villages.	Low increase in demand for this ecosystem service generally, but a medium increase in demand for this ecosystem service around coastal villages and growth nodes.	
	Rural/Lifestyle	Smallest levels of restoration activities in this Future, but smaller amounts of potential fragmentation of large bush land for lifestyle properties.	Some increase in demand for this ecosystem service generally close to villages and growth nodes. Demand for this ecosystem service may occur widely if it enables higher qualities of food and less impact from agricultural activities.	
Soil formation	City & Margins	Some impact on supply/delivery of this ecosystem service within area but increased resources and capacity to increase supply/delivery.	Low increase in demand for this ecosystem service.	±
	Marsden/Ruakaka	Some impact on supply/delivery of this ecosystem service within area but increased resources and capacity to increase supply/delivery.	Low increase in demand for this ecosystem service.	
	Coastal	No major impact on supply/delivery of this ecosystem service but increased resources and capacity to increase supply/delivery. Small amounts of restoration	Low increase in demand for this ecosystem service generally, but medium increase in	

	Settlements	activities outside coastal villages and growth nodes.	demand for this ecosystem service around coastal villages and growth nodes.	
	Rural/Lifestyle	Major impact on supply/delivery of this ecosystem service especially within villages and growth nodes. Small amounts of restoration activities outside villages, however this may change if land management changes. However, less fragmentation on productive soils may increase opportunities for soil formation within these areas, and less impact on marginal soils will allow for soil formation processes to occur.	Low increase in demand for this ecosystem service generally, but medium increase in demand for this ecosystem service around villages and growth nodes.	

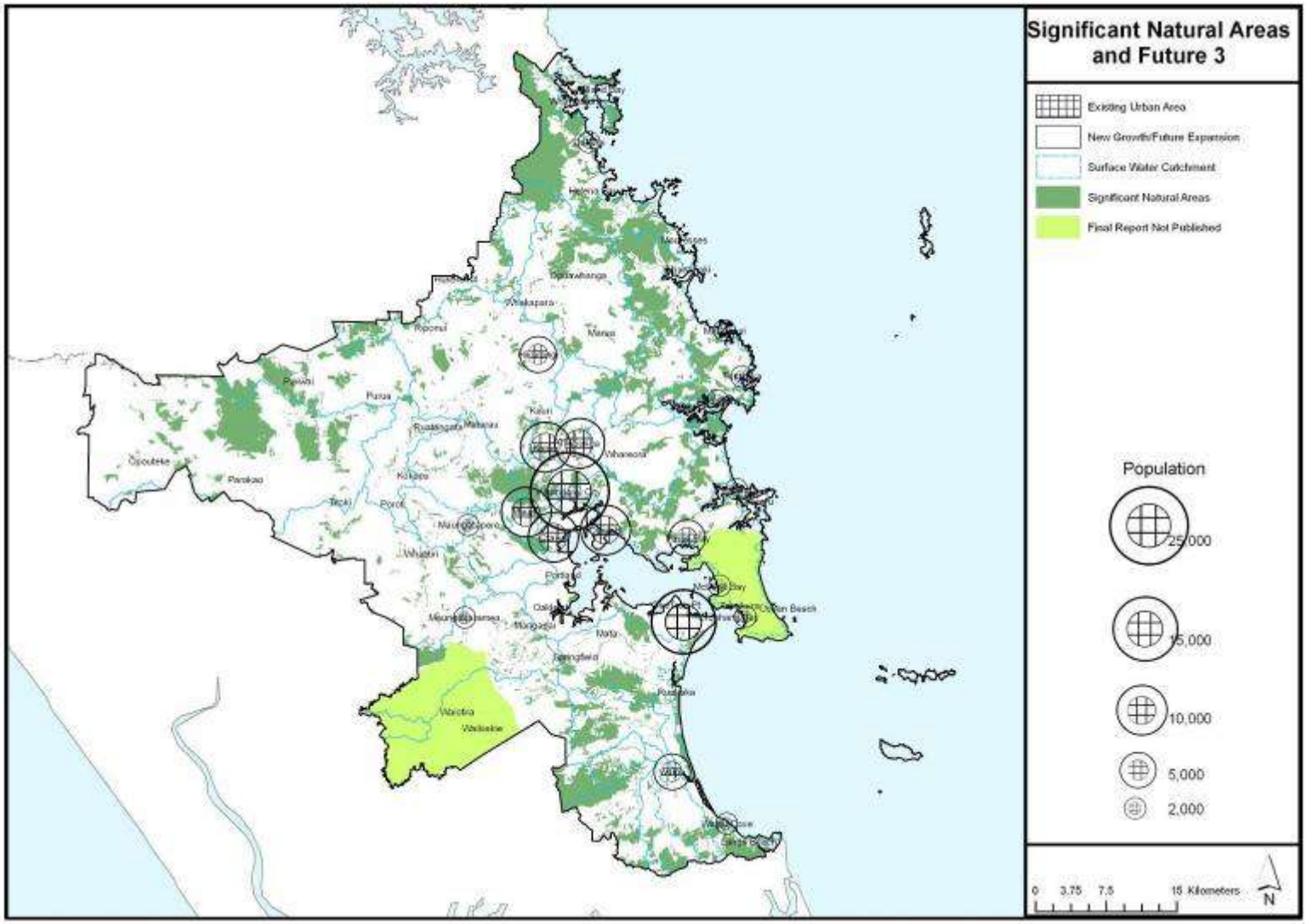

Figure 17 Map of Future Three and location of Significant Natural Areas

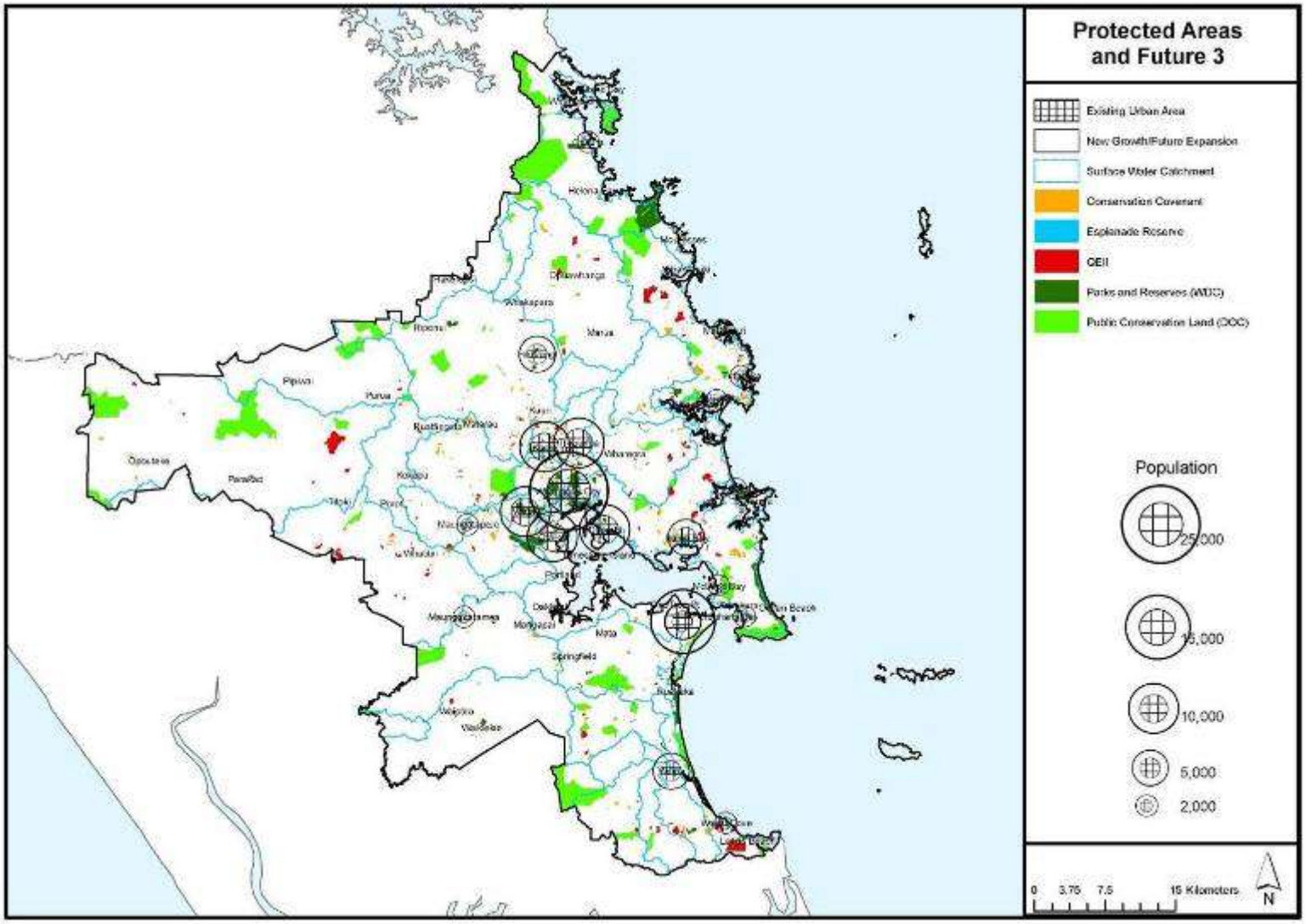

Figure 18 Map of Future Three and Location of Protected Natural Areas

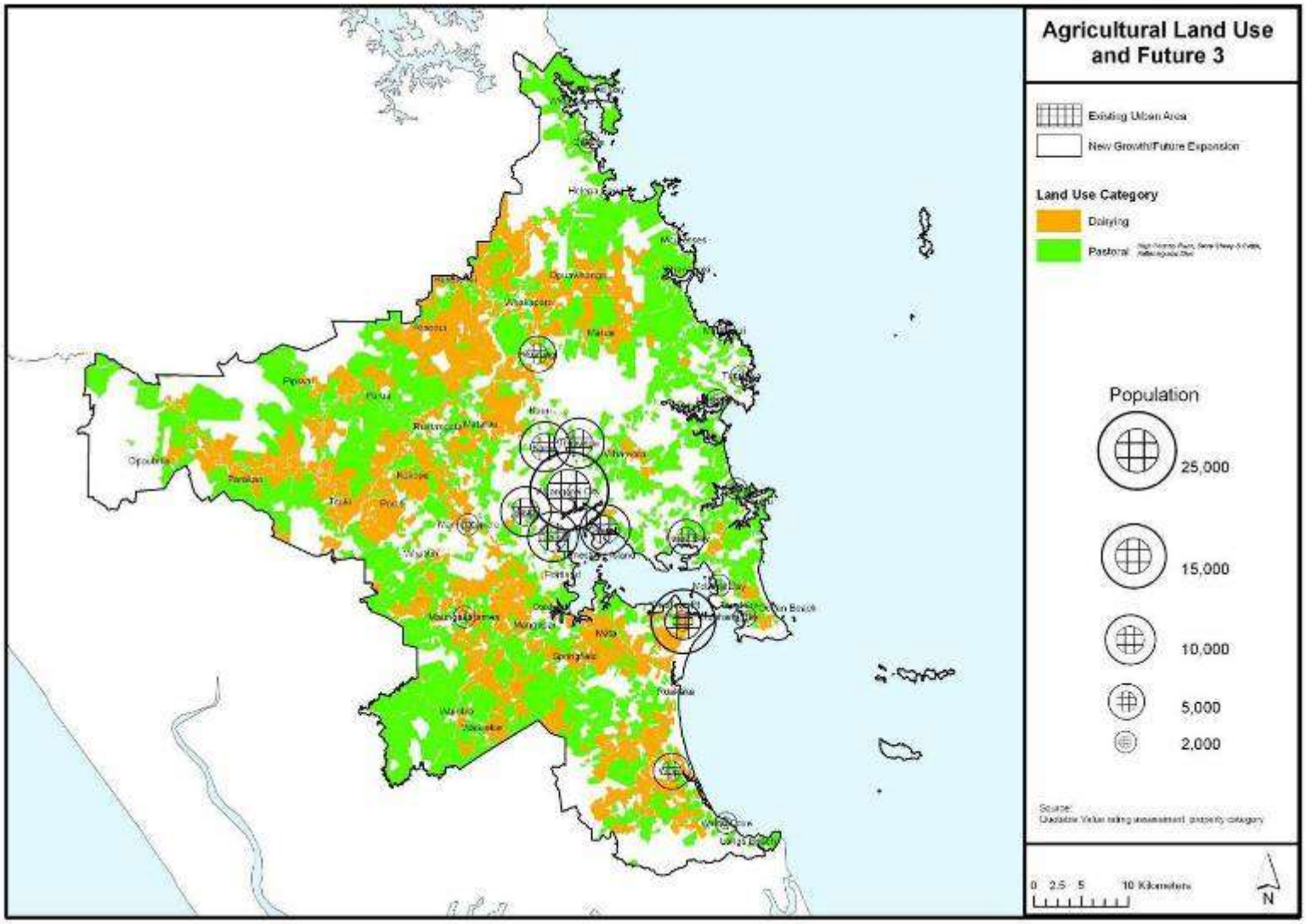

Figure 19 Map of Future Three and Location of Agricultural Land Use

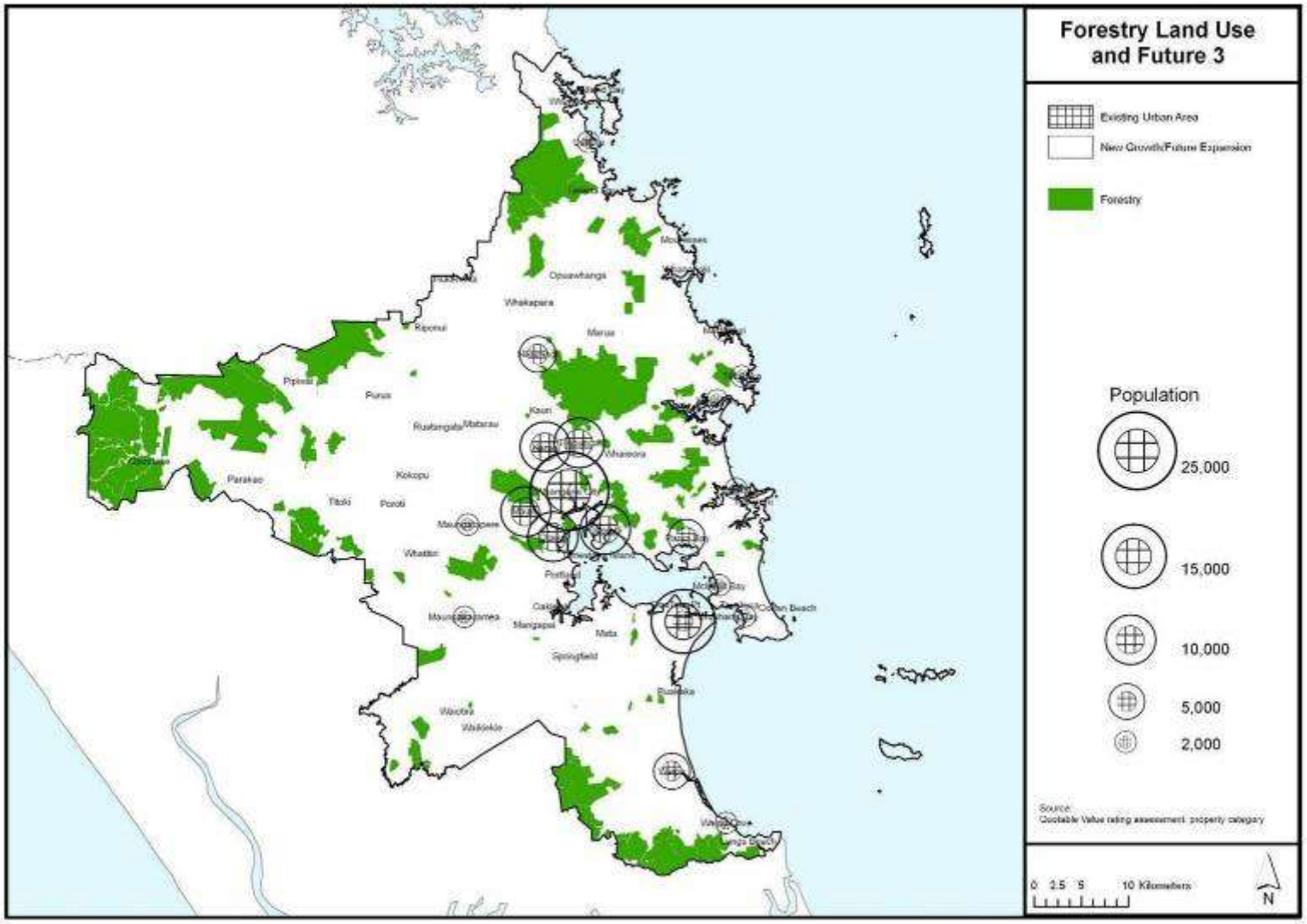

Figure 20 Map of Future Three and Location of Forestry Land Use

8.0 Conclusions

For the purpose of Sustainable Futures 30/50, the use of ecosystem services as an input into the preferred strategy is best served by being a series of broad principles that should be incorporated into understanding the effects of various activities. In addition, there is a growing trend towards the consolidation of settlements into more dense areas of population, and then there will be increased need to understand the dynamics within an ecosystem and the catchments within which many of these towns are located. For example, recent evidence in Waipu notes that past landuse that removed large segments of habitat are now contributing to the flood susceptibility of the settlement, a message that has been repeated in several small towns in Northland whose locations were generally based on past needs. Some of these towns are facing an increasing threat from increased rainfall intensities, and a subsequent rise in natural hazard risk. The recommendation in the Waipu catchment was to replant the riparian areas for flood attenuation reasons, but no final decisionhas been made.

As noted regularly in this document, ecosystem services is an emerging concept that is still subject to ongoing research and development. It strongly encourages a better understanding of the connections between development and environment, and the need for this to be taken into account during environmental decision-making. Whangarei District faces the challenge of melding an increasing population and continued reliance on natural resources for its well-being, whether for food and fibre production, recreational and tourism activities for residents and visitors and so on. Apart from the economic perspective, ecosystem services play a critical role in maintaining a quality of life for all our communities through natural hazard mitigation, the provision of water, or the aesthetic values that attract people and vitality to this district. A healthly environment has more resilient ecosystems that ensure the delivery of ecosystem services which can allow for more development opportunities. This, in turn, can improve economic, social, cultural and environmental wellbeing.

Without strategic planning and careful consideration of the links between the two, an increased population can impact on the natural resources upon which the district depends. Future One has the most widespread impact on the delivery of ecosystem services, but does allow for some restoration in some popular locations for lifestyle properties. It has the largest demand in terms of ecosystem services from coastal processes Future Three has the least impact on the provision of ecosystem services, but also has the largest demand from growing urban areas. Future Two has a very large demand of ecosystem services in the Ruakaka/Marsden Point area, and some of the coastal belts around Whangarei Heads and Ngunguru/Tutukaka. Conversely these are the areas where the development has the most impact on the supply of ecosystem services.

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