Changes in Indigenous Ecosystems and the Environment within the Boundary of the Waitakere Ranges Heritage Area Act 2008: 2008-2013 Report

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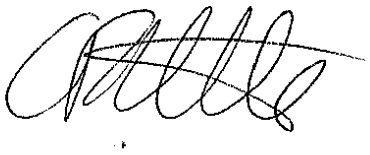
Approved for Auckland Council publication by:    Name: Greg Holland Position: Manager, Research, Investigations and Monitoring
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Changes in Indigenous Ecosystems and the Environment within the Boundary of the Waitakere Ranges Heritage Area Act 2008: 2008-2013 Report

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Executive Summary

This technical report summarises the state of indigenous ecosystems and the environment within the boundary of the Waitakere Ranges Heritage Area Act 2008 (WRHA or Heritage Area), and change within the Heritage Area over the period 2008 – 2012. The Heritage Area covers approximately 27,000 ha and contains one of the two largest blocks of continuous vegetation in the Auckland Region (c. 21,000 ha). The vegetation is characterised by a diverse mix of different native ecosystems. Altogether almost 80% of all the forest, scrub and wetland associations in the Heritage Area have statutory protection that prevents or limits habitat clearance.

A total of 52 different indicators are outlined in this report. In our opinion, these 52 indicators provide accurate indication of the general state of the natural environment of the WRHA, specific threats to important species, ecosystems and ecosystem services, and the community and council response to those threats. Monitoring changes in these indicators over time will be used to assess whether environmental protection and management within the Heritage Area is meeting the requirements of the Act. However, there are a number of limitations in the data that was available for this first monitoring report. These include missing data and/or inadequate length of time to judge whether changes in some indicators are natural variation or an actual trend. Therefore, the results presented in this report should be seen as provisional. One of the most important outcomes of this report is to outline a robust framework for future monitoring and stimulate the collection of 'missing' data.

Numerical data for a number of key indicators was not available for this report and only 27 of the 52 indicators were included in the numerical summary. Change was detected in 9 of these 27 indicators, and the majority these changes were negative (c.88%). There has been a decrease in indicator score of 0.012 to 0.015 points (1.2% – 1.5%) on a 1000 point scale, depending on how the various indicators are grouped to derive the total average figure. Overall, these data suggest there is likely to have been a small decrease in biodiversity values within the Heritage Area over the last four years. However, the size and direction of this trend cannot be confirmed by the data at this early stage of the monitoring programme. Auckland Council's regional environmental monitoring programmes are designed to detect relatively large-scale changes in biodiversity/environmental indicators and this small level of change could be the results of random, natural variation in indicator scores, rather than an actual negative trend.

Rates of habitat clearance were measured using desktop analysis of changes in aerial photographs. This work detected a loss rate of 0.03% of all indigenous habitats per year. Fifty years of clearance at this same rate would lead to a 1.5% reduction in the cover of indigenous ecosystems. This is likely to have a relatively small negative impact on overall biodiversity values within the Heritage Area, provided the cleared habitats do not include significant or uncommon ecosystems or habitat for threatened species. Only a very small amount of vegetation clearance of the highest value ecosystems (c. 0.5 ha) was detected. Aerial photographic analysis also showed there has been negligible loss of vegetation in the riparian zones of the Heritage Area watercourses (annual loss rate of c. 0.005%/year).

The Heritage Area currently supports approximately 93 nationally threatened species. The expansion of predator control work carried out in the Heritage Area in recent times means the proportion of threatened species with stable or increasing population sizes is likely to have increased from 2008 to 2012. We estimate that approximately 40 threatened species (43% of the total) in the Heritage Area are receiving some form of active conservation management that is helping the species to survive in the face of weed and pest pressures.

The Auckland Council has committed almost $250,000 annually towards the control of invasive weeds since the Act's inception in 2008. A variety of animal pest work has also continued throughout the Heritage Area over the last five years including a large scale trapping network, which has kept possum numbers close to the goal of 2% Residual Trap Catch index. Auckland Council, as part of the implementation of the Indigenous Biodiversity Strategy, will be putting more resources into collecting information about the location and status of threatened species and ecosystems. This will include threatened species and ecosystems in the Heritage Area that will input into these indicators for the 2018 monitoring report.

A significant emerging issue for the natural environment of the Heritage Area is kauri dieback. Significant resources have been expended over the last five years to identify the extent of the disease and minimise its further spread. This report contains a baseline measure of the spatial extent of Kauri dieback in the Heritage Area (which could be as high as 11%).

Values for all forest, wetland and duneland health indicators within the Heritage Area were 'high' or 'very high' in comparison with similar ecosystems throughout the rest of the Auckland Region, highlighting the very high naturalness of the Heritage Area's ecosystems. The Heritage Area includes two significant regional wetland complexes and several important dune lake wetlands. There have been some changes to landcover on duneland habitat post 2008; however, none of these changes were judged to have destroyed the underlying dune geology and geomorphology and there was only a very small amount of clearance of native duneland vegetation (c. 0.05 ha; 0.005% of total). A small amount (<0.5 ha) of wetland clearance/ drying was also detected.

The freshwater indicators are in general difficult to assess as the four-year time frame post 2008 is too short to robustly identify any environmental/ecological changes; however, years of freshwater sampling as part of the regional freshwater monitoring programme have shown there is a strong relationship between the health of rivers and surrounding landcover. Therefore, given the predominance of indigenous forest ecosystem within the Heritage Area, it is no surprise that the rivers and streams have excellent water quality and ecology.

More accurate information about the changes that are occurring and/or a longer-term dataset are required to reach firmer conclusions. Both of these will be available for the Act's next monitoring report.

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1.0 Background

This technical report is one of several reports which were written as supplementary documents for the main 2013 monitoring report required as part of the Waitakere Ranges Heritage Area Act 2008 (the Act). This report specifically details a variety of indicators pertaining to the indigenous ecosystems and the environment within the boundary of the Act (i.e. 'the WRHA' or 'the Heritage Area').

The Waitakere Ranges Heritage Area covers approximately 27,000 ha and contains one of the two largest blocks of continuous vegetation in the Auckland Region (c. 21,000 ha). The Heritage Area includes all of the Waitakere Ecological District, and small parts of Tamaki and Kaipara ecological districts. The vegetation within the Heritage Area is characterised by a diverse mix of different native ecosystems, which collectively provide extensive habitat for a wide range of indigenous plants, birds, reptiles, and insects. The vegetation cover is of particular significance due to the intact sequences of vegetation from the coast up to the inland hills, wild nature of its coastal ecosystems, and associations of wetland and dune lake systems (e.g. Anawhata and Whatipu beaches) (Auckland Council 2003).

Ecosystems within the Heritage Area are home to more than a quarter of New Zealand's flowering plant species and two-thirds of all native fern species. Fauna includes at least 50 species of native bird (14 of these being rare or endangered), 11 species of native freshwater fish, 1 native frog species, and 1 native terrestrial mammal (long-tailed bat) (Auckland Council 2003).

The most prominent ecosystem types found in the ranges include kauri forest, conifer-broadleaved forest, coastal forest, sand dune vegetation, and freshwater wetlands. Approximately 75% of the remaining native vegetation is protected, most of which is within the Auckland Council managed Waitakere Ranges Regional Park.

1.1.1 Geology and vegetation history

The Waitakere Ranges comprise the extensively eroded eastern flank of the Waitakere Volcano dating back to the early Micocene period between 22 and 15 million years ago, when the whole Auckland region was under the sea. In that period, the Australia and Pacific tectonic plates collided and a massive volcano (Waitakere Volcano) was pushed up out of the sea. The volcano, centred around 20km offshore from the present west coast, was 60km across and 40km from north to south, making it the second largest volcano that has ever erupted in New Zealand (Anon 2006). About 16 million years ago two lines of volcanic vents began erupting on the uplifted eastern flanks, one of these along the west coast. In some places magma flowed out and onto the slopes of the volcano, producing flows under the ocean that created pillow lava, an example of which can be found at the south end of Bethells Beach. The rocks of the Waitakere Ranges consist of a number of tilted or gently folded blocks of Manukau Subgroup with a low, overall west or north-

west tilt (Hayward 1976). Waitakere Volcanic Soils are the dominant soil type, with some overlapping Waitemata Residual Soils along the eastern boundary together with small, isolated areas of Alluvial Soils.

In terms of topography, the Waitakere Ranges is characterised by a highly dissected plateau with an average height of *c*.243m. The ranges are bounded on the west by precipitous cliffs which rise abruptly *c.*122m feet from the Tasman Sea. On the north and the east they drop away quickly to the gently undulating country that surrounds the upper reaches of the Waitemata and Kaipara harbours. Their southern boundary is defined by the shoreline of the Manukau Harbour. The Waitakere Ranges are deeply furrowed by the valleys and gullies of numerous streams, some of which flow through steep-walled gorges and over large waterfalls (Diamond 1955).

Between *c*.12,000 and 10,000 years ago, conifer-broadleaved species forest was the predominant vegetation cover on Auckland Isthmus (Newnham & Lowe 2006), and this forest type would most likely have dominated the Waitakere Ranges. Up until the time of human arrival (*c*.800 years ago), the Waitakere Ranges were covered in dense rainforest dominated by podocarp and broadleaved species such as kahikatea, rimu, karaka and tawa. Kauri forests were common in the eastern parts of the Ranges, with pohutukawa forest flourishing along the west coast and around the shores of the Manukau Harbour. The only open areas would have been inland bluffs and rocky outcrops, sea cliffs, dunelands and the margins of some wetlands.

1.1.2 Human impacts

Maori occupation and modification of this forest was primarily around coastal sites and resulted in conversion of forest habitat to native scrub and fernland vegetation. It has been suggested that early Maori fires induced kauri dominance in some parts of the Waitakere Ranges, however, it is presumed that the rugged interior of the ranges was virtually untouched until the arrival of Europeans (Denyer et al. 1993). In terms of wildlife, harvesting by Maori is likely to have had significant impacts on populations of fur seal, burrowing sea birds and moa, possibly resulting in local extinctions. In addition, the introduction of kiore and dogs would have had devastating effects on indigenous wildlife.

The early European settlers brought profound changes to the natural areas of the Waitakere Ranges. Extensive areas were logged and burnt, including virtually all mature kauri forest. Other activities such as flaxmilling, gumdigging, mineral extraction, quarrying and farming further contributed to the overall change from mature forest ecosystems to lower stature native forest and scrub. In addition, damming of some catchments for Auckland's water supply initially resulted in large-scale clearance for reservoir and dam sites. As well as changing the landscape, early Europeans facilitated the spread of many more introduced mammals such as possums, rats, mustelids and cats, all of which have wreaked havoc on the wildlife in the Waitakere Ranges.

By the 1940s all but 2% of the Waitakere Ranges had been modified by commercial logging to some extent. The greatest destruction to the coastal fringes of the District was caused by extensive bush fires, which were started to clear land for agriculture. Although 90% of the Waitakere Ranges

has returned to native bush, vegetation patterns have been altered, with the majority of vegetation now forming bands of successional and regenerating forest and scrub. A few areas have remained in their original state (e.g. the Cascades Kauri Park) and from these we are able to see what the historical vegetation patterns were like in the Waitakere Ranges. Pohutukawa still survive in exposed areas of the coastline, although much of the coastline vegetation now consists of manuka scrub (Auckland Council 1999).

Land protection has been an important positive human impact on the Waitakere Ranges. As early as 1895, while kauri was still actively being logged, plans were made to protect specific areas of the Waitakere Ranges as public reserves. Such visionary initiatives paved the way for subsequent land purchases by the Auckland City Council over the following decades. By 1936 the Council owned a total of 8,094ha of land, over 6,070ha of which was held for water catchment purposes, and over 2,023ha as public reserves. By 1947, parkland had increased to 3,764ha (Turner 2006).

1.1.3 Recent changes (1960 to present)

Source: Turner (2006)

In 1963, with the passing of the Auckland Regional Authority Act, the new authority was empowered to acquire land for public reserves. By 1969, the area of the park had increased to 5,785ha. The Auckland Regional Authority focused on acquiring small strategic areas that enhanced access to existing parkland or would facilitate the creation of a coastal walkway, and to providing facilities for the public. In 1982, the city Council finally transferred ownership and responsibility of remaining parks (except Goldie's Bush) to the Regional Authority with effect from April 1983, thereby increasing the regional parkland by over 1,619ha. By 1985, the total area of Waitakere Ranges parkland under regional management was 8,397ha. The final step in the consolidation of Waitakere Ranges land into one large park took place in 1992, nearly 100 years after the first steps were taken to reserve land for recreation and conservation. Major additions to the Heritage Area continued during the 1990s, and presently the area of land managed by the Auckland Council now totals *c*.17,080 ha.

In demographic terms, the past few decades have seen a significant increase in rural and residential development of the Waitakere Ranges foothills. Also, villages such as Titirangi, Piha and Bethells/Te Henga have experienced sharp increases in population as more people seek alternatives to city living. With more people spread out over larger areas, there has been a corresponding spread of invasive weeds, many of which have escaped from gardens. Invasive weeds are one of the main threats – if not the biggest threat – to the ecological integrity of the Heritage Area.

1.2 Auckland Plan Directives

The indicators presented in this report were designed to meet the reporting needs identified in the Waitakere Ranges Heritage Area Act. However, they also relate directly to a range of different Auckland Plan objectives (Table 1). The wide range of monitoring data summarized in this and other technical reports on the Act has the potential to be re-packaged and expressed in terms of Auckland Plan Objectives (and other ways). This may help to disseminate the data to a wider audience.

Table 1 Links between Environment and Ecosystem indicators and the directives in the Auckland Plan.

Auckland Plan Directives that 'crossover' with natural environment monitoring/indicators used for Waitakere Ranges Heritage Act reporting		Relevant indicators[1] from this report
Directive 7.2	Recognise and promote the contribution of natural heritage to urban character, quality, amenity and sense of place, and as part of sustainable rural land management.	H1, H2, H3, R1, R2, R3, R4, P1, P2, P3, F1, F2, W1, W2, D1, D2, D3, D4, D5
Directive 7.3	Identify significant landscapes, landscape character, natural character and natural features, and appropriately manage these to protect and enhance their biophysical and sensory qualities, and associated values.	H1, H2, H3, H4, H5, D1, D2, D3, D4, D5, W1, W2, W7, W8
Directive 7.4	Identify places of high natural heritage value, and where appropriate, protect, manage and expand public open space areas so they can be enjoyed by everyone.	P1, P2, P3, T1, T2, C1, C2, C3, K1, F3, F4, F5, F6, F7, F8, F9, F10, F11, W3, W4, W5, W6, W7, W8, W9
Directive 7.5	Protect ecological areas, ecosystems and areas of significant indigenous biodiversity from inappropriate use and development, and ensure ecosystems and indigenous biodiversity on public and private land are protected and restored.	H1, H2, H3, R1, R2, R3, R4, P1, P2, P3, F1, F2, W1, W2, D1, D2, D3, D4, D5
Directive 7.10	Manage land to support the values of water-bodies by protecting them where they are high and reviving them where they are degraded.	R1, R2, R3, R4, W1, W2, W3, W4, W5, W6, W7, W8, W9, FW1, FW2, FW3, FW4, FW5, FW6, S1, S2

Auckland Plan Directives that 'crossover' with natural environment monitoring/indicators used for Waitakere Ranges Heritage Act reporting		Relevant indicators[1] from this report
Directive 7.12	Protect coastal areas, particularly those with high values – including special natural character, significant marine habitats and recreational importance – from the impacts of use and development, and enhance degraded areas.	H1, H2, H3, H4, H5, P1, P2, P3, C1, C2, C3, D1, D2, D3, D4, D5, D6
Directive 8.2	Protect, enhance and increase Auckland's green infrastructure networks.	P1, P2, P3, C1, C2, C3, R1, R2, R3, R4, H2, F2, D6
Directive 9.1	Ensure that the resources and production systems that underpin working rural land are protected, maintained and improved.	R1, R2, R3, R4, C2, C3, W1, FW3, FW4, FW5, FW6, S1, S2

1 = Full descriptions of these indicators and their results are presented in Appendix one and two

1.3 The Heritage Area and the Waitakere Ecological District

Ecological districts are a commonly used by New Zealand ecologists as a framework for assessing the ecological significance of different areas of indigenous habitat in the landscape. Ecological district (ED) boundaries are determined by the important physical drivers, such as geology, landform and climate. The Waitakere Ecological District is 29,100 hectares in area and ranges from sea level to 474m. The ranges are the eroded remnants of a large, ancient volcano that emerged from what is now sea to the west of the Auckland Region around 23 million years ago (Lindsey et al. 2009). Its main unifying feature is the underlying volcanic basement rocks, which are different to the parent material of surrounding ecological districts.

The boundaries of the Heritage Area include the entire Waitakere Ecological District, and smaller parts of two adjoining ecological districts. The small sub-catchment surrounding Anzac Valley Road is part of Rodney ED (c. 610 ha or 2% of Heritage Area). Significant parts of the low-lying foothills in Henderson Valley, Swanson and Oratia suburbs (c. 2,200 ha or 8% of Heritage Area) are part of Tamaki ED, which includes the low-lying land of the Auckland Isthmus and Waitemata Harbour surrounds.

2.0 Methods

2.1 Indicator format and structure

A total of 52 different indicators are presented in this report (Table 2 and Appendix One and Two). The indicators were subjectively chosen by the authors based on the following:

1. Known drivers of biodiversity loss and environmental degradation such as habitat loss, the impact of pest plants and animals, and pollution;
2. Key environmental assets identified in the WRHA and other relevant statutory documents, e.g. inclusion of water supply, separate wetland and separate duneland indicators as the Act makes specific mention of these features. Wetlands, dunelands, threatened species and historically rare ecosystems are specific environmental features listed in the proposed National Policy Statement on biodiversity (MfE 2011);
3. Known indicators of biodiversity/environmental health used for similar monitoring in New Zealand in the past (e.g. MacLeod et al. 2012) and/or environmental indicators proposed for adoption by New Zealand Regional Councils (c.f. Lee and Allen 2011)
4. Existing data coverage for the WRHA, including the availability of aerial photos and regional landcover data, and the location and length of data record for Auckland Council environmental/biodiversity monitoring sites within the Heritage Area.

A total of 52 different indicators are outlined in this report. In our opinion, these 52 indicators provide a relatively robust and accurate picture of the state of the natural environment of the WRHA, threats to that environment, and environmental management activity by community and Council. Over time, monitoring changes in these indicators can be used to check if environmental protection and management within the Heritage Area is meeting the requirements of the Act. Almost no action was taken on measuring biodiversity and environmental objectives of the WRHA until 2012. This meant that no monitoring tailored to measuring Heritage Act objectives was instigated, beyond that collected in the regional monitoring programme. This has been rectified, and we hope that suitably robust data will be available for all 52 indicators in the 2013 – 2018 five-yearly monitoring report.

Numerical data for a number of key indicators were not available for this report and hence only 27 of the 52 indicators were included in the numerical summary

The indicators in Table 2 have been grouped in two different ways:

1. By eleven different broad ‘topic/issue’ groupings identified in the WRHA (H = habitat and landcover indicators, T = threatened species indicators, R = riparian quality indicators, etc.);
2. By five different ‘categories’ that approximate the Pressure/State/Response framework (OECD 1993, MfE 1997), with some additional separation of the ‘state’ category into ‘habitat’, ‘biodiversity’ and ‘ecosystem services’ components. Full descriptions of the methods used to calculate each indicator, data sources and workings are presented in Appendix Two.

Table 2. Summary of biodiversity, environment and ecosystem indicators used to report on changes in the natural environment within the Waitakere Ranges Heritage Area.

By topic	By category	Indicator name
H1	Habitat	Percentage cover of indigenous ecosystems
H2	Habitat	Loss or gain of indigenous ecosystems (area and %)
H3	Habitat	Loss or gain of significant indigenous habitat (area and %)
H4	Habitat	Loss or gain of threatened species habitat (area and %)
H5	Habitat	Loss or gain of originally rare ecosystem types (area and %)
R1	Ecosystem services	Proportion of riparian area around Zone I streams with indigenous wetland, forest and/or scrub landcover
R2	Ecosystem services	Proportion of riparian area around Zone II streams with indigenous wetland, forest and/or scrub landcover
R3	Ecosystem services	Proportion of riparian area around Zone I streams with wetland, forest or scrub landcover
R4	Ecosystem services	Proportion of riparian area around Zone II streams with wetland or indigenous vegetation landcover
T1	Biodiversity	Proportion of threatened species with a stable or increasing population size
T2	Response	Proportion of threatened species under active conservation management
P1	Response	Total area of ecosystems (area and %) protected in reserves
P2	Response	Total area of indigenous ecosystems (area and %) protected in reserves
P3	Response	Total area of significant indigenous ecosystems (area and %) protected in reserves
C1	Response	Proportion of indigenous forest habitat under active conservation management
C2	Response	Weed management
C3	Response	Pest animal management
K1	Threats	Change in the spatial extent of kauri dieback
F1	Biodiversity	Total area of forest and scrub habitats
F2	Habitat	Loss or gain of forest and scrub habitat (area and %)
F3	Biodiversity	Overall percentage biomass of indigenous plants in forest plots
F4	Threats	Overall percentage biomass of weedy exotic plants in forest plots
F5	Threats	Average biomass of exotic weeds in forest plots

By topic	By category	Indicator name
F6	Biodiversity	Proportion of forest plots with no exotic trees or saplings
F7	Threats	Average percentage dominance of weedy exotic saplings
F8	Threats	Average percentage dominance of weedy exotic seedlings
F9	Biodiversity	Species diversity of indigenous plants
F10	Biodiversity	Average species diversity of indigenous plants
F11	Biodiversity	Change in avian conspicuousness in forest and scrub habitat
W1	Biodiversity	Total wetland area
W2	Habitat	Loss or gain of wetland habitat (area and %)
W3	Biodiversity	Native: exotic plant biomass ratio in monitored wetlands
W4	Biodiversity	Average native: exotic plant biomass ratio in monitored wetlands
W5	Biodiversity	Average native: exotic plant frequency in monitored wetlands
W6	Threats	Average native: exotic weed plant frequency in monitored wetlands
W7	Biodiversity & threats	Change in wetland condition index
W8	Biodiversity & threats	Change in wetland perimeter condition index
W9	Biodiversity	Change in avian conspicuousness in wetland habitat
D1	Biodiversity	Total duneland area
D2	Habitat	Loss or gain of duneland habitat (area and %)
D3	Biodiversity	Proportion of duneland area with a landcover of indigenous ecosystems
D4	Biodiversity	Proportion of duneland area with urban or production agriculture landcover
D5	Biodiversity	Building and impervious cover on duneland area (area and %)
D6	Response	Proportion of indigenous duneland habitat under active conservation management
FW1	Biodiversity	Ecological quality (rivers/streams): Macroinvertebrate Community Index (MCI)
FW2	Ecosystem services	Native fish monitoring: Index of Biotic Integrity (IBI)
FW3	Ecosystem services	Water quality (rivers/streams)
FW4	Ecosystem services	Ecological quality (lakes): Rotifer index

By topic	By category	Indicator name
FW5	Ecosystem services	Ecological quality (lakes): Macrophytes (LakeSPI)
FW6	Ecosystem services	Groundwater quality (for discharge to rivers)
S1	Ecosystem services	Ecological quality (water supply) – Macroinvertebrates
S2	Ecosystem services	Water quality (water supply)

2.2 Numerical scoring and grades

Ideally, biodiversity reporting for the Act should consider changes in a range of different indicators, which can then be combined into various indices to get an overall picture of the changes in indigenous biodiversity. In the following section, numeric results for 27 of the 52 different indicators outlined in Table 2 are summarised and discussed.

The methodology used to summarise indicator results below is a highly quantitative one, and sometimes assigning numbers to indicators can give the final results a false impression of accuracy. In reality, the final numbers are only as robust as the field data and analytical approach allow. Therefore, the results presented below should not be seen as the 'final word' on the state of the environment and ecosystems within the Heritage Area, because there are a number of limitations built into the various indicators and the way they are combined to produce a final grade, including:

1. Missing or poor quality information for many of the baseline measures;
2. Lack of long-term data for those that we do have information on;
3. Lack of knowledge of measurement error/observer bias in data, and;
4. Lack of knowledge around the rate at which biodiversity values change for different indicators

For example, a linear response is assumed for each indicator when this probably is not actually the reality. The impact of vegetation clearance for instance will depend on how much vegetation is left - a 5% loss of forest when the landscape is 80% forested has a different impact than a 5% in a landscape that is only 8% forested.

The final scores produced in this report should therefore be seen as a guide to decision makers, rather than the final word. They should be used in conjunction with other information sources, including qualitative data such as the personal observations of field staff, in assessing the state of the environment/ ecosystems.

Data limitations mean it is hard to separate out natural variation in indicator values from actual positive/negative change and we therefore encourage caution in interpretation of relatively small increases/decreases in indicator data. Nevertheless, while our analysis might have some limitations, the indicators that we currently do have complete data for are able to identify gross negative/positive changes in biodiversity values in the Heritage Area between 2008 and 2013, and hence this analysis has merit in identifying broad changes. As well, this analysis introduces the framework which will be used and improved upon in the 2018 report.

As we used a variety of indicators with different data types and formats, it was important to develop a common scale to allow for comparisons and summaries. Indicator results were converted to a scale of 0.000 (low) to 1.000 (high). Many of the indicators were already based on proportions and hence no transformation was required; however, other data needed to be transformed. For example, the possum percentage residual trap catch data (indicator C3) was first transformed to a proportion and then the values were reverse scaled; 6.6% = 0.936 and 1.9% = 0.981. Another example is the wetland condition data, which were scores out of 25. These scores were divided by 25 to express the result as a percentage, and then transformed to a decimal proportion.

We note that this approach assumes biodiversity values for all indicators respond in a similar way along the 0.000 to 1.000 point scale (i.e. response function). For example, a 0.05 change from 0.95 to 0.90 means the same thing, in terms of its impact on biodiversity values, for the possum density index as it does for the change in wetland condition index. This assumption is almost certainly invalid and the actual biodiversity impact of a (say) 5% change is likely to vary widely both between and within (on different parts of the 1000 point scale) indicators. One of the technical questions that will be addressed before the 2018 report is a more robust approach to standardising the ‘response functions’ of each indicator.

3.0 Results – numerical indicator analysis

A table summarising the results and data status for all 52 indicators is provided in Appendix 1. Appendix 2 contains more detailed descriptions of the justification for each indicator, some more detailed methodologies for the indicator in question and the results. One of the simplest and most commonly used summary statistics is the average. Comparing indicator values for 2008 vs. 2012 shows there has been a decrease in average indicator score of 0.014 (Table 3). Or expressed another way the biodiversity/environmental quality of the WRHA (as measured by this simple index of quality) has decreased by c.1.4%.

Table 3: Change in the average value of 27 WRHA environmental indicators between 2008 and 2012. Scores are based on a 1.000 (high score) to 0.000 (low score) scale.

Indicator description	**Score in 2008**	**Score in 2012**	**Change**
Average score of 27 indicators	0.848	0.834	- 0.014

However, there are two important caveats that apply to the -0.014 (i.e. 1.4%) decrease figure in Table 3:

1. Many of the datasets, particularly for water supply and freshwater quality indicators, have too few sample sites and measures per site to be confident that the final result is an accurate one. The within and between year variation in these indicators is relatively large. Therefore it is difficult to determine if a decrease (or increase) in indicator score is a real long-term trend, or just 'noise' due to the highly variable nature of the freshwater invertebrate communities that these indicators are based on. These issues will be rectified as data over a longer time become available.
2. The final figure is an average and (as outlined below) care needs to be taken in the interpretation of averages, as they can conceal a lot underlying variation.

One of the problems with using averages to summarise indicators is they can disguise important information (e.g. is a small change in average due to small changes across all indicators, or large positive and negative changes in a range of different indicators that just happen to balance each other out?). Change was detected in nine of the 27 indicators for which we have data (Table 4 and Appendix 1), the majority of which were negative (c.88%), and the average rate of decrease (0.05 or 5%) was five times that of the single increase (0.01 or 1%).

Table 4: Indicator change summary data.

Total # indicators	# no change indicators	# positive change indicators	Average increase in score	# negative change indicators	Average decrease in score
27	18	1	0.01	8	0.05

Much like the overall average result (Table 3), Table 4 data suggest that there has probably been a small decrease in environmental quality in the WRHA over the last five years. However, the size and direction of this trend cannot be confirmed at this early stage of the monitoring programme. That is, this small level of change could be the results of random, natural variation in indicator scores, rather than an actual negative trend. Auckland Council's regional environmental monitoring programmes are designed to detect relatively large-scale changes in biodiversity/environmental indicators. Once data is available over a longer time span (i.e. 10-20 years), we will be able to more robustly test the trends revealed in this analysis.

3.1 Grouped indicator summary

Averaging across all 27 indicators means that the more indicators a specific ecosystem type or geographic area has assigned to it, the greater its influence on the final result. For example, there are eleven different forest indicators and only one kauri dieback indicator. This means that the forest indicators have 11 times the influence on the final result, compared to the single kauri dieback indicator. The number of indicators in a specific category is not always the best indicator of its relative contribution to the 'health' of indigenous ecosystems and natural heritage across the whole WRHA. For this reason it is useful to define groups of 'similar themed' indicators and calculate the average for each group separately, before combining them into a grand total.

There are a variety of different (and often equally valid) ways to group the indicators. We have chosen two different approaches:

(i) By ecosystem type/issue identified in the WRHA, which lists specific ecosystems (e.g. forest, wetland, duneland), biodiversity components (e.g. threatened species, riparian vegetation) or issues (e.g. weeds, pest animal, community response, quality of water supply) for reporting (see Table 5); and

(ii) In five different categories that approximate the Pressure/State/Response environmental reporting model, but with some separation of state components (i.e. into habitat extent, biodiversity diversity/ quality and ecosystem services components) (see Table 6).

Table 5: Average value of indicators presented in Table 2, averaged across topic codes. Scores are based on a 1000-point scale from 1.000 (high) to 0.000 (low). Scores marked with a * are estimates.

Code and category	Average score in 2008	Average score in 2012	Change
Habitat	0.915	0.915	no change
Ecosystem services	0.812	0.811	- 0.001
Protection	0.777	0.780	+ 0.003
Conservation management	0.981	0.934	- 0.047
Kauri dieback	0.980*	0.890	- 0.09
Forest indicators	0.951	0.950	- 0.001
Wetland indicators	0.830	0.830	no change
Duneland indicators	0.891	0.890	- 0.001
Fresh water	0.464[1]	0.464[1]	no change[1]
Water supply	0.925[2]	0.925[2]	no change[2]
TOTAL – overall average	**0.845**	**0.833**	**-0.014**

1 = There was actually a decrease in the value of this indicator (from 0.483 to 0.445) between 2008 and 2012. However, the small data set and highly variable nature of freshwater invertebrate data means this figure is unreliable. An average of the 2008 and 2012 values in presented in this table

2 = There was actually a decrease in the value of this indicator (from 0.965 to 0.885) between 2008 and 2012. However, the small data set and highly variable nature of freshwater invertebrate data means this figure is unreliable. An average of the 2008 and 2012 values in presented in this table

The data presented in Table 5 suggest there has been a small decrease (0.014 or 1.4%) in biodiversity values within the Heritage Area over the last four years. This result is in line with the earlier more aggregated indicator averages and fits with our professional observations about the likely trajectory of indigenous biodiversity in the Heritage Act area. Pressures such as land clearance, weeds and pest animals have been largely removed and reduced in the Heritage Area, however, there are low levels of ongoing clearance sufficient to create a (slightly) negative trajectory for this index.

The expansion of kauri dieback is a major negative driver in Table 5 (9% reduction in index value). Unfortunately, the long-term prognosis for the spread and ongoing impact of kauri dieback in the Waitakere Ranges means negative changes in this indicator may continue to drive the overall index down over the next 30 years or so. There was also a relatively large reduction in the indicator

value for conservation management. The 0.047 point decrease is the direct result of a temporary increase in possum numbers in one part of the Heritage Area, rather than a long-term effect. Management action will have reduced these possum numbers to the target density by now; control is stepped up in response to increases in possum numbers, which are continually monitored.

The exact nature of how the indicators are combined will influence the final result. The ten sub-categories used to group the data in Table 5 represent only one of a number of ways in which the different indicators could be grouped. Table 6 provides an alternative summary. In this table indicators have been grouped into five different categories, based on the types of indicators that might be provided in a standard Pressure/ State/ Response/ Impact monitoring approach. When this indicator format is used the overall result is a small (0.015 or 1.5% of the total index value) decrease in the 'biodiversity index' value of the Heritage Area.

Table 6: Average value of indicators presented in Table 2, averaged across sub-category codes. Scores are based on a 1000-point scale from 1.000 (high) to 0.000 (low).

Sub-category code	**Average score in 2008**	**Average score in 2012**	**Change**
Biodiversity and ecosystems	0.853	0.853	no change
Ecosystem services	0.757	0.723	- 0.034
Habitat extent and level of protection	0.915	0.915	no change
Response	0.828	0.818	- 0.010
Threats	0.985	0.957	-0.028
TOTAL – overall average	**0.868**	**0.853**	**-0.015**

Once again, the relatively high negative change values for ecosystem services and threats are the result of the variable nature of freshwater invertebrate datasets and a temporary increase in possum density in one part of the WRHA. That is, they probably **do not** represent a long-term trend that is likely to see a 3 – 4% reduction in index value (= 0.6 – 0.8% per annum) over the next 20 years.

The data presented in Table's 3 - 6 suggest that there has been very little change in indigenous biodiversity or natural heritage values in the Heritage Area over the last four years. It is unclear whether the ongoing trend is slightly positive or slightly negative, although in our opinion it is most likely to be a minor downward trend. More accurate information about the changes that are occurring and/or a longer-term dataset are required to reach firmer conclusions. Both of these will be available for the next WRHA monitoring report in 2018.

Based on the data from this first monitoring report, it seems that in the medium (15 -30 year) term the final indicator value will be determined by the 'balance' between the positive effects of a widening reserve network and better weed and pest animal control, and the negative effects of ongoing, low-level clearance, and the expansion of kauri dieback. This is discussed more fully in the summary

4.0 Results – all indicator analysis

This section provides a short summary for each of the indicator groupings (habitat, threatened species, wetlands, forest, water supply etc.) outlined in Table 2. Full details on the methodologies and calculations for individual indicators are presented in Appendix one and two.

4.1 Habitat indicators (H)

Worldwide, one of the primary drivers of species and ecosystem extinctions has been habitat loss. Therefore, the quantity of habitat is one of the most important determinants of the health or 'state' of indigenous biodiversity within the Heritage Area. Rates of habitat clearance varied between the two approaches used to measure it. Analysis of LCDB 2001 vs. 2008 remote sensing data detected a loss rate across the whole Heritage Area of 0.003% of native ecosystems/year. However, a desktop assessment of 2007 vs. 2010 aerial photos detected a 6 – 7 times higher loss rate of 0.02%/year. The reason why these two methods have produced different rates of clearance is likely to be the result of differences in the methodologies/measurement scale.

Irrespective of which method is used to measure change, the overall impact of a 0.5 - 1% reduction of indigenous forest (=50 years of change at these rates) on biodiversity values within the Heritage Area is likely to be relatively small, provided the cleared habitats do not include significant or uncommon ecosystems or habitat for threatened species. Only a very small amount of vegetation clearance of significant ecosystems (c. 0.5 ha) was detected, which is an annual loss of 0.13 ha per year. This loss is negligible; 100 years of change at this rate would result in a <1% loss of significant vegetation.

4.2 Riparian indicators (R)

Aerial photo analysis shows there has been a negligible loss of vegetation in the riparian zones of Heritage Area watercourses. Approximately 0.02% of forest and scrub ecosystems in the riparian zones of these streams were cleared over the period 2008 – 2012, which converts to an annual loss rate of c.0.005%/year. This loss should continue to be watched closely in future reports, given the key role of riparian vegetation in natural systems. However, current loss rates are almost certainly sustainable on a 100 -200 year time scale.

4.3 Threatened species indicators (T)

The Heritage Area currently supports approximately 93 nationally threatened species. While it is relatively simple to gauge the abundance of certain populations within specific areas (e.g. dotterel numbers at Whatipu), it is difficult to evaluate the overall success of threatened populations

throughout the entire Heritage Area. Monitoring patterns of population change for many threatened plants - particularly ephemeral or cryptic species such as orchids and easily overlooked herbaceous plants – and invertebrates requires a substantial commitment of financial resources and/or time. This type of information is not available for most threatened species in the Heritage Area.

The expansion of the buffer area adjacent to the 'Ark', together with the predator control work carried out at places such as Whatipu, Bethells Beach, and Karekare, means the proportion of threatened species with stable or increasing population sizes is likely to have increased from 2008 – 2012. However, we are not in a position to provide robust data on the proportion of threatened species with stable or increasing population sizes for this monitoring report. Over the next five years the Auckland Council, as part of the implementation of the biodiversity strategy, will be putting more resources into collecting information about the location and status of threatened species and ecosystems. This will include threatened species and ecosystems in the Heritage Area that will input into these indicators for the 2018 monitoring report.

We estimate that approximately 40 threatened species (43% of the total) in the Heritage Area are receiving some form of active conservation management that is helping the species to survive in the face of weed and pest pressures. However, the proportion of the total population of these species that is being actively managed is impossible to determine with the current data. An additional 28 threatened plant species that are highly vulnerable to weed invasions probably occur in locations with active conservation management. However, because targeted weed control for these species is not being carried out, we regarded them as unmanaged populations.

4.4 Protection/ reserve indicators (P)

Altogether, almost 80% of all the forest, scrub and wetland associations in the Heritage Area have statutory protection for that makes it impossible or very hard, (i.e. would require a lengthy planning and permissions process) to legally clear woody vegetation from these sites. This is a very high percentage of protected land in comparison to almost all other parts of the Auckland Region, New Zealand and globally, and should ensure that the Heritage Area continues to be an environment that is dominated by forests and natural coastal ecosystems and processes.

4.5 Conservation management indicators (C)

The Heritage Area in general is being well managed with a large variety of conservation initiatives, from small to large community-driven projects such as the impressive Ark in the Park mission to larger scale pest and weed control programmes driven by Auckland Council. Many of these projects have been running well before the Act's inception in 2008 and are continuing to produce

fruitful results and conservation outcomes. This report as well as the Waitakere Ranges Heritage Area Community Wellbeing technical report contains baseline inventories of these conservation management projects which will be used to assess in the 2018 Act report any changes to the amount of the Heritage Area actively being managed. Auckland Council has continued commit almost $250,000 annually towards the control of invasive weeds since the Act's inception in 2008. A variety of animal pest work has continued throughout the Heritage Area over the last five years including a large scale trapping network which has kept possum numbers close to the residual trap catch close to the 2% goal.

Weed and pest control programmes in Ark in the Park appear to be working well. Pests are much less important in the ARK, compared with forest in the rest of the WRHA. A small number of weed seedlings were recorded in one ARK plot, which is a very low level of weed penetration. Values for the surrounding Waitakere plots are much higher, although weed pests still comprise only 0.3% of total basal area (on average) in forest plots. Chew card data analysis confirmed that animal pest control at ARK is reducing the abundance of mice, rats and possums, compared to the surrounding forest. The 'reduction effect' is less pronounced for mice (20 – 40% improvement) than for rats and possums (mostly 50%+ improvement).

4.6 Kauri dieback indicator (K)

Kauri dieback is a major concern in the Heritage Area and consequently significant resources have been applied over the last five years to identify the extent of the disease and minimise its further spread such as the Kauri Dieback PTA Operational Plan Regional Parks written by Auckland in 2011. A multi-agency response to address kauri dieback has been underway since late 2008 when MAF Biosecurity New Zealand declared it an 'Unwanted Organism' under the Biosecurity Act. An aerial survey was undertaken in 2010 to assess the extent of kauri dieback off track (Jamieson 2010). The aerial survey identified numerous unhealthy trees and groups of trees that had not previously been recorded by ground surveying and increased the known extent of unhealthy trees at several locations where kauri dieback had previously been identified. All trees identified by the aerial survey with ill thrift (1700) were inspected, with 970 confirmed with PTA.

Kauri dieback is now widespread throughout the Waitakere Ranges, with an estimated 8% of dense areas of kauri forest known to be affected, and an additional 3% probably affected. All kauri forest within the entire Waitakere Ranges may now be considered at very high risk of infection by kauri dieback. As such there is now an extreme risk of continued spread of the disease locally, regionally and nationally out of these zones, unless mitigation management and compliance levels are significantly improved (Parks Recreation and Heritage Forum 2011). This report contains the baseline measure of the spatial extent of Kauri dieback in the Heritage Area which is as high as 11%. This measure will be monitored and reported on in either the 2018 or 2023 Act report

(pending funding allocation). Specific monitoring of the disease using permanent vegetation plots have also been setup in the Heritage Area which should be reported on in the 2018 Act report.

4.7 Forest indicators (F)

Forest has been the most dominant indigenous ecosystem within the Heritage Area for most of the last 12,000 years and indicators of forest health are therefore a key part of the health of the natural environment. Values for all forest health indicators were very high in comparison with forest ecosystems around the rest of the Auckland region, highlighting the very high naturalness of forest ecosystems in the Heritage Area and the low impact of weeds. The data included in this report is a baseline measure and therefore it will be 2018 before change data is available for forest indicators.

4.8 Wetland indicators (W)

The Heritage Area includes two significant regional wetland complexes, several important dune lake wetlands and a handful of several smaller and more fertile/modified wetlands surrounded by farmland. Overall, wetlands are a lot weedier than forests, although Heritage Area wetlands are still relatively weed free compared with other parts of the Auckland Region. Condition and pressure in wetlands appear to be stable or improving over the 2008 -2013 monitoring period. The data included in this report is a baseline measure and therefore it will be 2018 before change data is available for wetland indicators.

4.9 Duneland indicators (D)

There are approximately 925 ha of duneland habitat in the Heritage Area. The overwhelming majority of this (c.80%) is found at Whatipu, where aggregation of sand over the last 60+ years has formed an extensive dunefield and wetland complex. Desktop analysis of time series aerial photographs revealed there had been some changes to landcover on duneland habitat post 2008, however none of these changes were judged to have destroyed the underlying dune geology and geomorphology.

Changes detected included vegetation clearance, regeneration of new vegetation, construction and/or removal of structures, and construction or removal of impervious surfaces. There was only a very small amount of clearance of native duneland vegetation (c.0.05 ha (0.005% of total) scattered across three different dune systems) and this loss was balanced by a c.0.7 ha increase/re-growth of indigenous dune vegetation in the Te Henga dune system.

Only a very small (c. 0.5 ha or 0.05%) increase in the amount of duneland covered by non-natural vegetation was detected. Continuing the current rate of dune conversion (c.0.01% per annum) into the future would require c.100 years to produce a 1% increase in the proportion of duneland within the Heritage Area covered in non-natural vegetation. This level of change is almost certainly sustainable in the long term, particularly if a sensitive approach is taken to future buildings.

Active management of dunelands is likely to significantly lower the risks and damage from environmental pressures and we have included an indicator for 'active management of dunes' (D6). This indicator requires the collation of information from a wide variety of sources, many of which were not available for this report. We recommend that this data is collated and presented in an interim report (March 2014) with the full indicator to be included with the other data from 2018 onwards.

4.10 Freshwater indicators (FW)

The freshwater indicators are in general difficult to assess any major changes since the Act's inception in 2008 being this is too short of a time frame to robustly understand the factors affecting any environmental changes. We do know though from years of freshwater sampling as part of the regional freshwater monitoring programme throughout Auckland that there is a strong relationship between the health of rivers and the type of landcover, and hence with the predominance of indigenous forest ecosystem within the Heritage Area it is no surprise that the rivers and streams have excellent water quality and ecology. The lakes in the Heritage Area are more degraded with weed issues that are being dealt with by various Council and community driven projects. It is expected that the 2018 report will be able to elucidate the broad freshwater patterns that have taken place since the Act's inception.

4.11 Water supply indicators (S)

The five reservoirs in the Heritage Area overall indicate good water quality with moderate to low levels of impairment, and hence fair to good habitat. These trends act as a baseline to be used for future analyses where a more detailed quantitative approach may be used.

5.0 Key Questions

Key question 1: Has the extent of indigenous species and ecosystems within the Heritage Area increased or decreased the last five years?

Calculation of the total loss of indigenous ecosystems varied between the two approaches used to measure it. However, a desktop assessment of aerial photos detected a loss rate of 0.02% of all indigenous ecosystems in the Heritage Area per year. At this rate, it would take around fifty years of change to reduce indigenous ecosystems by 1%. Therefore the overall effect of this loss on biodiversity values within the Heritage Area is likely to be relatively small, provided the cleared habitats do not include significant or uncommon ecosystems or habitat for threatened species. Only a very small amount of vegetation clearance of significant ecosystems (c. 0.5 ha) was detected, which is an annual loss of 0.13 ha per year. This loss is negligible; 100 years of change at this rate would result in a <1% loss of significant vegetation.

Key question 2: Has the general condition or natural values of important species and ecosystems within the Heritage Area increased or decreased the last five years?

The forest and wetland indicator data, and our professional opinion, suggest that (overall) there is likely to have been a small decrease in biodiversity values within the Heritage Area over the last four years. Pressures such as land clearance, weeds and pests have been largely removed and reduced in the Heritage Area; however there are low levels of ongoing clearance sufficient to create a (slightly) negative trajectory for this index. The expansion of kauri dieback is also a negative driver, and may have future consequences for biodiversity. In the long term, the balance between the negative effects of ongoing, low level clearance and the expansion of kauri dieback, and the positive effects of a widening reserve network and better weed and pest control, is likely to drive the overall status of biodiversity in the Heritage Area.

More accurate information about the changes that are occurring and/or a longer term dataset are required to reach firmer conclusions. Both of these will be available for the Act's next monitoring report.

Key question 3: Has the extra protection provided by the Waitakere Ranges Heritage Act provided better environmental or biodiversity outcomes over 2008 - 2012; compared to pre 2008?

There is currently insufficient data to answer this question, as most of the indicators we have used date back only to mid 2000s and there are only a small number of comparisons possible between pre 2008 and post 2008 datasets.

Key question 4: Has the extra protection provided by the Waitakere Ranges Heritage Act provided better environmental or biodiversity outcomes compared with parts of the region that do not have this additional statutory protection?

There is currently insufficient data to answer this question. To do this, we would need to carry out 'Heritage Act type monitoring' in a similar (in terms of ecosystems and development pressures) part of the Auckland Region that does not have the extra protection of the Waitakere Ranges Heritage Act, and then compare results. At this stage this dataset does not exist. However, comparing environmental change in different parts of Auckland will be possible once we have longer term datasets from the various regional environmental monitoring programmes. The less intensive monitoring in other parts of the Auckland Region (i.e. outside the WRHA) means a smaller number of indicators (i.e. <52) would be available for these comparisons.

6.0 Recommendations

1. Continue to support collection of long-term environmental and ecological datasets.

   The quantitative data used to formulate many of the forest, wetland, duneland and freshwater indicators presented in this report is collected from a network of plots/sites, and includes measures of birds/vegetation/weeds/pests/macroinvertebrates and ecosystem condition. For example, baseline measures for all vegetation plots in the Heritage Area will be completed by March 2014; the plan is then to re-measure these plots on a five – ten year rotation. It is important that regional monitoring continues to be funded and carried out. The real benefits of the plot networks for detecting and reporting on environmental change will only be realised in the fullness of time; that is, after several re-measurements (to allow long-term trends to be established beyond doubt) of the whole plot network (to allow comparisons between different ecosystem types and geographical areas).

2. Support acquisition of high resolution aerial photography and digitizing of key data (such as building footprint layer) on a regular basis.

   One of the three main information sources used in this report was the analysis of aerial photography and associated digital layers (e.g. building footprint and impermeable surface data). Surveying and mapping the vegetation of the Heritage Area every five years using fieldwork is impractical due to the large amount of time and $ that would have to be set aside for this task. High-resolution aerial photography provides the key resource that allows ecologists to more rapidly carry out this task as a desk-top exercise, and means we can also detect change in locations that are difficult or impossible to see without aerials. For future measurements it is important to have high-resolution aerial photography at a minimum five year interval. Accurate building footprint and impermeable surface layers should also continue to be digitized.

3. Acquire better baseline information on some threatened species and ecosystem types.

   One of the main data gaps in this report is the lack of good quality information around the location and population/ecosystem dynamics of threatened species and ecosystems. It is important that more effort is expended to detect and monitor these threatened species/ecosystems over the next five years in the Heritage Area. Auckland Council's Biodiversity Strategy has also identified this basic data need, and this means ecologists from throughout Council are likely to be putting substantially greater resources into better defining, locating and monitoring threatened/rare ecosystems and species over the next three years. This will occur throughout the region, although the high natural values of the Waitakere Ranges mean there is likely to be a focus on the Heritage Area.

4. Establish processes/technology to allow easier and timelier collection/comparison of environmental, resource consent and community group data.

   One of the strengths of the monitoring mandated by the Heritage Act is its multi-disciplinary nature. The Auckland Council is directed by the Act not just too record changes in the environment, but to look for causes of those changes and also examine if the extra protection provided by the Act are actually resulting in a change in land management on the ground. The most efficient way to carry out this type of reporting involves a spatial analysis of vegetation change data (from aerial photographs), planning zones, building consents, impermeable surface changes, the location of community group activities etc. In most cases these datasets are in different formats, taken at different times, don't have all the fields required for analysis etc. It becomes a major task to combine them together, and the lack of standard formats/approaches can also lead to errors and lower resolution in the data itself. It is important that the Council clearly identifies data needs and standard data formats for the next monitoring report by December 2013, and that information is collated and entered (and checked by someone who is responsible for the data quality) over the next five years. We should not wait for 2018 and trying to combine information from different sources *post hoc*, which is the approach that was taken (out of necessity) for this report.

5. Kauri dieback monitoring, research and management protocols are carried out and resourced.

   Auckland Council Biosecurity Team, in conjunction with a number or other government organisations and research providers, is carrying out research on a wide range of issues relating to kauri dieback. It is very important that support continues to be given towards research of the disease so as to understand its biology and levels of natural resistance within kauri, and curb its spread.

6. Kauri hygiene procedures are audited, improved (if required) and followed.

   There is a high risk of the disease spreading both locally in the Heritage Area but also to other forests such as the Hunuas and hence strict operational procedures must be upheld for all parties visiting affected areas. One particular high risk pathway is the daily operational work undertaken by Watercare staff, particularly the movement of personnel, vehicles and equipment between diseased areas in the Waitakere Ranges and the Hunua Ranges. An operational hygiene plan covering this aspect of Watercare operations should be developed urgently.

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Appendices

9.0 Appendix one - Indicator results summary table

Summary indicators for Heritage Area. Scores are based on a 1000 point scale from 1.000 (excellent) to 0.000 (very poor)

Code and category	Sub-category	Name	Score in 2008	Score in 2012
Habitat 1	Habitat	% cover of indigenous ecosystems	0.830	0.830
Habitat 2	Habitat	Loss or gain of indigenous ecosystems (area and %)	n/a	0.999
Habitat 3	Habitat	Loss or gain of significant indigenous habitat (area and %)	0.999	0.999
Habitat 4	Habitat	Loss or gain of threatened species habitat (area and %)	No data	No data
Habitat 5	Habitat	Loss or gain of originally rare ecosystem types (area and %)	No data	No data
Riparian 1	Ecosystem services	Proportion of riparian area around Zone I streams with indigenous wetland, forest and/or scrub landcover	0.940	0.940
Riparian 2	Ecosystem services	Proportion of riparian area around Zone II streams with indigenous wetland, forest and/or scrub landcover	0.644	0.642
Riparian 3	Ecosystem services	Proportion of riparian area around Zone I streams with wetland, forest or scrub landcover	0.950	0.950
Riparian 4	Ecosystem services	Proportion of riparian area around Zone II streams with wetland or indigenous vegetation landcover	0.712	0.710
Threatened spp 1	Biodiversity	Proportion of threatened species with a stable or increasing population size	No data	No data
Threatened spp 2	Response	Proportion of threatened species under active conservation management	No data	No data

Code and category	Sub-category	Name	Score in 2008	Score in 2012
Protection 1	Response	Total area of ecosystems (area and %) protected in reserves	0.690	0.700
Protection 2	Response	Total area of indigenous ecosystems (area and %) protected in reserves	0.790	0.790
Protection 3	Response	Total area of significant indigenous ecosystems (area and %) protected in reserves	0.850	0.850
Conservation 1	Response	Proportion of indigenous forest habitat under active conservation management	No data	No data
Conservation 2	Response	Weed management	No data	No data
Conservation 3	Response	Pest management	0.981	0.934
Kauri 1	Threats	Change in the spatial extent of kauri dieback	1.000	0.890
Forest 1	Biodiversity	Total area of forest and scrub habitat	0.805	0.805
Forest 2	Habitat	Loss or gain of forest and scrub habitat (area and %)	n/a	0.999
Forest 3	Biodiversity	Overall percentage biomass of indigenous plants in forest plots	0.999 (estimate)	0.999
Forest 4	Threats	Overall percentage biomass of weedy exotic plants in forest plots	0.999 (estimate)	0.999
Forest 5	Threats	Average biomass of exotic weeds in forest plots	0.999 (estimate)	0.998
Forest 6	Biodiversity	Proportion of forest plots with no exotic trees or saplings	No data	0.840
Forest 7	Threats	Average percentage dominance of weedy exotic saplings	No data	0.999

Code and category	Sub-category	Name	Score in 2008	Score in 2012
Forest 8	Threats	Average percentage dominance of weedy exotic seedlings	No data	0.999
Forest 9	Biodiversity	Species diversity of indigenous plants	TBD	TBD
Forest 10	Biodiversity	Average species diversity of indigenous plants	No data	1.000
Forest 11	Biodiversity	Change in avian conspicuousness in forest and scrub habitat	No data	No data
Wetland 1	Biodiversity	Total wetland area	0.950	0.950
Wetland 2	Habitat	Loss or gain of wetland habitat (area and %)	n/a	0.999
Wetland 3	Biodiversity	Native: exotic plant biomass ratio in monitored wetlands	0.810 (estimate)	0.810
Wetland 4	Biodiversity	Average native: exotic plant biomass ratio in monitored wetlands	0.850	0.850
Wetland 5	Biodiversity	Average native: exotic plant frequency in monitored wetlands	0.600	0.600
Wetland 6	Threats	Average native: exotic weed plant frequency in monitored wetlands	0.940	0.940
Wetland 7	Biodiversity & threats	Change in wetland condition index	No data	0.876
Wetland 8	Biodiversity & threats	Change in wetland perimeter condition index	No data	0.868
Wetland 9	Biodiversity	Change in avian conspicuousness in wetland habitat	No data	0.810 (estimate)
Dune 1	Biodiversity	Total duneland area	0.950	0.950
Dune 2	Habitat	Loss or gain of duneland habitat (area and %)	n/a	1.000

Code and category	Sub-category	Name	Score in 2008	Score in 2012
Dune 3	Biodiversity	Proportion of duneland area with a landcover of indigenous ecosystems	0.810	0.810
Dune 4	Biodiversity	Proportion of duneland area with urban or production agriculture landcover	0.914	0.911
Dune 5	Biodiversity	Building and impervious cover on duneland area (area and %)	No data	No data
Dune 6	Response	Proportion of indigenous duneland habitat under active conservation management	No data	No data
Freshwater 1	Biodiversity	Ecological Quality (Rivers): Macroinvertebrate Community Index (MCI)	0.840	0.840
Freshwater 2	Biodiversity	Native fish Index of Biological Integrity IBI	0.840	No data
Freshwater 3	Ecosystem services	Water Quality (Rivers)	0.915	No data
Freshwater 4	Ecosystem services	Ecological Quality (Lakes): Rotifer Index	0.383	No data
Freshwater 5	Ecosystem services	Ecological Quality (Lakes): Macrophytes (LakeSPI)	0.125	0.050
Freshwater 6	Ecosystem services	Groundwater Quality (for discharge to rivers)	1.000	No data
Water supply 1	Ecosystem services	Ecological quality – change in macro invertebrate index above vs. below dam	0.930	0.770
Water supply 2	Ecosystem services	Water quality in supply lakes	1.000	1.000

10.0 Appendix two: Indicator descriptions and calculations

10.1 Indigenous habitat (H) indicator results

10.1.1 Introduction

Despite its close proximity to the Auckland CBD, the Waitakere Ranges offers a completely contrasting experience in terms of the dominant role of nature and native plants and animals. Indigenous vegetation types, principally scrub and forest, are the most common landcover within the Heritage Area (c.82% cover, Figure 5) and most of this habitat is concentrated in a large contiguous block.

Worldwide, one of the primary drivers of species and ecosystem extinctions has been habitat loss. Therefore, the quantity and quality of habitat is one of the most important determinants of the health or 'state' of indigenous biodiversity within the Heritage Area. The impact of many negative processes such as weed invasion, pest browsing and predation, habitat clearance, overharvesting, etc. on indigenous species and ecosystems is encapsulated in indicators of habitat quality and loss.

10.1.2 Indicator H1: Percentage cover of indigenous ecosystems

Summary

The information for this indicator is based on a quantitative assessment of data from the New Zealand Landcover Database version 3 (LCDB3), and a separate qualitative assessment of the vegetation change detected in a desktop aerial photographic comparison analysis (see Appendix 4 for methods). The data cover two separate time periods LCDB2 (2001) vs. LCDB3 (2008) and 2007 aerial photographs vs. 2010 aerial photographs. We note that spatial resolution of these two information sources is quite different; LCDB3 has a resolution of 1 ha (=10,000 m^2) pixels, whereas the photo interpretation data recorded changes down to around 5-10 m^2 in size. This means that some caution needs to be used in interpretation of results from the combination of these two datasets. However, the following analysis presents a good general summary of likely changes in the cover of indigenous ecosystems within the Heritage Area since 2001.

There are approximately 22,100 ha of indigenous habitat within the Heritage Area. Indigenous forest is the dominant cover (66% of total) with regenerating indigenous forest and scrub an important secondary component (31%). Saline and freshwater wetlands, mangroves and open sand dunes comprise the remaining 3%.

Change before 2008

Historical change in the Heritage Area is summarized in the introduction section of this report. It outlines a history of dramatic vegetation change resulting from fire, logging, mining, and farm clearance etc. throughout an initial resource exploitation phase that lasted until the 1940s. In more recent decades, creation of the Waitakere Ranges Regional Park and increasing Council and community action on pest and weed control has almost certainly seen an increase in the quantity and quality of native ecosystems in the Heritage Area.

Changes 2001 – 2008

The data in this section is based on the NZ Landcover Database (LCDB) is a central government funded digital map of the type of vegetation or infrastructure (e.g. native forest, pine forest, high productivity pasture, and urban, etc.) that covers the land surface. The map is derived from remote sensing of satellite images. Being digital, it can be combined with other geographic information to reveal new patterns and trends of land use and land cover.

Comparing data from LCDB2, which is based on 2001 satellite imagery, with the LCDB3 (2008) values allows a coarse scale calculation of changes in vegetation cover between 2001 and 2008. The LCDB is based on a minimum patch size of 1 ha, and therefore it is more appropriate for gross comparisons across the landscape, rather than detailed assessments of vegetation change. Table 6 shows that there have been only relatively small changes in the dominant landcovers (i.e. forest and scrub) between 2001 and 2008.

Table 6 Summary of main[1] changes in landcover classes for the Heritage Area between LCDB2 (2001) and LCDB3.

Landcover class	**2001 area in ha**	**2008 area in ha**	**Area change (ha)**	**% change**
Indigenous forest	14,658	14,656	- 2.71	- 0.018
Manuka and kanuka	5,854	5,853	- 0.96	- 0.016
High producing exotic grassland	2,375	2,375	- 0.41	- 0.017
Regenerating indigenous short forest and scrub	1,233	1,234	+ 0.96	+ 0.078
Built up urban areas	668	669	+ 0.54	+ 0.080

[1] Results for landcover classes that had negligible change and/or were only a very small proportion of the WRHAA are not presented. These classes included coastal sand and gravel, deciduous forest, herbaceous freshwater vegetation, herbaceous saline vegetation, lakes and ponds, mangrove, other exotic scrub, and surface mines and dumps

Exotic forest, including production pine plantations	284	284	0	0
Low producing exotic grassland	347	347	0	0
Orchards, vineyards and other perennial crops	205	205	0	0
Other ecosystems	1,438	1,440	+ 2.57	+ 0.178

A total of c.0.5 ha of urban landcover has been added. It is unclear what the previous landcover of newly urbanised areas was without a more detailed examination of the results. There has been some loss of indigenous forest (2.71 ha). This amounts to 0.019% of the total area of indigenous forest in 2001. The 0.019% figure converts to an annual indigenous forest loss of around 0.003% per year over the seven years between 2001 and 2008.

Including native scrub and regenerating forest in the calculations brings the total loss of indigenous forest and scrub habitat to 2.7 ha[2], or 0.02%, which represents an annual loss of 0.003% per year. A continuation of these same annual rates (i.e. 0.003% of 2001 area) of native forest and scrub clearance for 50 years would see a 0.15% reduction in the total area of scrub and forest habitat in the Heritage Area. This biodiversity and environmental effects of this clearance are likely to be relatively small, provided the cleared habitats did not include significant or uncommon ecosystems or habitat for threatened species.

Change 2008 – 2013

2008 value	2012 value	Change
83%	>82.95% – <83%	Somewhere in range of >0% - <0.05%

Changes between (approx) 2007 and 2010 (i.e. three years, rather than the full five year monitoring period) were also analysed using desktop comparisons of aerial photographs taken at these two dates. A total of 4,728 different[3] patches of vegetation clearance were identified, totalling

[2] This figure is the same as the forest clearance value because the 'manuka or kanuka' landcover class decreased by the same amount as the 'broadleaved indigenous hardwood' landcover class increased, so their net effect when added to loss the of forest landcover was zero

[3] This figure includes sub-patches created through comparing different layers. For example, a single vegetation clearance 'patch' that covered bits of three different LCDB3 classes (e.g. built up area, low producing grassland and indigenous forest) would be recorded as three patches in terms of its contribution to the total

40.5 ha in area (7). There were also some examples of vegetation expansion recorded (436 patches, totalling 8.5 ha). Unfortunately, it was impossible to determine from aerial photographs alone whether the cleared (or newly created) patches of scrub and forest habitat were native, mixed or exotic vegetation. Therefore the total clearance figure does not represent the total loss of indigenous forest and scrub habitat.

Table 7 Summary of vegetation and other landcover change recorded in the Heritage Area from a desktop analysis of aerial photographs over a three-year period since Act's inception.

Type of change	# of patches	Average patch size	Total area
Vegetation clearance	4,728	0.0086 ha (c. 100 m^2)	40.2 ha
Regeneration	436	0.019 ha (c.200m^2)	8.5 ha
Vegetation change	N/a	N/a	c. 31 ha net loss

Some indication of the pre-clearance vegetation cover of cleared locations can be determined by consulting the LCDB3 class of the cleared location. Although we note this is an indicative comparison given the different spatial resolutions of the two datasets. This data is presented in Table 8.

Table 8 Vegetation clearance locations summarized in Table 7 where the cleared area had an indigenous landcover according to LCDB3

LCDB3 vegetation cover class at cleared and re-growth locations	Clearance	% loss (% annual loss) of native ecosystems
Native: Indigenous forest and scrub	17.70 Forest 8.0 ha Scrub 9.7 ha	0.08% (0.02%)
Native: Wetlands	0.07	0.00%
Total changes (native only)	17.77	0.08 (0.02)%

A loss of 17.8 ha of native ecosystems is a c.0.08% loss of all native ecosystems within the Heritage Area[4]. Or converting this to an annual figure for the three-year period over which change was measured, this is a loss of 0.02% of native ecosystems/year (Table 8). This is about ten times of the annual rate recorded between 2001 and 2008 using LCDB2/3 comparisons. In our opinion, the differences in clearance rates from 2001/08 (0.003%/year using LCDB 2/3) to 2008/11 (0.03%/year) is due to the measurement scale of the methods used, rather than any dramatic increase in clearance post 2008. Most of the clearance recorded in aerial photographs were very small (Table 5) well below the 1 ha pixel size that is used for the LCDB. This means that small clearances of 0.01 – 0.1 ha in size often do not register as vegetation change in the LCDB comparisons.

Many individual trees in forest communities can live for hundreds and years, and even very small changes can have a large cumulative effect on these types of time scales. A continuation of these same annual rates (i.e. 0.03%) of native forest and scrub clearance for 50 years would see a 1.5% reduction in the total area of scrub and forest habitat in the Heritage Area. Again, the overall impact of a 1.5% clearance of 2001 forests on indigenous biodiversity values within the Heritage Area is likely to be relatively small, provided the cleared habitats did not include significant or uncommon ecosystems or habitat for threatened species.

While the overall rate of change is relatively slow, clearance activity has been concentrated in some specific parts of the Heritage Area, such as the coastal village, upper foothills and lower foothills landscape zones, and the rates of change for these particular locations are correspondingly higher (Table 9). The rates of change in these landscapes (on the order of 0.1 – 0.25%/year) mean a 50-year cumulative impact would result in a 5 – 25% loss of 2008 native ecosystem cover.

Although geotechnical and planning restrictions may in practice limit the practical amount of extra clearance in these landscape zones. Even a 10% loss of native vegetation would have an impact on the naturalness of these landscape zones. Therefore the rates of clearance and replanting in the coastal village, lower foothills and upper foothills landscape zones should be closely monitored for the next five-year report. The very low rates of clearance in parkland are expected, and have probably been more than offset by the restoration of new habitat within the park.

Table 9 Loss of forest and scrub habitat summarized by landscape zone. Percent change figures are based on the total area of LCDB3 indigenous scrub and forest vegetation in that landscape zone.

Landscape Zone	Vegetation clearance	% annual loss this zone
Conservation/parkland (16,800 ha)	0.4 ha	0.0008%

[4] Based on LCDB3, 2008 cover estimates a total of c.22,100 ha of indigenous forest, scrub and wetlands

Lower foothills (580 ha)	2.6 ha	0.148%
Upper foothills (2,330 ha)	9.4 ha	0.134%
Dense bush living (2,300 ha)	3.9 ha	0.057%
Coastal villages (200 ha)	1.4 ha	0.233%
All zones combined (22,100)	17.7 ha	0.027%

The clearance information presented in Table 8 and Table 9 takes no account of re-planted habitat. Restoration of indigenous forests and wetlands – e.g. by dense plantings of indigenous seedlings that are weeded and managed until a dense canopy is established – have become much more common in the past 10 years, are a regular activity of Council and community groups on Council land, and are often stipulated as part of resource consent conditions. There is no doubt that, in time, restored vegetation can provide useful habitat for indigenous plants and animals. However, there is still a great deal of dispute in the professional ecological community over exactly how successful restored habitat is at mimicking natural habitat, and how long it takes for these benefits to be fully realised. In most cases, planted ecosystems are a poor substitute for a native ecosystem; with its myriad of species, ecosystem process and interactions.

Table 10 combines the clearance data of Table 9 with figures for regeneration/new plantings of forest and scrub identified at the same time as the clearance. When these areas of newly planted habitat are counted, the overall clearance rate approximately halves (0.03% to 0.014% of all indigenous ecosystems/year). The change is more dramatic for individual landscape zones; clearance in the lower foothills has actually been reversed, resulting in a net annual gain of indigenous ecosystems, if new habitat is rated as being of the same 'value' as cleared habitat. This probably reflects the investment in riparian planting in the lower foothills over the last 10 years as many of the waterways in this area flow east into the Waitemata Harbour.

Table 10 Loss and regeneration of forest and scrub habitat summarized by landscape zone. % change figures are based on the total area of LCDB3 indigenous scrub and forest vegetation in that landscape zone.

Landscape Zone	Vegetation clearance	Regeneration	Net gain/ loss	% annual loss this zone
Conservation/parkland (16,800 ha)	0.4 ha	0.0	- 0.4 ha	0.0008%
Lower foothills (580 ha)	2.6 ha	2.7 ha	+ 0.1 ha	n/a
Upper foothills (2,330 ha)	9.4 ha	2.8 ha	- 6.6 ha	0.094%

Dense bush living (2,300 ha)	3.9 ha	1.8 ha	- 2.1 ha	0.030%
Coastal villages (200 ha)	1.4 ha	1.2 ha	- 0.2 ha	0.033%
All zones combined (22,100)	17.7 ha	8.5 ha	- 9.2 ha	0.014%

How change will be monitored 2013+

This indicator will continue to be monitored using the approaches outlined above. However, the power of the indicator to detect change will be increased by the creation of a better quality, higher resolution vegetation map of indigenous ecosystems within the Heritage Area. This better quality map, rather than the LCDB layer, will then be used for comparison with the change layer. This monitoring approach relies on the regular acquisition of high-resolution aerial photography or satellite imagery for the Waitakere Ranges, which is outside the budget of funds allocated to reporting for the Act in the Long Term Plan.

10.1.3 Indicator H2: Loss or gain of indigenous ecosystems (area and %)

Summary

Change for this indicator is summarised in H1. The purpose of separating H1 and H2 is that future measurements of H1 will allow the total area of indigenous ecosystems at that time to be compared with the 2008 baseline, and therefore calculate cumulative change. Whereas H2 will assess the change in vegetation cover over the preceding five-year period. For this initial five-year reporting period, comparison back to a 2008 baseline and change over the preceding five years are the same figures.

10.1.4 Indicator H3: Loss or gain of significant indigenous habitat (area and %)

Summary

The Heritage Area includes around 22,100 ha of indigenous habitat, mostly comprising indigenous forest, scrub and shrubland habitat. However, the ecological value or significance of all these habitats is not equal (i.e. some specific patches of habitat have higher/lower ecological value than others). Ecosystems can have higher ecological values for a number of reasons. For example, they might provide habitat for a threatened or unusual animal or plant species or are one of the best

remaining examples of a habitat types (e.g. mature kauri forest) that has been largely cleared in the past.

Vegetation clearance can degrade natural values because it involves the removal of habitat for indigenous plants and animals as well as facilitating the invasion of environmental pest plants; however, the overall impact of vegetation clearance on the environment and ecosystems will depend on exactly where that clearance is. The loss of 2 ha of a widespread and common ecosystem type is much less damaging than the loss of 2 ha of prime breeding habitat for a threatened species. This indicator looks at the loss of **ecologically significant**[5] vegetation, as opposed to all native vegetation, which was covered in indicators H1 and H2.

A 'significant indigenous habitat' layer was created for the Heritage Area in GIS. As a starting point, this layer used a series of high value, ecologically significant sites that had been identified in the Waitakere Ranges Protected Natural Areas Programme (PNAP) report. Additional polygons were then added to this core layer, based on survey work in the Heritage Area since the PNAP report was published. These extra areas included wetland and duneland ecosystems (both specifically identified as priorities for protection in national guidance documents), threatened species habitat and areas that support originally rare ecosystems. In addition, areas of contiguous indigenous forest that were not already included in the aforementioned habitats were added to the layer. Areas of houses, pasture and water supply lakes that had been included within the original PNAP site boundary were removed from the significant indigenous habitat layer.

The figures in the table below were determined by overlaying a 'significant indigenous habitat layer' with the 'vegetation change layer' in GIS and determining if any clearance (or regeneration, etc.) had occurred within any of the significant habitat areas. Results are summarized below.

Change before 2008

Change in areas of significant habitat prior to 2008 was influenced by most of the same drivers as those outlined in the H1 section above. However, many of the significant ecosystems are likely to have suffered a relatively high level of habitat destruction and modification (e.g. mature kauri forests) and this is the reason they are regarded as ecologically significant sites today.

Change 2008 – 2013

2008 value	2012 value	Change
8,020 ha	8,020 ha	0.5 ha (0.006%) loss

[5] Note this definition of ecological significance is different to that used in the Auckland Council Unitary Plan (notified October 2013) to delineate significant ecological areas (SEA) and this map does not replace the significance layer in the Unitary Plan.

Only a very small amount of vegetation clearance of significant ecosystems (c. 0.5 ha) was detected in the desktop assessment of 2008 vs. 2012 aerial photographs. The overall area of significant vegetation in the Heritage Area is just over 8,000 ha, so a 0.5 ha loss translates to a 0.006% loss of significant vegetation. Dividing by the three-year period between aerials gives an annual loss of 0.002% of significant vegetation per year. This loss is negligible; even 100 years of change at that rate would still result in a <0.25% loss of significant vegetation. Therefore, provided no habitats or threatened species are threatened with extinction by these losses, this scale of significant habitat loss is within acceptable limits.

How change will be monitored 2013+

Change from 2013 onwards will be monitored using the same methodologies outlined above (i.e. combining a vegetation change layer derived from aerial photo analysis with a significant site layer). It is likely that the significant indigenous habitat layer will continue to be edited as new information on species and ecosystem distributions is collected. Our knowledge of the distribution and condition of patches of originally rare ecosystems for instance is very poor, and the same could be said for many of the more cryptic threatened species.

10.1.5 Indicator H4: Loss or gain of threatened species habitat (area and %)

Summary

Habitat loss is second only to invasive species in terms of the adverse effects on threatened species in New Zealand. Plants and less mobile fauna such as geckos, snails, frogs and many insects are particularly vulnerable to loss of habitat. A high proportion of threatened species are likely to be found in freshwater wetlands and kauri forest as well as originally rare ecosystems such as coastal cliffs and rock stacks, gumlands, and active sand dunes. On a national scale, freshwater wetlands, in particular, support a disproportionate amount threatened species, while kauri forest is the most diverse forest type in New Zealand. Recent conservation projects have been developed in order to protect the precious fauna and flora within some of these habitats, including Ark in the Park, La Trobe mainland island, and shorebird protection administered by Friends of Whatipu. Unfortunately, with the spread of kauri dieback disease throughout the Waitakere Ranges, there is currently little that can be done to prevent the loss of kauri forest and its associated species in areas already affected.

It is important to note that threatened plant and animal species are likely to occur right across the Heritage Area, even in highly modified habitats. However, it is not realistic, at least for the purposes of future conservation efforts, to label the entire Heritage Area as a ‘threatened species

habitat'. Instead, areas or habitats must be prioritised based on recent data and/or the likelihood of them supporting good numbers of threatened species. Certainly, a more accurate inventory of threatened species is required, although this is something the Council aims to produce for future reporting cycles. This will prove to be very challenging, given the cryptic and ephemeral nature of many threatened species in the Heritage Area.

How change will be monitored 2013+

All wetlands and dunelands have been digitised in the Council GIS system. Future comparisons can be made by using aerial photography and GIS mapping in order to determine the loss or gain of such habitat. Similarly, recent aerial photography flown to assess the extent of kauri dieback can be used a baseline for future comparisons. Accurate mapping of originally rare ecosystems will also be invaluable for monitoring changes in threatened species habitat (see next section).

10.1.6 Indicator H5: Loss or gain of originally rare ecosystem types (area and %)

Summary

Historically (or originally) rare ecosystems are those that were uncommon prior to human colonisation of New Zealand. They often have highly specialised and diverse flora and fauna characterised by endemic and nationally rare species, many of which are under threat from factors such as anthropogenic modification, pest animals and weeds (Williams et al. 2007). To date, 72 types of historically rare ecosystems have been identified as occurring in New Zealand, although as the classification system is refined it is likely that this number will change.

The Heritage Area contains at least nine types of originally rare ecosystems, most of which are concentrated along the coastal margins (see Table 11 below). A key objective of the Act's next reporting cycle is to accurately survey, map and quantify these ecosystems.

Table 11 Originally rare ecosystems known within the Heritage Area, together with their key characteristics, threats, and approximate extent.

Ecosystem type	Key characteristics	Threats	Approx. extent
Active sand dunes	Active sand dunes are those dunelands whose physical landscape and ecological character results from continuously moving wind–blown sand. They are	Invasive weeds (e.g. marram, lupin and kikuyu), rabbits, coastal development, human disturbance (e.g. four-wheel driving, horse	By far the largest area of active sand dunes occurs at Whatipu, followed by Bethells/Te Henga and Karekare.

Ecosystem type	Key characteristics	Threats	Approx. extent
	predominantly coastal, geomorphically unstable, mobile (Johnson & Rogers 2003) and bare to sparsely vegetated (Hilton et al. 2000).	riding) (Williams et al. 2007).	
Basic cliffs, scarps and tors	Basic cliffs, scarps, and tors occur throughout the North Island and are especially prominent in Northland and the Coromandel Peninsula. They occur inland on tuffaceous sandstones and mudstones, andesite, diorite, basalt, and gabbro. Plant species are tolerant either of shallow soils, full sunlight, and intermittent drought, or damp and shady crevices (Williams et al. 2007).	Weed invasion, especially by woody weeds, can be a serious problem as these species can out–compete existing native species and readily colonise available habitat as it arises. Possum browse also threatens indigenous plant communities.	Unknown
Coastal cliffs of basic rocks	Coastal cliffs are very steep to perpendicular or overhanging rock faces above the sea. They provide many varied habitats: from bare rock colonised only by mosses and lichens, to deeper soils supporting woody vegetation; from highly exposed situations, to heavily shaded and sheltered habitats; and from very dry to permanently wet surfaces. Coastal cliffs are particularly influenced by salt spray, which is evident in the type of vegetation they support.	Erosion, combined with subsequent invasion by weeds, may be a problem for native species. Livestock and goats do not present a threat in the Heritage Area.	Coastal cliffs are common between Muriwai and Karekare.
Coastal rock stacks	A coastal rock stack is an isolated pinnacle of rock off the coast, generally with steep to vertical sides (Priestly 1990). The bases of stacks occur below the high tide line. Some	Most coastal rock stacks are protected by their inaccessibility to humans. Weed invasion can occur, however, promoted by instability	Coastal rock stacks are largely scattered along the west coast, and include Nun Rock near Piha, Keyhole Rock offshore from

Ecosystem type	Key characteristics	Threats	Approx. extent
	are always surrounded by water, while others are surrounded by sand at low tide (Williams et al. 2007).	of cliffs and seed transport by wind and birds. Native plants, however, tend to dominate (Williams et al. 2007).	Anawhata, and Kauwahaia Island at O'Neill Bay. There is a cluster of small rock stacks between Raetihinga Point and Kirikiri Bay in the north-western corner of the Heritage Area.
Damp sand plains	Damp sand plains are flat areas where wind has removed sand down to a level where the water is permanently just below the surface or occasionally above it. This stabilises the sand and prevents the surface being lowered further. They often form between a series of sand dunes. These systems are initially colonised by small plants such as sand carex and prostrate herbs, and then by progressively taller plants over time such as knobby club rush (Williams et al. 2007).	Weeds, coastal development, agriculture, vehicles, and climate change. (Williams et al. 2007).	The majority of this habitat type is likely to occur at Whatipu. Other possible locations include river mouths at Bethells/Te Henga and Karekare.
Estuary	Estuaries are where fresh water from rivers mixes with salt water. They are formed where the underlying or adjacent topography constrains the mixed water throughout the tidal cycle. They are formed behind barriers such as sand spits and coastal embayments, at river mouths, in drowned river valleys with gently sloping substrates, and even in fjords. Their inland limit is where salinity reaches a dilution of 5% of the marine concentration (Clarkson et al. 2003).	Aggressive invasive weeds such as *Spartina* spp. and saltwater paspalum. Estuarine margins in agricultural settings are grazed, trampled, and there are potential problems of nutrient enrichment from fertiliser and stock. Introduced animals pose a high threat in unfenced estuarine margins. Drainage is mainly a threat on margins that	Estuarine habitat is restricted largely restricted to sheltered sites within the Manukau Harbour (e.g. Huia Bay, Cornwallis, Laingholm Bay), although small areas do occur along the west coast at Bethells/Te Henga, Anawhata, Karekare, and Piha.

Ecosystem type	Key characteristics	Threats	Approx. extent
		are less influenced by tidal regimes. Aquaculture is an increasing threat in some localities (Williams et al. 2007).	
Gumland	Gumlands are shrub–covered, flat to rolling land in northern New Zealand, which have deposits of kauri gum. Soils are very infertile, acidic, seasonally waterlogged, and mostly have a thin siliceous topsoil (sometimes with peat) above a slowly permeable or cemented horizon. They have become more widespread since human settlement as a result of repeated fires. The vegetation is typically heathland, comprising low–growing manuka, *Dracophyllum lessonianum* and other shrubs, sedges, and ferns, especially tangle fern (Williams et al. 2007).	Most gumlands have been lost to agricultural and urban development, both of which are continuing. Remaining sites are vulnerable to a suite of woody weed species such as prickly hakea and gorse (Williams et al. 2007).	Unknown at present. Gumland has quite specific environmental and vegetation characteristics. There are certainly areas of stunted, slow growing manuka scrub on skinny soils depleted by burning and gum extraction (e.g. Cornwallis); whether these meet the official 'definition' of gumland requires further investigation into their vegetation and soils
Lake margin	Lake margins comprise the mainly damp fringes that are periodically inundated. The type of vegetation that this ecosystem can support is diverse, and includes podocarp forest through tall reedland and rushland, to sedgeland and herbfield, and down to open land with only scattered herbs (Williams et al. 2007).	Many lakes in NZ are located in agricultural areas where they are vulnerable to grazing, trampling, and nutrient enrichment by domestic and feral animals. Very few are fenced. Recreational activities on lakes can also threaten lake margin vegetation (Williams *et al*. 2007). Fortunately, the lakes in the Heritage Area are relatively well-	Lake margin vegetation is likely to occur at lakes Wainamu, Kawaupaka and Waiaturu, as well as wetland systems within Whatipu and near Ohaka Head and Parahara Bay.

Ecosystem type	Key characteristics	Threats	Approx. extent
		protected from such effects.	
Seabird burrowed soils and/or guano deposits	These areas commonly have only very limited vegetation because of bird trampling and the exceedingly high nitrogen status of their fresh guano, but towards the edges, in sparse colonies, or on shallow deposits, vascular plants can occur (Williams et al. 2007).	Most seabird colonies are threatened by exotic predators, grazing stock, domestic pets, off–road vehicles, human disturbance, and encroaching urbanisation. Exotic weeds are present, but these are mostly transient. Climate change also poses a threat due to rising sea levels (Williams et al. 2007).	

How change will be monitored 2013+

Field survey will be required to identify and map originally rare ecosystems that cannot be mapped using aerial photography and geological GIS layers, e.g. gumland and seabird burrowed soils and/or guano deposits. Obtaining baseline data on key indicators such as the current abundance of invasive plants will be critical to measuring changes in the health of originally rare systems.

Establish permanent plots and photopoints to monitor changes in indigenous and exotic plant communities. Gumlands, in particular, are vulnerable to land clearance/subdivision, therefore it is a priority that such areas within the Heritage Area are quantified.

10.2 Riparian vegetation (R) indicator results

10.2.1 Introduction

Riparian vegetation includes those ecosystems in the immediate surroundings of a watercourse. Riparian vegetation is important because structurally diverse vegetation (such as forest, scrub, reeds and rushes etc.) surrounding a stream provides a range of benefits. These include filtering and reducing surface water flows, shading and lowering water temperature, providing organic

matter input into freshwater food webs, spawning and shelter for fish and invertebrates, etc. In addition, riparian vegetation provides habitat for native plants and animals. A number of different measures have been used to define the width of the riparian zone in New Zealand, including 10m, 20m and 50m. For the purposes of this report the riparian zone was defined as a 20m wide strip on either side of the watercourse.

Watercourses within the Heritage Area were classified into two main groupings for calculating indicators R1 to R4 (Table 12). This was done in order to take account of the different character and potential threats of watercourses in different parts of the Heritage Area. There are a large number of pristine streams within the Waitakere Ranges Regional Park that have high quality riparian vegetation and are unlikely to be affected by vegetation clearance. If all the watercourse data was combined together then it is possible the lack of change within the regional park could mask important changes to riparian vegetation alongside the more modified watercourses of the upper and lower foothills. For this reason it was decided to treat the watercourses as two separate groups.

Table 12 Classification of watercourses in the Heritage Area into two different zones for the purposes of biodiversity reporting.

Zone	Streams	General values
I	All watercourses draining west into the Tasman Sea and south into the Manukau Harbour (except Little Muddy Creek and Green Bay coastal strip)	Relatively unmodified, largely stony bottomed streams with high levels of riparian buffering and shading, and excellent hydrological heterogeneity. The clean water, high oxygen, and constant supply of leaves and other vegetative detritus support a diverse range of macroinvertebrate communities, which in turn support many species of indigenous fish, including several threatened species.
II	Watercourses draining north and north-east into the Waitemata and Kaipara Harbours (including Oratia, Opanuku, Swanson, Kumeu and Whau catchments), Little Muddy Creek and the Green Bay coastal strip	Headwaters are well-buffered by indigenous vegetation, although lower down in the foothills the watercourses are subjected to a combination of rural and urban impacts together with a marked decrease in riparian buffering. Despite their relatively modified status, these watercourses support an abundance of indigenous fish and provide critical migratory links between the Waitakere Ranges and the Kaipara and Waitemata harbours.

10.2.2 Indicator R1: Proportion of riparian area around Zone I streams with indigenous wetland, forest and/or scrub landcover

Summary

Intact and well-buffered indigenous ecosystems, including scrub, forest and wetland vegetation provide the best possible riparian environment for streams and creeks in the Heritage Area. The figure of 94% indigenous cover is very high, probably the highest for watercourses in any part of the Auckland Region. Most Zone 1 catchments in the Heritage Area are within parkland, where all vegetation is protected in perpetuity. As such a very high proportion of the watercourses are unmodified and thus afforded extensive indigenous riparian buffering, particularly by forest (61%) and scrub (27%) habitats. Riparian vegetation within freshwater wetlands contributes approximately 5%. Built-up areas (<1%) present are largely restricted to catchments draining into the northern Manukau Harbour, while small orchards, farms and vineyards (4%) are scattered throughout.

2008 value	2012 value	Change
94%	94%	-0.02% (c.0.3 ha loss only)

Change before 2008

The composition of native ecosystems in the riparian zones of Waitakere Ranges streams has probably changed quite dramatically in the last 200 years; generally in response to activity in the surrounding landscape, such as burning and logging. However, since the gazetting of Waitakere Ranges Regional Park loss of vegetation has almost ceased, the major change being a shift from lower stature, less woody vegetation to tall forest

Change 2008 – 2013

Aerial photographic analysis shows there has been a negligible loss of vegetation in the riparian zones of Type I watercourses. Only 0.51 ha of vegetation clearance was recorded around these streams, which was balanced by 0.2 ha of new habitat being planted for an overall loss of 0.3 ha. This represents a loss of only 0.02% of forest and scrub ecosystems[6] in the riparian zones of these streams over the period 2008 – 2012. This loss should continue to be watched, but seems to be sustainable on a 100 -200 year time scale.

Aerial photo interpretation also detected c. 0.04 ha of new construction in the riparian zone of Type I streams. This is c. 10 x less than vegetation loss figure and therefore this rate of change is sustainable in the long term (100+ year time scales).

[6] This figure is based on loss of both native and exotic forest and scrub ecosystems, as native/exotic forest was difficult to distinguish during the aerial photograph interpretation work.

How change will be monitored 2013+

Inspection of new regional scale aerial photography resources to determine recently cleared areas. Collection and mapping of building consents data. Analysis of future national vegetation classifications, such as LCDB4 and LCDB5, which are planned for national release in the next 3 – 5 years.

10.2.3 Indicator R2: Proportion of riparian area around Zone II streams with indigenous wetland, forest and/or scrub landcover

Summary

Catchments within Zone II drain the eastern and north-eastern foothills of the Heritage Area and are thus significantly more influenced by rural and residential activity. The proportions of riparian vegetation attributed to indigenous forest (33%), scrub (31%) and production land (e.g. orchards and vineyards) (31%) are comparable, which is indicative of the more recently modified seral nature of the area. Similarly, the complete absence of freshwater wetland riparian vegetation suggests that former wetlands have been drained for rural and urban use. Nevertheless, a figure of 64% native cover in the riparian zone of type II watercourses is likely to be contributing substantial ecosystem services for the upper catchments of these more modified streams.

2008 value	2012 value	Change
64%	64%	- 0.2% (c.0.6 ha loss)

Change before 2008

The composition of native ecosystems in the riparian zones of Waitakere Ranges streams has probably changed quite dramatically in the last 200 years in response to logging and burning activity in the surrounding landscape. See R1 for more information.

Change 2008 – 2013

Aerial photographic analysis shows the loss of indigenous vegetation in the riparian zone of type II streams has been more than double that of type I streams (0.7 ha), although the total loss of habitat is still quite small. Only 1.2 ha of vegetation clearance was recorded around these streams,

which was balanced by 0.5 ha of new habitat being planted for an overall loss of 0.7 ha. Because the total riparian area of type II streams is much smaller than type I, the 0.7 ha figure represents a loss of 0.2% of forest and scrub ecosystems[7] in the riparian zones of these streams over the period 2008 – 2012. This is 10 x higher than the proportional loss recorded for type I streams and the loss of habitat in the headwaters of these highly modified streams should be closely monitored over the next few decades. However, even this rate seems sustainable on the 10 – 50 year time scale.

Aerial photo interpretation also detected c.0.17 ha of new construction in the riparian zone of type II streams. This is c. 5 x less than vegetation loss figure and therefore this rate of change is sustainable in the longer term. In addition, this new construction was balanced by an almost 9 ha reduction in built structures in the riparian zone (due to the removal of some large greenhouse units).

How change will be monitored 2013

Inspection of new regional scale aerial photography resources to determine recently cleared areas. Collection and mapping of building consents data. Analysis of future national vegetation classifications, such as LCDB4 and LCDB5, which are planned for national release in the next 3 – 5 years.

10.2.4 Indicator R3: Proportion of riparian area around Zone I streams with wetland, forest and/or scrub landcover

Summary

This indicator looks at all structurally complex woody vegetation, and wetlands, in the riparian zone of streams. Many of the stream protection and enhancement values of riparian vegetation can be provided by exotic forest and scrub. For example, the contribution of riparian wattle or willow forest to freshwater ecosystem services such as filtering and reducing surface water flows, shading and lowering water temperature, organic matter input into freshwater food webs, spawning and shelter for fish and invertebrates can be substantial.

2008 value	2012 value	Change
95%	95%	-0.02% (c.0.3 ha loss only)

[7] This figure is based on loss of both native and exotic forest and scrub ecosystems, as native/exotic forest was difficult to distinguish during the aerial photograph interpretation work.

Change before 2008

See R1 comments. The proportion of exotic vegetation in the riparian zone is likely to have increased over time through ongoing naturalisation and expansion in the range of planted exotics and weeds.

Change 2008 – 2013

See R1 comments. There was only a very low level of change in the riparian area of zone I streams, and no distinction was made between native and exotic vegetation, so this figure is the same as that reported for R1

How change will be monitored 2013

Inspection of new regional scale aerial photography resources to determine recently cleared areas. Collection and mapping of building consents data. Analysis of future national vegetation classifications, such as LCDB4 and LCDB5, which are planned for national release in the next 3 – 5 years.

10.2.5 Indicator R4: Proportion of riparian area around Zone II streams with wetland, forest and/or scrub landcover

Summary

2008 value	2012 value	Change
71%	71%	- 0.2% (c.0.6 ha loss)

Change before 2008

See R2 comments. The proportion of exotic vegetation in the riparian zone is likely to have increased over time through ongoing naturalisation and expansion in the range of planted exotics and weeds.

Change 2008 – 2013

See R2 data. There was detectable, but probably sustainable, decrease in complex vegetation cover in the riparian area of zone II streams, and no distinction was made between native and exotic vegetation, so this figure is the same as that reported for R2

How change will be monitored 2013

Inspection of new regional scale aerial photography resources to determine recently cleared areas. Collection and mapping of building consents data. Analysis of future national vegetation classifications, such as LCDB4 and LCDB5, which are planned for national release in the next 3 – 5 years.

10.3 Threatened species (T) indicator results

10.3.1 Introduction

What are threatened species and how are they defined?

Threatened species are those species of plants and animals that have diminished in population size and abundance to such an extent that, without some kind of conservation management intervention and/or fundamental change in resource management, face the prospect of becoming extinct at a local, regional or national scale.

The New Zealand Threat Classification System (NZTCS) is used to assess the threat status of New Zealand taxa (species, subspecies, varieties and forms), with the status of each taxon group being assessed over a 3-year cycle. The system methodology was revised in 2008 to improve its utility (Townsend et al. 2008). The NZTCS was developed so that any described or undescribed taxon that exists in the wild in New Zealand (includes all terrestrial, freshwater and marine areas within the NZ Exclusive Economic Zone, not including the Ross Dependency in Antarctica) has the potential to be listed. The system applies equally to terrestrial, freshwater and marine biota in recognition of the broad functions DOC has under section 6 of the Conservation Act 1987. However, certain marine species are currently managed under the Fisheries Act 1996 and so inclusion of these species will be scoped with the Ministry of Fisheries (DOC website 2012).

Under the NZTCS, there are four broad categories of threat: ‘Extinct’, ‘Threatened’ and ‘At Risk’ and ‘Not Threatened’ (refer to Figure 1). For the purposes of this report, only taxa that are listed as ‘Threatened’ or ‘At Risk’ are included.

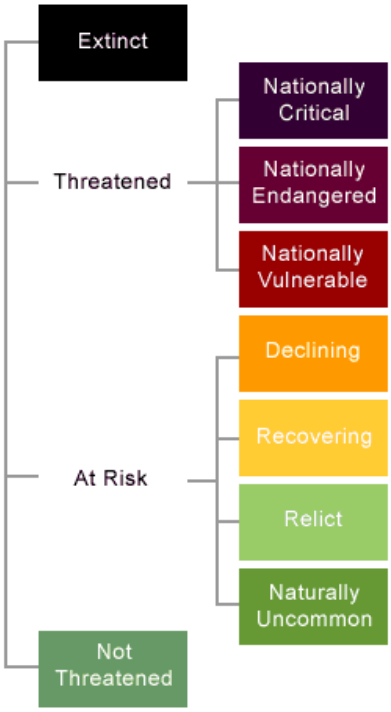

Figure 1 Threat classification as per Townsend et al. (2008).

Why is it important to monitor threatened species?

Monitoring the presence and abundance of threatened species is a critical element of managing their conservation. The implementation of a monitoring regime will evaluate whether management actions (such as predator control, weed control for threatened plants) are improving the status of the species in question. Monitoring is also an excellent means by which to involve the public in species conservation. For example, shore bird numbers at Bethells Beach and Whatipu are currently monitored (in conjunction with carrying out pest control) by community groups and other volunteers.

For bird species, in particular, baseline counts coupled with an understanding of annual fluctuations in counts enables conservation managers to set realistic targets relating to ecological gains made from management measures (Chapman & Alexander 2004). Environmental management actions are often better assessed through monitoring the follow-on benefits (i.e. positive ecological outcomes) rather than measuring the management action *per se*. For example, the effectiveness of a predator control operation should be gauged by measuring changes in the environmental attributes being protected (native birds, invertebrates, etc.) rather than by measuring the number of predators eliminated (Wellington Regional Council 2001), although the latter can still provide useful data.

Threatened species in the Heritage Area - general summary

Since the arrival of humans c.800 years ago, ten plant species and 11 native bird species have been lost from the Waitakere Ranges, while 15 bird species have become extinct from the foothills and urban areas (Waitakere City Council 2002). An additional twenty-seven bird species are at risk of extinction in the medium to long- term (Table 24). Other taxa, such as short-tailed bat and species of mistletoe are presumed to be extinct from the Ranges. Predators such as rodents, mustelids, cats and possums are probably the greatest threat to native bird, reptile and invertebrate populations in the Heritage Area, while invasive pest plants threaten the integrity of native ecosystems such as freshwater wetlands, dunes and shrublands. There are now 240 plant species identified as actual or potential threats to native vegetation, and there are 19 introduced bird species, 9 introduced mammals and 2 amphibians, all competing with our native species (Waitakere City Council 2009).

The Heritage Area currently supports approximately 93 nationally threatened species, comprising of 58 vascular plants (including one endemic shrub), one species of moss, 27 birds, 3 reptiles, one species of frog, one species of bat, and at least three invertebrates (refer to Tables 9-14). One hundred and forty-eight plant species are considered to be regionally threatened (Stanley et al. 2005), although only regionally threatened species that also have a nationally threatened ranking are included in Appendix 3.

10.3.2 Indicator T1: Proportion of threatened species with a stable or increasing population size

While it is relatively simple to gauge the abundance of certain populations within specific areas (e.g. dotterel numbers at Whatipu), it is difficult to evaluate the overall success of threatened populations throughout the entire Heritage Area. In saying that, however, a good proportion of the threatened species listed above are likely to occur within key conservation sites in the Heritage Area, including ‘Ark in the Park’ and Whatipu Scientific Reserve.

Bird counts carried out in 2007-2009 for tomtit, tui and fantail indicate that populations of native bird species present in the ‘Ark’ area are likely benefitting from the increased and year round predator control (de Porter 2010), although these trends need to be confirmed over a longer time period. The benefit of pest control would also extend to other biota such as reptiles, invertebrates and plant species vulnerable to foliar browse and seed predation, including many threatened species. Similarly, pest control aiming to protect threatened shorebirds at Whatipu has been carried out by Friends of Whatipu since 2003. Fledgling numbers for northern New Zealand dotterel and variable oystercatchers have increased since pest control commenced. This is likely to benefit other birds such as NZ pipit, white-fronted tern and little blue penguin.

It is much more difficult to assess the patterns of population change for threatened plants, particularly ephemeral and often cryptic species such as orchids, as well as easily overlooked herbaceous species that are highly vulnerable to competition from weeds.

2008 value	2012 value	Change
No data	No data	Likely to have increased

Change before 2008

No data

Change 2008 – 2013

With the expansion of the buffer area adjacent to the 'Ark', together with the predator control work carried out at places such as Whatipu, Bethells Beach and Karekare, the proportion of threatened species with stable or increasing population sizes is likely to have increased from 2008 – 2012.

How change will be monitored 2013+

Data collected over previous years will provide important baselines by which to compare the results of future monitoring. The key tools for monitoring include:

- Bird counts
- Anecdotal observations (local volunteers)
- Number of chicks fledged (dotterels and oystercatchers)
- Using artificial cover objects and closed cell foam covers to monitor the presence and abundance of lizards
- Tracking tunnels (presence and abundance of pests re: effectiveness of pest control programmes)
- Establishing transects for Hochstetter's frog
- Using bat boxes to detect the presence of long-tailed bat
- Bait takes and trapping records

10.3.3 Indicator T2: Proportion of threatened species under active conservation management

Of the 27 threatened bird species known to occur in the Heritage Area, at least 12 species (50%) are likely to occur in areas under active conservation management. Of the 59 nationally threatened

plants that occur in the Heritage Area, at least 14 (24%) threatened are highly vulnerable to animal browsers. The assumption has therefore been made that some populations (large or small) of each species are likely to occur in areas under active conservation management and will therefore be protected from browsing animals. There are at least 28 (48%) threatened plants that are highly vulnerable to weed invasions. Although populations of each species are likely to occur in active conservation management areas, they will only benefit if weed control is being carried out.

Populations of other threatened fauna known to occur in the Heritage Area, including long-tailed bat, Hochstetter's frog, two geckos, one skink, three freshwater fish, and at least three invertebrates will almost certainly occur in areas under active conservation.

2008 value	2012 value	Change
Birds (50%) Plants (24%) Bat (100%) Reptiles (100%) Freshwater fish (100%) Invertebrates (100%)	Birds (50%) Plants (24%) Bat (100%) Reptiles (100%) Freshwater fish (100%) Invertebrates (100%)	Poor time series data? Possibly a slight increase in the total number of individuals being protected, but same number of species.

Change before 2008

No data.

Change 2008 – 2013

With the relatively recent expansion of the buffer area adjacent to the 'Ark', together with the predator control work carried out at places such as Whatipu, the total number of individual threatened plants and animals under active conservation is likely to have increased from 2008 – 2012.

How change will be monitored 2013+

Data collected over previous years will provide important baselines by which to compare the results of future monitoring. The key tools for monitoring, some of which have commenced since 2008 – e.g. regional reptile monitoring programme, regional short-tailed bat surveys - include:

- Bird counts
- Anecdotal observations (local volunteers)
- Number of chicks fledged (dotterels and oystercatchers)

- Using artificial cover objects and closed cell foam covers to monitor the presence and abundance of lizards
- Tracking tunnels (presence and abundance of pests re: effectiveness of pest control programmes)
- Establishing transects for Hochstetter's frog
- Using bat boxes to detect the presence of long-tailed bat
- Bait takes and trapping records

10.4 Reserves and protected areas (P) indicator results

10.4.1 Introduction

Habitat loss is one of the most important and pervasive environmental/ecological problems and incorporating an area of native habitat into a reserve, or placing a conservation covenant over it, is usually the most secure protection against physical clearance. Reserves prevent important ecosystems from being cleared, but they can also provide a range of other benefits including the following: better protection for less valuable ecosystems that buffer the significant vegetation; keeping options for future restorations open; limiting the scale and intensity of physical disturbance in the surrounding landscape.

The actual level of protection (both practical and statutory) will vary between different types of reserve or covenant, and in response to local conditions. Unfortunately, there are many examples (although none that we know of within the Heritage Area) of covenanted or reserved vegetation being cleared or otherwise modified by people who had no idea it was protected. In addition, without additional effort reserve status alone offers no protection from a range of other pressures that might be negatively affecting the site; for example: weeds, feral pests, stock grazing if the site is not fenced, and/or predation by domestic cats. Therefore it is possible for the proportion of an ecosystem that is protected in reserves to increase, while its overall health and condition decreases due to other pressures. For this reason it is important to assess indicators of protection status (i.e. those outlined in this section P1 – P4) in conjunction with indicators of the actual health of the ecosystems within the reserves and covenants (i.e. indicators in the wetland, forest, sand dune, threatened species, etc. sections of this report).

10.4.2 Indicator P1: Total area of ecosystems (area and %) protected in reserves

Summary

This indicator summarizes the total area (and proportion) of all protected ecosystems in the Heritage Area. 'Ecosystems' are defined as any native vegetation and any structurally complex scrub or forest vegetation, even if this vegetation is dominated by exotic or plants, or is a mixed exotic-native community. All the vegetation types included in this indicator provide a wide range of ecosystem services, such as intercepting and purifying water, carbon sequestration, trapping airborne pollutants and providing habitat for native fauna. For some ecosystem services a patch of exotic vegetation is able to provide a similar level of service to a similar sized patch of native vegetation.

Orchards were not included as ecosystems due to their high intensity/high input nature. Exotic production forests (pine plantations) were included as an ecosystem due to the long-term watershed protection it offers and its relatively low input/low intensity nature.

Altogether, almost 80% of all the forest, scrub and wetland associations in the Heritage Area have statutory protection that makes it impossible or very hard, (i.e. would require a lengthy planning and permissions process) to legally clear woody vegetation from these sites. This is a very high percentage of protected land in comparison to almost all other parts of the Auckland Region and should ensure that the Heritage Area continues to be an environment that is dominated by forests and natural coastal ecosystems and processes.

Change before 2008

In 1894 a group led by Sir Algernon Thomas of the University of Auckland persuaded the Auckland City Council to preserve 3,500 acres (14 km²) in the Nihotupu area of the ranges as a bush reserve. In 1895 the national Government vested the land, and several other smaller areas of the ranges, in the City Council as "reserves for the conservation of native flora and fauna". These earliest purchases have been successively added to over the years, and the Waitakere Ranges Regional Park now contains more than 16,000 hectares (160 km^2) of native forest and coastline; an area more than eleven times larger than the original purchase. In addition to regional parkland the Heritage Area also includes other types of reserves and covenants that have been acquired in the 100 years or so between the first purchase and the passing of the act in 2008.

Other significant reserve holdings include the Department of Conservation (c. 240 ha in 15 blocks), private landowners with QEII Trust conservation covenants registered on the title (c. 315 ha in 22 blocks), private landowners with Council Conservation Covenants registered on the title (c. 360 ha in 49 blocks) and other (non regional park) Council reserves on the lower foothills in the south – eastern extremity of the Heritage Area. The network of protected areas has been built-up, bit-by-bit as new areas of native habitat were gazetted in the 110+ years between the initial reserve acquisition in 1894 and the passing of the ACT in 2008. By 2008 almost 18,800 ha of land in the

Heritage Area had some form of statutory protection for its ecosystems (c.69% of the whole Heritage Area).

Change 2008 – 2013

2008 value	2012 value	Change
18,785 ha (69%)	18,963 ha (70%)	+178 ha (+1%)

Reserves and covenants created in the period 2008 – 2012 were determined from a GIS generated list of all covenants and reserves within the Heritage Area and their acquisition dates. Reserves and covenants that had been registered after the enactment of the act in 2008 were identified and summed to give the total change in protected area. Around 180 ha of new land was protected between 2008 and 2012 an almost 1% increase in the total area of land protected.

How change will be monitored 2013+

Baseline data is the current reserve layer in the Council GIS system; any additions to the reserve layer from 2013 onwards will be clearly visible when the new layer is plotted for future monitoring reports.

10.4.3 Indicator P2: Total area of indigenous ecosystems (area and %) protected in reserves

Summary

This indicator summarizes the total area (and proportion) of protected indigenous ecosystems in the Heritage Area. Indigenous ecosystems were defined using LCDB3 and included the following standard landcover classes: native forest, manuka and/or kanuka, broadleaf indigenous hardwoods, herbaceous saline vegetation, herbaceous freshwater vegetation, mangrove, flaxland and lake and pond. In terms of conservation their values, indigenous ecosystems are superior to exotic or mixed communities as they provide habitat for the widest possible range of native plants and animals. In addition, indigenous habitat provides the ‘standard’ range of ecosystem services, such as intercepting and purifying water, carbon sequestration, and trapping airborne pollutants.

The results of this indicator (P2) are very similar to Indicator P1. This is because most of the ecosystems protected in reserves and covenants are native ecosystems, and the current trends means that ever increasing patches of native habitat are likely to be added over time. LCDB3 data

shows that almost 94% of the covenant/reserve network is dominated by indigenous landcover, with the remaining c.6% characterised by small, isolated patches of exotic forest and scrub and some areas of open grassland.

Altogether, almost 80% of all the indigenous forest, scrub and wetland associations in the Heritage Area have statutory protection for that makes it impossible (or very hard, i.e. would require a lengthy planning and permissions process) to legally clear woody vegetation from these sites. This is a very high percentage of protected land in comparison to almost all other parts of the Auckland Region and should ensure that the Heritage Area continues to be an environment that is dominated by forests and natural coastal ecosystems and processes.

Change before 2008

See the description for P1. Most of the land acquired over the period between 1894 (when the first section of the regional park was gazetted) and 2008 was covered with indigenous ecosystems. The indigenous dominance in the landscape is likely to have increased over time as the more weedy scrub and shrubland associations (e.g. with common weeds such as gorse, broom, pine, and hakea, etc.) have been displaced by indigenous dominated tall forest.

Change 2008 – 2013

2008 value	2012 value	Change
17,567 (79%)	17,737 (79%)	+170 ha (+0%)

Reserves and covenants created in the period 2008 – 2012 were determined from a GIS generated list of all covenants and reserves within the Heritage Area and their acquisition dates. Reserves and covenants that had been registered after the enactment of the Act in 2008 were identified and summed to give the total change in protected area. Of the almost 180 ha of new land that was protected between 2008 and 2012 (see P1) around 170 ha of this was dominated by native ecosystems, based on LCDB3. This means around 96% of the newly acquired land is native ecosystems (170 ha/180 ha = 96%), which is consistent with historical reserve acquisitions over the period 1894 – 2008.

How change will be monitored 2013+

Baseline data is the current reserve layer in the Council GIS system; any additions to the reserve layer from 2013 onwards will be clearly visible when the new layer is plotted for future monitoring reports.

10.4.4 Indicator P3: Total area of significant indigenous ecosystems (area and %) protected in reserves

Summary

This indicator summarizes the total area (and proportion) of protected **significant indigenous** ecosystems in the Heritage Area. Significant indigenous ecosystems were identified using a 'significant indigenous habitat layer' that was created in GIS specifically for Heritage Area reporting (see Indicator H3 above for more detail). Significant indigenous ecosystems are the 'best of the best' in terms of their conservation and indigenous biodiversity values. Typically they include areas of indigenous habitat that are of special quality due to their size, representativeness, unusual/uncommon species composition, and the fact that they provide habitat for rare/threatened animals. To ensure a good representative example of the special features/natural heritage sites within the Heritage Area are protected in perpetuity, it is important to protect the highest possible proportion of significant indigenous ecosystems.

The 'significant indigenous habitat layer' was created using desktop assessment of existing information and local expert knowledge. As a starting point, this layer used a series of high value, ecologically significant sites that had been identified in the Waitakere Ranges Protected Natural Areas Programme (PNAP) report. Additional polygons were then added to this core layer, including wetland and duneland ecosystems, threatened species habitat and areas that support originally rare ecosystems. The significant habitat layer created for this report is different to the Significant Ecological Area (SEA) layer in the Auckland Council Unitary Plan, and does not replace the Unitary Plan process/ information with respect to the determination of ecological significance.

Altogether, more than 85% of all the significant indigenous forest, scrub and wetland associations in the Heritage Area have statutory protection that makes it impossible (or very hard, i.e. would require a lengthy planning and permissions process) to legally clear vegetation from these sites. This is a relatively high figure. The increasing proportion of protected habitat for the P1, P2 and P3 indicators [i.e. 69%/79%/85% for ecosystems/native ecosystems/significant native ecosystems, respectively] suggests that reserve network has been designed to include a higher proportion of the most important ecosystems. This is a good thing.

Change before 2008

See the description for P1. Most of the land acquired over the period between 1894 (when the first section of the regional park was gazetted) and 2008 was covered with indigenous ecosystems.

Change 2008 – 2013

2008 value	2012 value	Change
6,828 ha (85%)	6,830 ha (85%)	+2 ha (+0%)

Reserves and covenants created in the period 2008 – 2012 were determined from a GIS generated list of all covenants and reserves within the Heritage Area and their acquisition dates. Reserves and covenants that had been registered after the enactment of the Act in 2008 were identified and summed to give the total change in protected area. Of the almost 180 ha of new land that was protected between 2008 and 2012 (see P1), around 170 ha of this was dominated by native ecosystem (see P2). However, of the c.170 ha of new indigenous habitat incorporated into the reserve network 2008 – 2012, only c.2 ha (1.5%) of this area was ecologically **significant** indigenous habitat. The total proportion of significant indigenous vegetation protected has therefore remained unchanged.

This result is not unexpected, given the way that the reserve/covenant network has expanded over the past 100 years. Most of the significant indigenous ecosystems are concentrated in the large, extensive tracts of habitat, or along the coastline. Most of these areas were protected (either through DOC or as part of the regional park) relatively early on. More recent reserve acquisitions have tended to be of smaller blocks of habitat on the eastern margin of the ranges generally by QEII and Council covenanting of smaller sites. While useful additions to the reserve network, these smaller and more modified areas of habitat are less likely to include patches of significant indigenous ecosystems.

How change will be monitored 2013

Baseline data is the current reserve layer in the Council GIS system; any additions to the reserve layer from 2013 onwards will be clearly visible when the new layer is plotted for future monitoring reports.

10.5 Conservation management (C) indicator results

10.5.1 Auckland Council pest management

Introduced plants and animals can significantly threaten indigenous biodiversity and the healthy functioning of ecosystems. The Auckland Council developed the Auckland Regional Pest Management Strategy 2007-2012 (ARPMS) in accordance with the Biosecurity Act 1993 which

provides a strategic and statutory framework for managing pest plants and animals. This document includes harmful pathogens such as kauri dieback (Chapter 7). The ARPMS objectives include maintaining both extensive and intensive biosecurity programmes on regional parks and buffer zones to address pathways of pest incursions and to optimise the effectiveness of pest control programmes. These objectives includes working with local boards, tangata whenua, DOC, community groups, volunteers and private property owners to deliver effective pest control programmes.

At present there are eight primary pest management projects run by the Auckland Council Biosecurity Team in the WRHA (Table 13). Each of these projects run annually based on the Council's financial year from 1 July to June 30th, with specific budgeted monies and staff time coming primarily from the Biosecurity Team's annual budget. Several indicators are presented below in this and the following sections dealing directly with some of the major pest projects. The other projects are highlighted below as well.

Table 13 Auckland Council pest management projects in the Heritage Area.

Project name	Purpose
Community Pest Control (Indicator C1)	Assist community groups and private landowners manage pests for biodiversity protection
Low Incidence Pest Plants/Pest Fish	Eradicate/control key rare, high threat pest plants; intensively manage pest fish at Lake Wainamu
Regional Parks Ecological Weeds (Indicator C2)	Tactical ecological weed control in key habitats and/or for key weed species
Strategic Weeds Initiative (Indicator C2)	Control pest plants on key areas of private land adjoining regional parkland to protect it from external weed threats
Regional Possum Control (Indicator C3)	Protect ecosystems in the Heritage Area by monitoring possum densities and undertaking contracted possum control where necessary
Regional Pest Animal Management	Protect ecosystems in the Heritage Area by undertaking contracted feral pig and other selected pest animal control; maintaining feral goat and deer exclusion programmes
Kauri Dieback Management (Indicator K1)	Prevent spread of kauri dieback disease by implementing phytosanitary measures, outreach and compliance programmes, and research and monitoring programmes
Te Henga Pest Plant Control	Remove key pest plants (willows, alligator weed, Mexican water lily etc) from the Te Henga wetland

Low Incidence Pest Plants/Pest Fish

In addition to the weed projects there are efforts to curb key rare pest plants and fish. One of the most significant aquatic pest plants in the Heritage Area is egeria (*Egeria densa*) which has been present in Lake Wainamu since the mid-1990s and which occupied almost all available habitat in the lake down to 4 m. Consequently, Auckland Council Biosecurity released 270 herbivorous grass carp in 2009 in order to eradicate the beds of egeria that had occupied most of the available habitat in the littoral zone of the lake. Results have been very successful with Lake Wainamu now in a non-vegetated state.

Lake Wainamu pest fish have also been being investigated for their role in water quality clarity through the Auckland Council pest fishing programme where intense bouts of fishing have been carried out each summer since 2004. The latest figures as of summer of 2012 reveal the fishing programme has resulted in the removal of over 16,000 exotic fish from Lake Wainamu with over 97% of the catch consisting of perch (*Perca fluviatilis*), goldfish (*Carassius auratus*) and rudd (*Scardinius erythrophthalmus*). Aquatic plant abundance is rising and it appears water clarity is improving as well. The success at Lake Wainamu has encouraged the Te Henga community to undertake a similar community lead parallel fishing programme at the neighbouring Lake Kawaupaku.

Regional Pest Animal Management

At present within the Heritage Area there are no feral goats or deer and Auckland Council Biosecurity works continuously with DOC to maintain the deer buffer zone to help keep this status. Biosecurity also maintains a wide feral goat buffer that encompasses all of the Heritage Area.

Feral pigs are present in the Waitakere Ranges Regional Park and hence the Ranges and buffer zone are subject to an annual Biosecurity programme involving 5 or 6 rounds of contracted hunting. This includes monitoring of kills for population trends plus transect monitoring of the forest for soil and vegetation disturbance trends.

The Regional Pest Animal Management project does not specifically control for other mammalian pests (e.g. cats, stoats, rats, mice, etc), however Council undertake control on a specific site basis such as at Whatipu where Council support the Friends of Whatipu community group (see Indicator C1 below) to control animal pests helping to enhance the relatively recent arrival of NZ dotterel which has had 6 fledged chicks since the Act's inception.

Te Henga Pest Plant Control

The former Waitakere City Council and now Auckland Council have been working to control key pest plants in the Te Henga wetland area, specifically grey willow, crack willow, Mexican water lily and alligator weed. The programme had its genesis in willow control for flood protection but has

expanded to include ecological protection. The programme involves targeted pest plant control, working with the wider local community to educate the value of the work, explain rules around notification of work on private and public property, and address concerns about the use of herbicides. In addition to achieving control of key pest plants at Te Henga, this project has also raised the profile of the wetland through the community interactions and pest work.

10.5.2 Indicator C1: Proportion of indigenous forest habitat under active conservation management

Summary

Indigenous forest is by far the most abundant habitat type in the Heritage Area, covering well over 14,000 ha. Fortunately there are many community groups that are actively involved in pest and weed control and replanting programmes within the forests (See Waitakere Ranges Heritage Area Community Wellbeing technical report). Collectively, their efforts make a huge difference protecting forest habitat within the ranges. The Council provides assistance to these groups through helping with the establishment and running of groups, planting days, bait and traps for pest control, and technical advice. The Council also provides assistance to many groups and schools through its native plant nursery at Arataki.

The four largest projects/reserves in the Heritage Area are listed in Table 14 below.

Table 14 The four largest conservation management projects/reserves in the Heritage Area.

Reserve/Project name	Size	Administered by
Ark in the Park	2,350 ha	Auckland Council, Forest and Bird, volunteers, local landowners
La Trobe Forest Restoration Project	200 ha	Local residents
Lone Kauri Forest Restoration Group	200 ha	Local residents
Makatu Reserve	120 ha	Forest and Bird, QE II Open Space Trust

Change before 2008

Focus for this indicator is placed on the time since the Act's inception.

Change 2008 – 2013

Most major conservation projects have been operating prior to 2008, although it is likely that an increase in smaller, community-based project has occurred within the last four years. In addition, one of the most significant changes was the addition of 600 ha to 'Ark in the Park' in 2007 (M. Bellingham pers. comm.. 2013), which is essentially a buffer zone on adjacent private land. Overall, it is highly likely that the proportion of forest under active conservation in the Heritage Area has increased over the past four years.

How change will be monitored 2013+

Consultation with local community groups, residents and schools will continue in the future with the aim to track these interactions. All existing projects and reserves found at the time this report have been mapped and digitised in the Auckland Council GIS database which will allow for future spatial tracking of the size and extent of these projects in 2018 (See Waitakere Ranges Heritage Area Community Wellbeing technical report). Funding applications (e.g. Environmental Funding Initiative) will also provide a useful record regarding new and existing ecological restoration project. Additional data may also be monitored using Nature Space which is community restoration and conservation groups website which Auckland Council recently endorsed and is helping to develop for Auckland-based groups.

Ecological Restoration Projects in the Heritage Area

Ark in the Park

The project started in January 2003 with the aim to restore functioning native ecosystems through pest control and re-introduction of native animals and plants lost from the Waitakere Ranges. This community-based project is a partnership between Forest & Bird (Waitakere Branch) and the Auckland Council. The project area encompasses 1,750 ha of parkland with an additional 600 ha buffer zone on adjacent private land. Main predators targeted are ship rat and other rodents, mustelids (stoat, ferret and weasel) possums, and feral cats. Some weed control is also included. The success of the project has led the Department of Conservation (DOC) to approve the re-introduction of whitehead, North Island robin, and hihi. Most recently, re-introduction of North Island kokako to the 'Ark' was approved by the Kokako Recovery Group (which is led by DOC) and 8 birds have already been released (de Porter 2010).

Weed pests are much less important in the ARK, compared with forest in the surrounding landscape. A small number of weed seedlings were recorded in one ARK plot, which is a very low level of weed penetration. Values for the surrounding Waitakere plots are much higher, although weed pests still comprise only 0.3% of total basal area (on average) in forest plots.
Animal pest control at ARK is reducing the abundance of mice, rats and possums, compared to the surrounding forest. The 'reduction effect' is less pronounced for mice (20 – 40% improvement) than for rats and possums (mostly 50%+ improvement).

Pest plant indicators	Plots across Waitakere Ranges	Plots within ARK in the Park
Average native: weed species ratio	28	35
% plots with no weeds	68%	92%
Average weed basal area	0.003	0.000
Average weed sapling density	2.1	0.0
Average weed seedling density	0.3	0.0
Animal pest indicators	**Waitakere plots**	**ARK plots**
Average % mouse chewed cards/ line	40	10
% of lines not chewed by mice	20	60
Average % rat chewed cards/ line	50	0
% of lines not chewed by rats	20	90
Average % possum chewed cards/ line	20	10
% of lines not chewed by possums	20	80
% of lines not chewed by any spp.	10	50

Friends of Whatipu

Friends of Whatipu is a group of about 30 people who have knowledge of and links with the Whatipu area and have resolved to act as guardians of the area, helping to preserve its special character, and where possible assisting the Auckland Council in its management of the area. Whatipu supports good numbers of threatened birds such as NZ dotterel, variable oystercatcher, white-fronted tern, fernbird, and bittern. The Friends of Whatipu, together with the Auckland Council, undertake intensive predator control over hundreds of hectares in order to protect indigenous wildlife. In addition to pest control, the Friends of Whatipu hold tree planting days, help keep the beach clear of rubbish, and maintain local tracks.

La Trobe Forest Restoration Project

This project comprises a c.200 ha mainland island in the Karekare area, which is run by a group of local residents. The group aims to restore a sub-tropical rainforest ecosystem through intensive pest management. The group is controlling rats, mice and possums using a bait station grid and attempting to control mustelids using kill traps. Possum numbers are below 5% and rat numbers are around 5% trap catch level with ongoing regular monitoring using tracking tunnels. Recent results (2011) indicate that pest control is having a significant positive impact on bird and invertebrate numbers, which in turn has greatly enhanced critical ecosystem services such as pollination and seed dispersal. La Trobe supports a healthy population of the threatened Hochstetter's frog.

Lone Kauri Forest Restoration Group

A group of local residents established the Lone Kauri Forest Restoration Group in October 2001 with the aim of providing a better environment for indigenous fauna and flora through pest control in a c.200 ha block of forest near Karekare. This group is close to, but does not overlap with, the La Trobe Forest Restoration Project. Land tenure within the project area is a mixture of private and parkland. Work to date has concentrated on animal pest control, targeting possums, rats, mustelids, feral cats and exotic birds. Future plans involve recruiting more volunteers to monitor the uptake of bait and to replenish bait stations, plus supplementary trapping and potentially a couple of people working full time on the project.

Arataki Gateway Sanctuary

This is a Council-supported project started in 2009 that involves volunteers from the surrounding community carrying out animal pest control near the Arataki Visitors Centre. The key pest species targeted are possums, stoats, ship rats and mice. Despite problems with suppressing mouse numbers, an overall decline in pest numbers has been correlated with a significant increase in invertebrate numbers. It is hoped that the 2012/13 season will see an increased size of the project area together with additional training for volunteers, although any expansion of project area is subject to volunteer numbers and volunteer leadership. Comprehensive mapping that captures the full project area, including all trap and monitoring lines and community foothill involvement, will greatly enhance the effectiveness of the project.

10.5.3 Indicator C2: Weed management – Change in expenditures on weed control

Summary

Invasive weeds (i.e. pest plants) within the Heritage Area are reviewed in section 2.3 above. The Auckland Council's obligation under the ARPMS may require some pest plants to be eradicated whereas others may require only boundary control to prevent the spread from parks into neighbouring properties. Eradication of all pest plants is not always practical or affordable and hence a strategic weed management approach is taken based on priorities set annually. A wide number of individual weed management projects are carried out throughout the Heritage Area each year based on this strategic approach (Figure 2). Although historically outcome monitoring has not occurred very often, this practice is improving as well as the storage of data in a readily reportable format. One of the best indicators available at present to assess the change in weed management since the inception of the Act in 2008 is by using financial figures on the amount of budget allocated to weed management within the Heritage Area.

2008 value	2012 value	Change
$247,090 (2008-09 financial year)	$248,631 (2011-12 financial year)	$1,541 (<1% increase)

Change before 2008

Monetary figures before the Act's inception are not included.

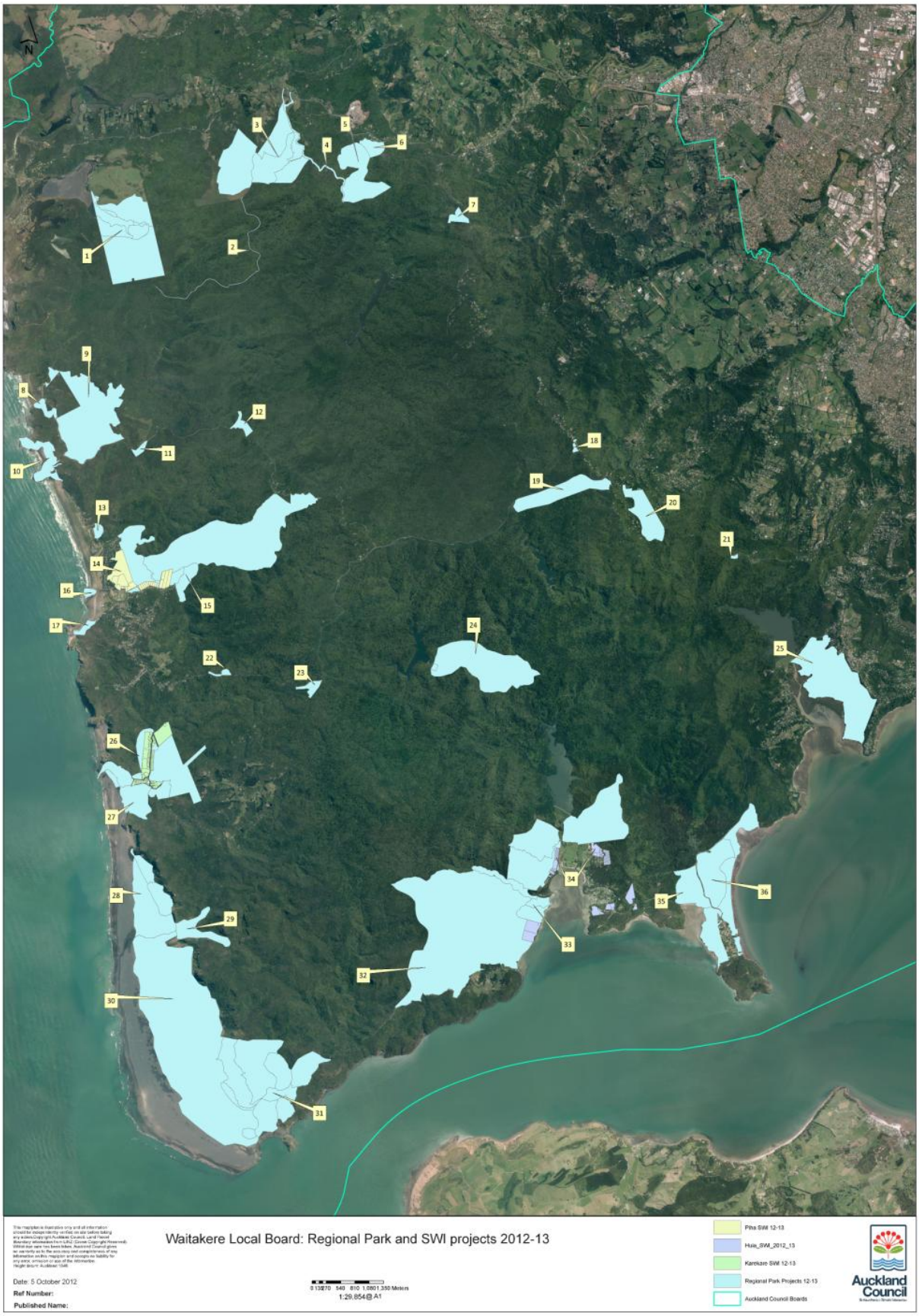

Figure 2 Auckland Council weed management projects in the Heritage Area.

Change 2008 – 2013

Each of the financial years from 2007-2008 through to the present year have had roughly the same amount of budget allocated to plant pest control in the Heritage Area. Although these are not necessarily accurately indicative of how pest management has changed throughout the time of the Act, they are a good indication that weed management efforts have remained consistent within the Heritage Area.

How change will be monitored 2013+

The accessibility of weed management data for work in the Heritage Area will be greatly improved by the time of the Act's next monitoring report in 2018, due to rollout of the digital field recording system, allowing for more detailed and descriptive indicators to be developed.

10.5.4 Indicator C3: Animal pest management – Change in possum Residual Trap Catch (RTC) levels

Summary

Similar to pest plants (as described above), the ARPMS sets minimum standards of pest control for animal pests which Auckland Council must achieve; however, in general the Council strives to maintain an even higher standard of pest animal control. Many pest animals are particularly difficult to eradicate or control due to the lack of resources and technology (e.g. possums, mice, rats, and mustelids), and hence a sustained pest control approach is taken whereby key pests are managed to levels which allows for the recovery of the ecosystems and inclusive indigenous species.

Brush-tailed possum (*Trichosurus vulpecula*) is the target of the largest animal pest species programme in the Heritage Area. The Regional Possum Control programme has the goal to keep Residual Trap Catch (RTC) levels of possums below 2%. RTC levels are a useful indicator for monitoring animal pest management in the Heritage Area as they are reported on regularly and reflect one of the most devastating animal pests in the Heritage Area. RTC levels for the Regional Possum Control programme in the Heritage Area were just under 2% in 2008 with a slight increase in the subsequent years (Figure 3).

The length of the data record for the time frame since the Act's inception precludes the analysis of trends, therefore the information presented below should be taken with caution as RTC levels may be affected by periodic 'hot spots' (described below) and hence overall patterns should be inferred from longer term data (available for the Act's 2018 monitoring report).

2008 value	2012 value	Change
1.87%	6.58%	See text below.

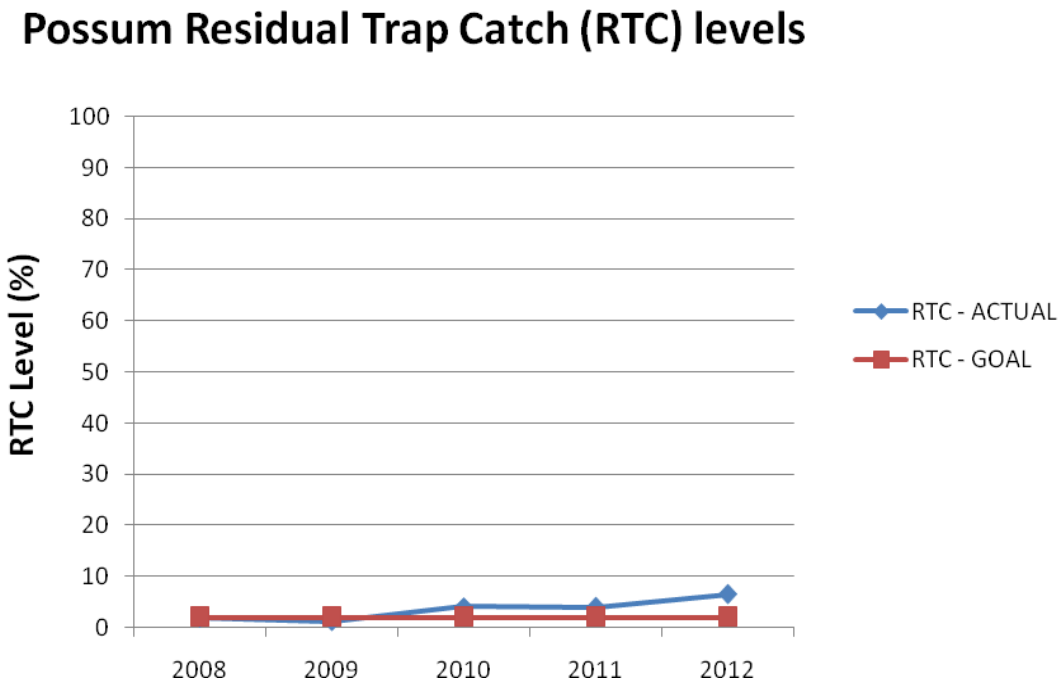

Figure 3 Residual Trap Catch (RTC) levels of possums caught in Auckland Council parkland within the Heritage Area.

Change before 2008

RTC values before the Act's inception are not included.

Change 2008 – 2013

Although changes over this short period of time must be taken with caution (as mentioned above), the general trend appears to show a slight increased in possum numbers. This trend is not necessarily representative of the whole Waitakere park area as the occasional increased RTC values that take place tend to be localised to particular areas ('hot spots'), which the Auckland Council quickly responds to so as to reduce the RTC level back below the 2% RTC goal. For example, in 2010 when the RTC level reached 4.19% the data showed that the main cause of the elevated levels was due to high possum numbers in the Whatipu and Cornwallis area. A response team quickly planned and initiated possum poisoning in these areas which resulted in the final RTC levels dropping to 0.9% in these two areas. A similar 'hot spot' occurred in 2012 in one area in the North West region of the park when the RTC level reached 6.58%, after which a plan was developed and control measures will be taken during the 2013-14 financial year to bring the RTC back to the 2% goal.

How change will be monitored 2013+

RTC monitoring will continue to monitor possum densities into the future and hence this indicator will continue to be used for Heritage Area reporting.

10.6 Kauri dieback (K) indicator results

10.6.1 Introduction

Kauri dieback disease is caused by a microscopic fungus-like plant pathogen, commonly known as PTA (Phytopthera taxon *Agathis*). In New Zealand, it is known only to affect kauri (*Agathis australis*); however, PTA poses a significant threat to the species as it can kill trees and seedlings of all ages. Kauri dieback has been confirmed in the Waitakere Ranges Regional Park and dozens of private properties in the Heritage Area. The pathogen has also been confirmed from several urban Council parks, DOC reserves (Pakiri, Albany, Okura) and on Great Barrier Island.

A multi-agency response to address kauri dieback has been underway since late 2008 when MAF Biosecurity New Zealand declared it an 'Unwanted Organism' under the Biosecurity Act. Firstly, a surveillance programme was initiated in 2008 to determine the distribution of kauri dieback disease across the Auckland region, with particular focus on the Waitakere Ranges Regional Park, where significant tree illness and death were being reported by staff and park users. In 2009, a targeted survey identified five significant disease zones along the track network. As a result of this, an aerial survey was undertaken in 2010 to assess the extent of kauri dieback off track (Jamieson 2010). The aerial survey identified numerous unhealthy trees and groups of trees that had not previously been recorded by ground surveying. These affected areas are scattered widely throughout the ranges on both public and private land. In addition, the aerial survey increased the known extent of unhealthy trees at several locations where kauri dieback had previously been identified. All trees identified by the aerial survey with ill thrift (1700) were inspected, with 970 confirmed with PTA.

Kauri dieback is now widespread throughout the Waitakere Ranges, with an estimated 8% of dense areas of kauri forest known to be affected, and an additional 3% probably affected. All kauri forest within the entire Waitakere Ranges may now be considered at very high risk of infection by kauri dieback. As such there is now an extreme risk of continued spread of the disease locally,

regionally and nationally out of these zones, unless mitigation management and compliance levels are significantly improved (Parks Recreation and Heritage Forum 2011).

Threat to kauri ecosystems

Kauri dieback does not just threaten individual kauri trees – the disease has the potential to destroy an entire ecosystem. Kauri is a key 'ecosystem driver' in that the species has a significant influence on soil chemistry and local plant diversity. This is reflected in the unique array of flora associated with kauri ecosystems. For example, certain species of indigenous orchids and ferns are only found growing under kauri. The loss of kauri therefore has the potential to cause a cascading loss of flora and fauna within the ecosystem, most of which will be replaced by other species.

Considering the Waitakere Ranges are primarily kauri or mixed kauri ecosystems, kauri dieback should be classified as a major biosecurity threat to the Heritage Area. It is clear that kauri dieback poses a far larger threat in the Ranges than traditional pest organisms such as possums, rodents, and invasive weeds. This is underscored by the fact that researchers have no proven tool to combat the pathogen and no cheap diagnostic methodologies (surveillance for kauri dieback is both costly and laborious).

Known vectors of kauri dieback

The distribution of kauri dieback appears to be slightly higher in areas more regularly visited by walkers, with areas such as Piha and the Cascades being the most affected. There appears to be a positive correlation between the track network and kauri dieback zones, indicating that humans are a significant vector in the spread of the disease (almost 70% of known kauri dieback sites are within 0-50m to the track network) (Hill & Hill 2012). In order to prevent further human spread of kauri dieback, Auckland Council has implemented track closures and protection areas.

In addition to humans, animals such as pigs are also likely to spread the disease. Feral pigs have been controlled by contract hunting in the Heritage Area since 2004, and the programme was greatly enhanced in 2008 as a measure to contain the spread of kauri dieback.

Risk of kauri dieback spreading to the Hunua Ranges

An aerial survey of kauri in the Hunua Ranges and surrounding forests from Kawakawa Bay to Mangatangi (Waikato region) was carried out in 2011 to detect the presence of kauri dieback (Jamieson et al. 2011). All trees with ill thrift (1330) were inspected by ground. Although kauri dieback was not detected during the survey, an ongoing soil and tree surveillance programme was

implemented at high-risk sites. This has been expanded into a Healthy Hunuas programme involving regular soil surveillance at all entry points and high risk sites.

One particular high risk pathway for the potential introduction of kauri dieback into the Hunua Ranges is via the daily operational work undertaken by Watercare Services Ltd (Watercare) staff. Routine operations within the diseased areas of Waitakere catchments could lead to the movement of contaminated soil to the Hunua Ranges via dirty equipment, footwear and vehicles. An operational hygiene plan covering all Watercare operations between the Waitakere and Hunua Ranges should be developed urgently.

Kauri Dieback Regional Parks Operations Plan

The 2011 Operational Plan for Management of Kauri Dieback on Regional Parks (Auckland Council 2011) addresses the practical actions that Council is taking to prevent and minimise spread of kauri dieback. The primary focus of this plan is to keep kauri dieback out of the Hunua Ranges, while still carrying out targeted disease management in other regional parkland.

The general management approach in both affected and unaffected areas is to minimise kauri dieback spread and maintain kauri health by:

- monitoring parks for signs of kauri ill-health and kauri dieback spread
- raising public awareness and encouraging long-term behaviour change through public and park user
- establishing and monitoring phytosanitary stations in targeted areas
- carrying out track upgrades in the vicinity of kauri trees
- considering closing tracks in high-risk areas that have kauri near the track, that run through unaffected areas, and which have nearby alternative tracks

All Council local parks with kauri have been surveyed by Biosecurity, with several positive sites confirmed. A plan for the management of kauri in local parkland is needed.

Long-term monitoring

It is critical that resources are made available to carry out a comprehensive long-term monitoring programme for kauri health. Such a programme should include the establishment of permanent vegetation plots that are measured on a five-yearly basis. In addition, the aerial and ground surveys and mapping of the distribution and spread of kauri dieback that have been undertaken, in the Waitakere and Hunua Ranges, need to be undertaken at least five-yearly.

10.6.2 Indicator K1: Change in the spatial extent of kauri dieback

2008 value	2012 value	Change
No data available	8% + ~3% totalling ~11%	Not available

Change before 2008

No data is available before 2008.

Change 2008 – 2013

Change since the Act began is not available.

How change will be monitored 2013+

The results of the kauri surveys described above are mapped in Auckland Council's GIS system (see Figure 4) and provide a baseline with which to monitor changes in the presence of kauri dieback within the Heritage Area. Future surveys in approximately 5 years are planned for (pending budget allocation). Research work on kauri dieback is being conducted via several institutions, which including monitoring plots within the Heritage Area.

APPENDIX 1: Map of Waitakere kauri dieback aerial survey photo locations

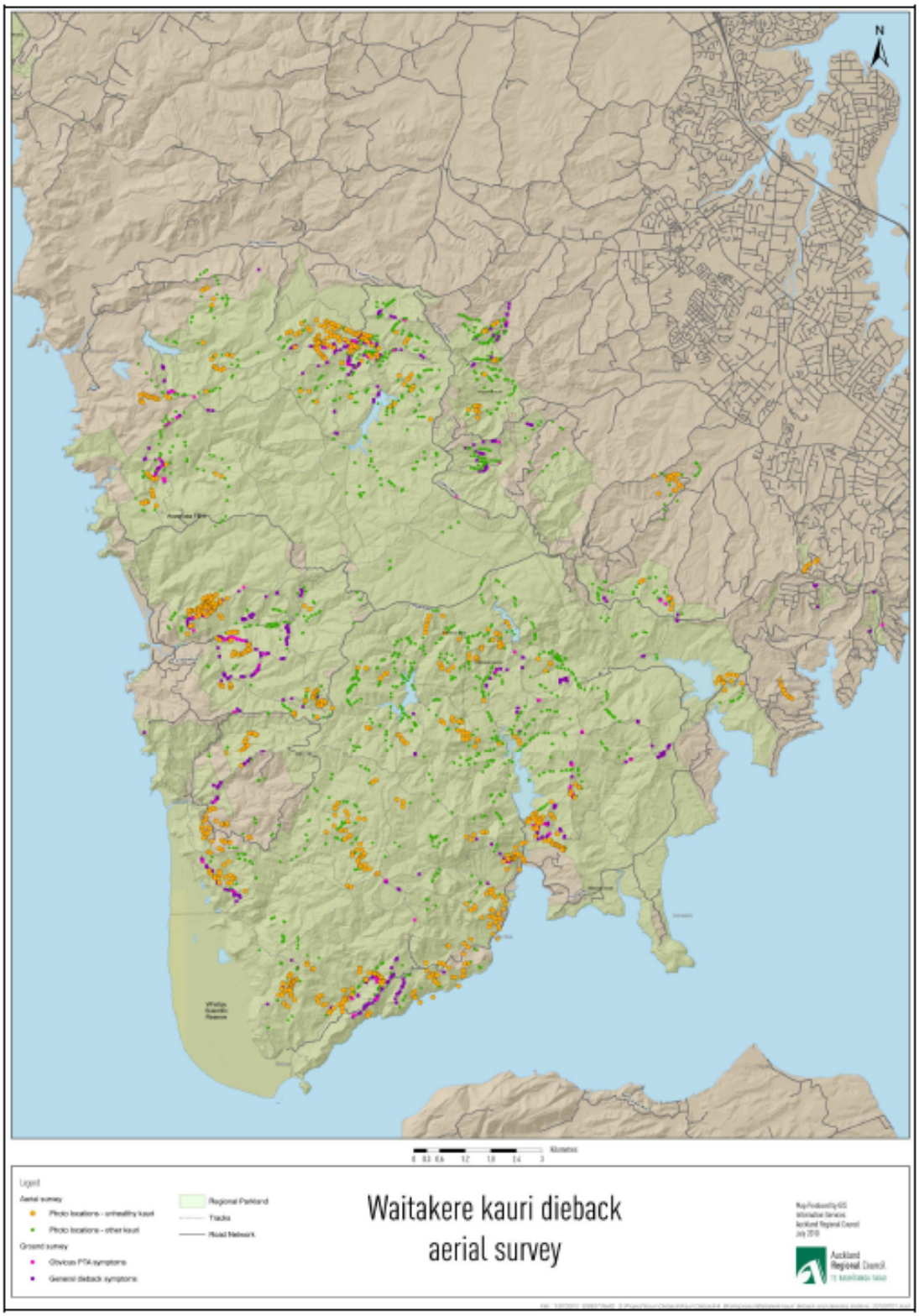

Figure 4 Kauri dieback in the Waitakere Ranges.

10.7 Forest and scrub ecosystems (F) indicator results

10.7.1 Introduction

Prior to the Maori arrival the Auckland Region, much like the rest of New Zealand, was almost entirely forested (McGlone 1989). The main exceptions to this were high alpine environments (which are not found in the Auckland Region) and those patches of habitat that had been cleared by large disturbance events (such as from volcanic activity, wind throw and flooding.). Like the rest of the region, the Waitakere Ranges would have densely cloaked in mature forest, with scattered patches of scrub in recently disturbed locations and along some parts of the coastline. Dense podocarp-broadleaf forest, dominated by species such as taraire, rimu, tawa, towai and miro, was the most common forest type with kauri forest more prominent on the eastern slopes and ridges. The rugged interior of the ranges was virtually untouched until the arrival of Europeans. Since then, timber milling, flaxmilling, gumdigging, mineral extraction, quarrying and farming has resulted in a change from mature forest ecosystems to lower stature native forest and scrub.

This sections summaries the environmental indicators for forest and scrub ecosystems. These are based on two main data sources: forest and scrub growth/clearance based on a comparison of late 2007/early 2008 to late 2010 aerials; the network of Council forest monitoring plots in the Waitakere Ranges (see below for summary).

10.7.2 Regional Forest Monitoring Programme

The regional forest monitoring programme is part of a wider Auckland Council programme to systematically monitor indigenous plants and animals, weeds and pests in the natural environment across the Auckland Region (Figure 5). This information can then be used for a wide range of planning and operational purposes, including: meeting the council's statutory environmental reporting requirements; assessing the impact of Council plans, rules and policies on the natural environment; improving the effectiveness and efficiency of biodiversity management in Council reserves and regional parks etc.

The monitoring data is collected from a network of c.400 forest and scrub plots that are scattered throughout the region. It is planned to measure each of these 400 plots once every five - ten years, depending on location. Currently we are four years into a five year plot establishment/baseline measures phase, with the first five yearly re-measures due to be commenced in November/December 2014. The Waitakere Ranges is one of the key biodiversity sites for the

Auckland Region and approximately 50 forest plots are planned for the Heritage Area. Twenty of these plots will be within the boundaries of Ark in the Park, and the remaining 30 are

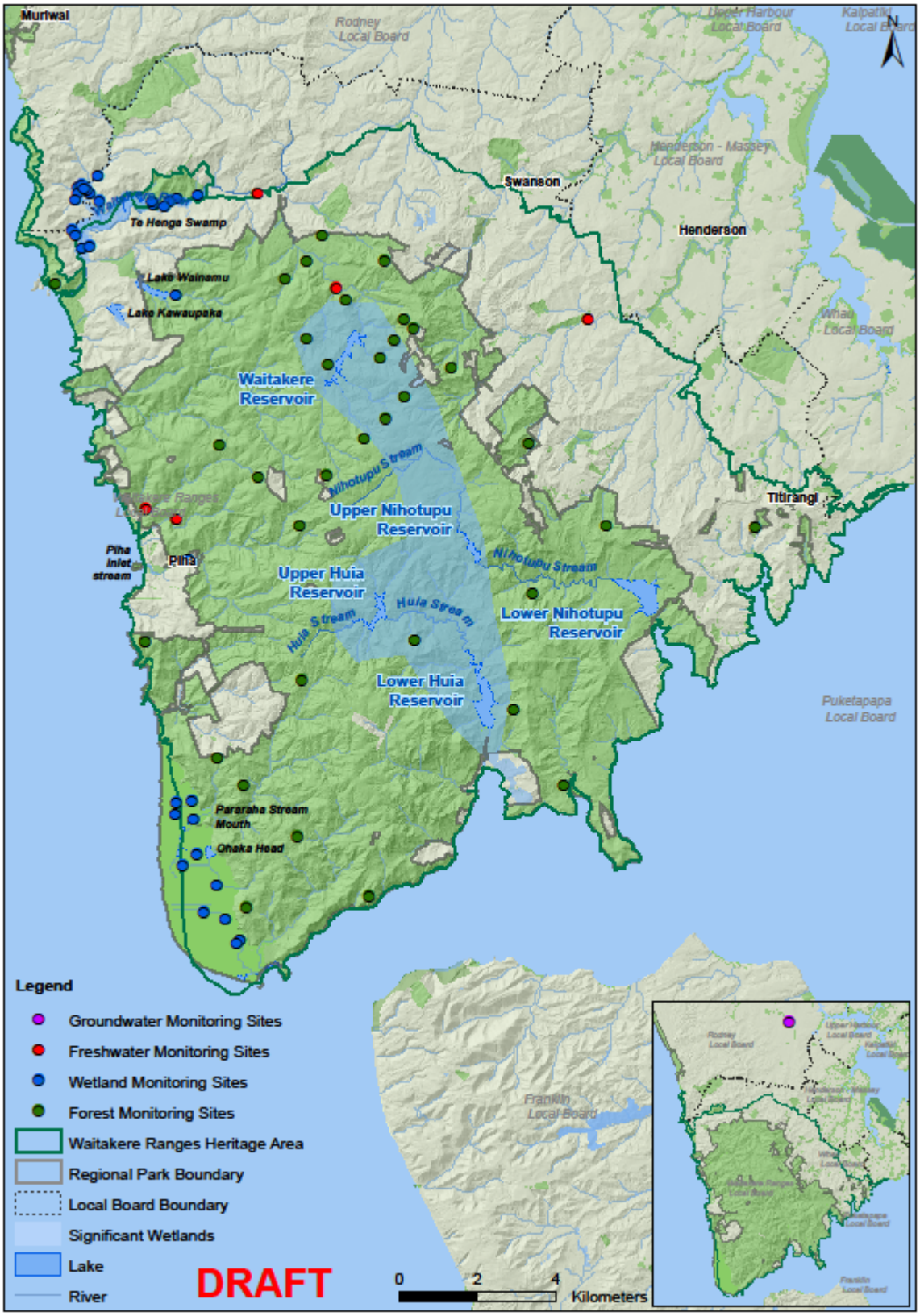

Figure 5 Monitoring sites and reservoirs within the Heritage Area.

scattered through the rest of the Heritage Area. This distribution of plots in different locations allows the values of forest ecosystems in the Ark and wider Waitakere Ranges to be compared with each other, and with forest and scrub ecosystems from other locations across the Auckland Region (e.g. with forest in Hunua Ranges, forest on offshore islands, urban forest, and forest fragments in the rural landscape).

10.7.3 Indicator F1: Total area of forest and scrub habitat

Summary

The information for this indicator is based on a quantitative assessment of data from the New Zealand Landcover Database version 3 (LCDB3), based on 2008 satellite imagery, combined with a qualitative assessment of the vegetation change detected in the desktop aerial photo comparison (2008 vs. 2012 aerials) work. We note that spatial resolution of these two different information sources is quite different; LCDB3 has a resolution of 1 ha pixels, whereas the photo interpretation data recorded changes down to around $10m^2$ in size. This means that some caution needs to be used in interpretation of results from the combination of these two datasets. However, the following analysis presents a good general summary of likely changes in the cover of indigenous forest and scrub ecosystems within the Heritage Area since 2001.

Change before 2008

Historical change in the Heritage Area is summarised in the introduction section of this report. It outlines a history of dramatic vegetation change resulting from fire, logging, mining, farm clearance etc. throughout an initial resource exploitation phase that lasted until the 1940s. In more recent decades, creation of the Waitakere Ranges Regional Park and increasing Council and community action on pest and weed control has almost certainly seen an increase in the quantity and quality of native ecosystems in the Heritage Area.

Comparing data from LCDB2, which is based on 2001 satellite imagery, with the LCDB3 (2008) values allows a coarse scale calculation of changes in vegetation cover between 2001 and 2008. The LCDB is based on a minimum patch size of 1 ha, and therefore it is more appropriate for gross comparisons across the landscape, rather than detailed assessments of vegetation change. Table 15 shows there has been only a very small reduction in the cover of native forest and scrub between 2001 and 2008.

Table 15 Change in area of broad ecosystem classes between 2001 and 2008 in the Heritage Area, based on LCDB2 and 3.

Vegetation class	2001 area	2008 area	Change
Indigenous forest and scrub	21,745.8 ha	21,743.1 ha	- 2.7 ha
Other indigenous ecosystems	585.4 ha	585.4 ha	
Exotic forest and scrub	284.8 ha	284.3 ha	- 0.5 ha
Open space (lakes, gravel etc.)	827.5 ha	827.5 ha	
Farmland, orchards, crops etc.	2,936.1 ha	2,936.1 ha	
Urban	683.6 ha	686.8 ha	+ 3.2 ha
TOTAL	27,063.3 ha	27,063.3 ha	

A total of c. 3.2 ha of urban landcover has been added. Most of this gain in houses has been at the expense of indigenous forest (2.7 ha or 84% of the 3.2 ha figure), with loss of exotic forest contributing a further 0.5 ha. This is a very small proportional loss of forest habitat (0.01%) and converts to an annual indigenous forest loss of around 0.001%/year.

Change 2008 – 2013

Changes between late 2007/early 2008 to late 2010 (i.e. three years, rather than the full five year monitoring period – see Appendix 4) were analyzed using desktop comparisons of aerial photographs taken at these two times. More than 4700 different patches of forest and scrub vegetation clearance were identified, totalling c.40 ha in area (Table 16). There were also some examples of vegetation expansion recorded. Unfortunately, it was impossible to determine from aerial photographs alone whether the cleared (or newly created) patches of scrub and forest habitat were native, mixed or exotic vegetation. Therefore the total clearance figure does not represent the total loss of indigenous forest and scrub habitat.

Table 16 Summary of vegetation and other landcover change recorded in the Heritage Area from a desktop analysis of late 2007/early 2008 and late 2010 aerial photographs.

Type of change	# of patches	Average patch size	Total area
Vegetation clearance	4,728	0.009 ha (90m^2)	40.5 ha
Regeneration	438	0.019 ha (190m^2)	8.5 ha
Vegetation change	N/a	N/a	32 ha net loss

Some indication of the pre-clearance vegetation cover of cleared locations can be determined by consulting the LCDB3 class of the cleared location. Although note this is an indicative comparison given the different spatial resolutions of the two datasets. This data is presented in Table 17.

Table 17 Land Cover Database version 3 land class at vegetation clearance locations summarized in Table 16.

LCDB3 vegetation cover class	Total area
Indigenous forest and scrub	17.7 ha
Wetlands	0.1 ha
Exotic forest and scrub	3.3 ha
Exotic grassland and other productive ecosystems	14.9 ha
Urban	4.4 ha
Other	0.1 ha
Total	40.5 ha

The information provided in Table 16 and Table 17 can be summarized to determine the total area of indigenous forest and scrub in the Heritage Area, and how much of this was cleared by human activity, as follows:

2008 value	2012 value	Change
21,743.1 ha	21,727.3 ha	-15.8 ha (0.07%)

A net loss of c.15.8 ha of native ecosystems is a c.0.07% loss of all forest and scrub within the Heritage Area. Or converting this to an annual figure for the three-year period over which change was measured, this is a loss of 0.03% of indigenous forest and scrub/year. This is 30 times faster than that recorded using LCDB3 but probably not enough to create a cumulative effects problem when the Heritage Area as a whole is considered. However, clearance activity has been concentrated in some specific parts of the Heritage Area and the rates of change for these particular locations are correspondingly higher (see Indicator H1 discussion for more information on the distribution of clearance within the Heritage Area).

How change will be monitored 2013+

This indicator will continue to be monitored using the approaches outlined above. However, the power of the indicator to detect change will be increased by the creation of a better quality, higher resolution vegetation map of indigenous ecosystems within the Heritage Area. This better quality map, rather than the LCDB layer, will then be used for comparison with the change layer. This

monitoring approach relies on the regular acquisition of high-resolution aerial photography or satellite imagery for the Waitakere Ranges, which is outside the budget of funds allocated to reporting for the Act in the Long Term Plan.

10.7.4 Indicator F2: Loss or gain of forest and scrub habitat (area and %)

Summary

Change for this indicator is summarised in F1. The purpose of separating F1 and F2 is that future measurements F1 will allow the total area of indigenous forest at that time to be compared with the 2008 baseline and therefore calculate cumulative change. Whereas F2 will assess the change in vegetation cover over the preceding five year period. For this initial five-year reporting period, comparison back to a 2008 baseline and change over the preceding five years are the same figures.

10.7.5 Indicator F3: Overall percentage biomass of indigenous plants in forest plots

Summary

The biomass of native plants and weeds was estimated using measurements of the diameter of tree trunks (at 1.35m above the ground) in all forest monitoring plots within the Heritage Area. A value of almost 100% for this indicator means the biomass of native plants is almost 10,000 times greater than the biomass of exotic plants in Waitakere plots. This is a very impressive figure and is a testament to the effectiveness of past weed control work in Waitakere Ranges Regional Park and the inherent resistance of large tracts of dense native forest to weed invasion.

The 99.99% figure is high in comparison with forest ecosystems around the rest of the Auckland region (Figure 6), highlighting the very high naturalness of forest ecosystems in the Heritage Area.

2008 value	2012 value	Change
No data	99.99%	No change data available, but see Figure 6 for regional comparisons

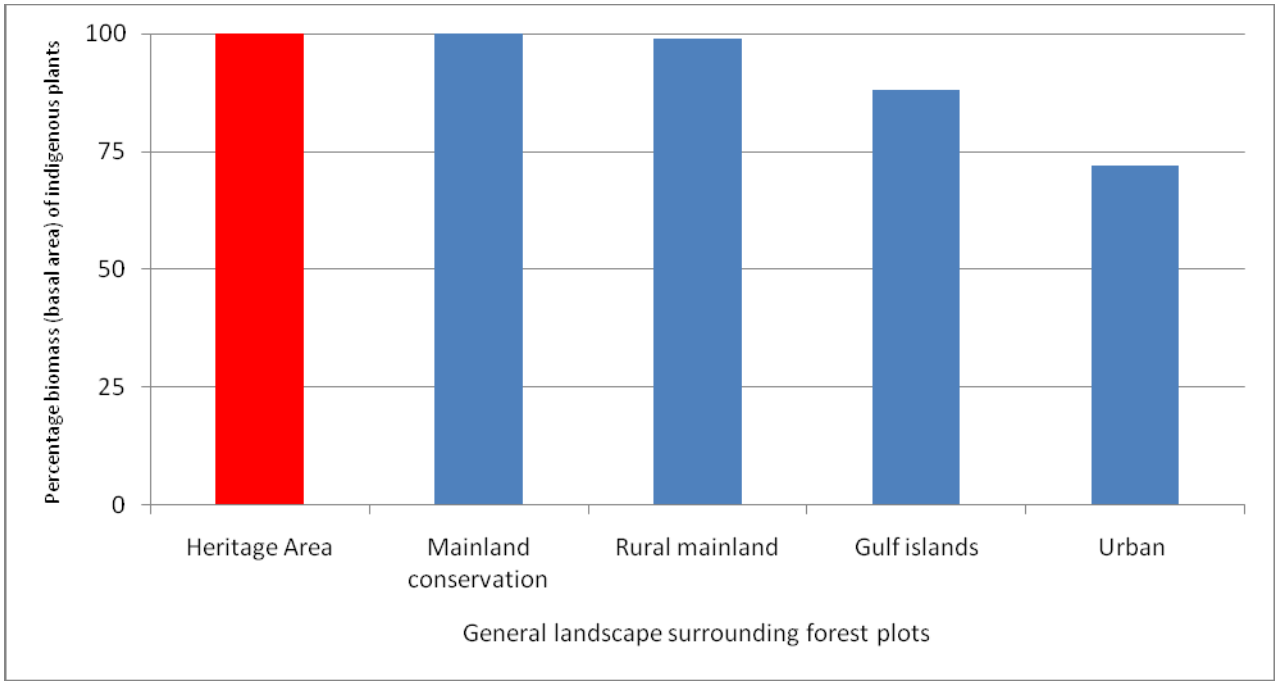

Figure 6 Native: exotic basal area ratio for all woody plants >2.5cm in regional forest monitoring plots in the Heritage Area in comparison with forest ecosystems around the rest of the Auckland region grouped by general landscape character.

Change before 2008

Auckland has been described by Landcare scientists (2006) as "the weediest city in the world" due to our very high number of naturalized[8] exotic plants and the high rate of new naturalizations. In many rural areas, especially those that are more suitable for farming, there has been wholesale replacement of native ecosystems (i.e. mostly forest, scrub and wetlands) with exotic grassland and shelterbelts. However, despite these pressures, the majority of the Heritage Area has been less affected by weeds than most other parts of the Auckland Region.

The dominance of weeds in the Heritage Area has actually probably decreased over the last 50 – 100 years. Disturbance favours the establishment and growth of many weed species, and the influence of large scale disturbances associated with logging, gum extraction and early farming attempts in the early to mid 20th century is beginning to decline. This slow process occurs as indigenous forest grows and displaces lower stature weedy species (such as gorse, broom and exotic grasses) that were the first colonisers of the large clearances associated with logging and fires.

[8] Naturalized plants are exotic plant species that have been introduced to New Zealand and have subsequently escaped from cultivation, produce viable seed and germinate/grow a new generation of seedlings outside the location in which they were originally established.

Change 2008 – 2013

Forest plot establishment runs over five years from 2009 – 2013, and therefore there is no change data available for this indicator. Change data will be available from 2014 onwards for a subset of plots, with the full 1st re-measurement of all forest plots planned for 2018. Our observations of forest ecosystems in the Heritage Area, and the currently very low level of weed penetration into the dense tracts of indigenous forest suggest that this indicator is likely to be static or improved from 2008 – 2012, although we have no plot data to support this observation.

How change will be monitored 2013+

The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data for around 80% of the forest plots in the Heritage Area.

10.7.6 Indicator F4: Overall percentage biomass of weedy exotic plants in forest plots

Summary

Indicator F3 included all exotic plants in the native: exotic biomass ratio, irrespective of how weedy they are. This indicator (F4) recognizes that some exotic plants have a much greater effect on indigenous ecosystems than others. Small populations of inconspicuous, herbaceous weeds[9] often have little or no impact on the structure of a native forest. That is, they do not grow into woody plants that are likely to grow quickly and/or suppress native plant species in the forest shrub and ground tiers. In contrast, the impact of important weeds species such as gorse, ginger or climbing asparagus has a much greater impact on the native forest. These species are capable of completely altering the structure of a native forest and displacing native plants by smothering and out-competing them across relatively large tracts of land.

The definition of a 'weed' for the purposes of this indicator was any exotic plant species that was listed in the Regional Pest Management Strategy (Auckland Regional Council 2007) or was a known ecological weed species. The value of 0.10% for this indicator suggests that ecological weed species comprise only a very small portion of the sampled forests. The value is identical to that recorded for F3; which suggests that 100% of the exotic tree stems measured in forest plots are weedy exotic species. This value of 0.10% weeds is a very low (good) result. In comparison with other landscapes within the Auckland Region (see Figure 7) it is the equal best result.

[9] For example, wall lettuce, lotus, cats ear and clover

2008 value	2012 value	Change
No data	0.10%	Not change data available

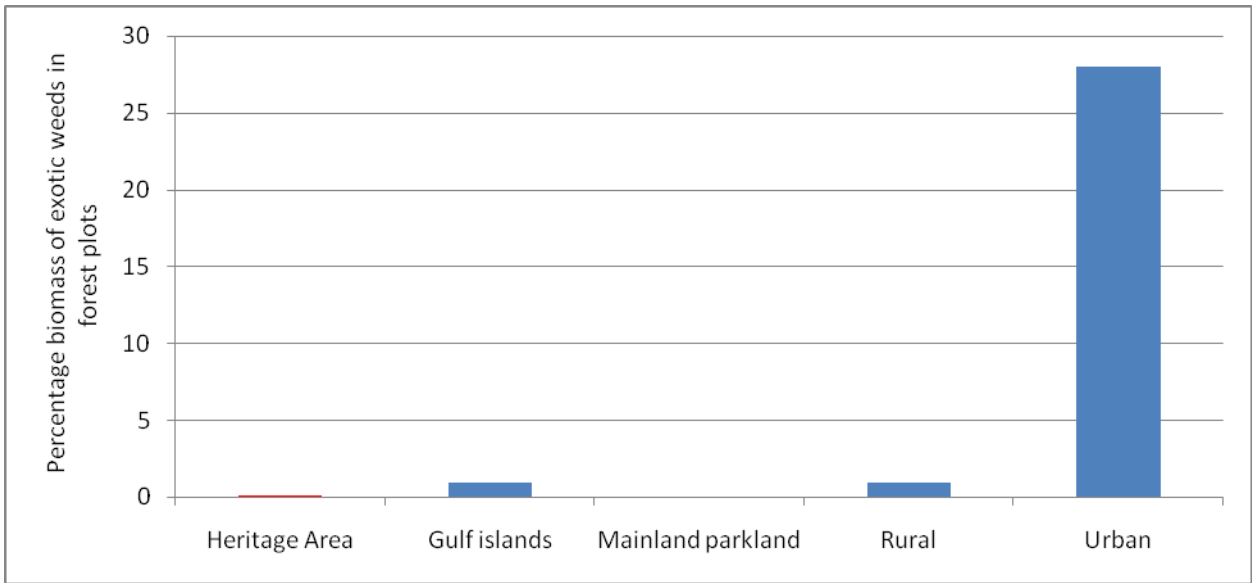

Figure 7 Percentage biomass of weedy exotic tree stems in forest plots

Change before 2008

See F3 data. All exotic woody species recorded in the forest monitoring plots were also classed as weed species. Therefore the value and interpretation of this indicator is identical to F3.

Change 2008 – 2013

See F3 data. All exotic woody species recorded in the forest monitoring plots were also classed as weed species. Therefore the value and interpretation of this indicator is identical to F3.

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.7 Indicator F5: Average biomass of exotic weeds in forest plots

Summary

Indicator F4 summarized the total native: exotic biomass ratio across all plots. Total value indicators are more sensitive to changes in individual plots than averages because values are summed across all plots. This means that a dramatic decrease in indicator F4 (i.e. an increase in exotic plants at the expense of native ones) could be the result of an 'across the board' increase in the importance of weeds in all plots OR could be the result of a big increase in weeds in one or a handful of locations with the majority of other locations having no-change (or even small improvements) in their native: exotic balance.

This indicator (F5) provides more information about the distribution of any changes in weed dominance among the various wetland plots. Similar values for indicators F4 and F5 suggests that the negative impacts of exotic encroachment are equally shared between the various sample locations across the network. A wide divergence between these two figures show that reductions (or improvements) in this indicator are occurring in a subset of plots.

2008 value	2012 value	Change
No data	0.15%	No change data available, but see Figure 8 for regional comparisons

The data used for this indicator is from recently established plots and only baseline measures are available for this report. This baseline will be used to monitor future change. However, it is clear from comparing average native biomass percentages of wetlands across the Auckland Region (Figure 8) that wetlands in the Heritage Area are relatively high quality in terms of their dominance of native plants (i.e. naturalness).

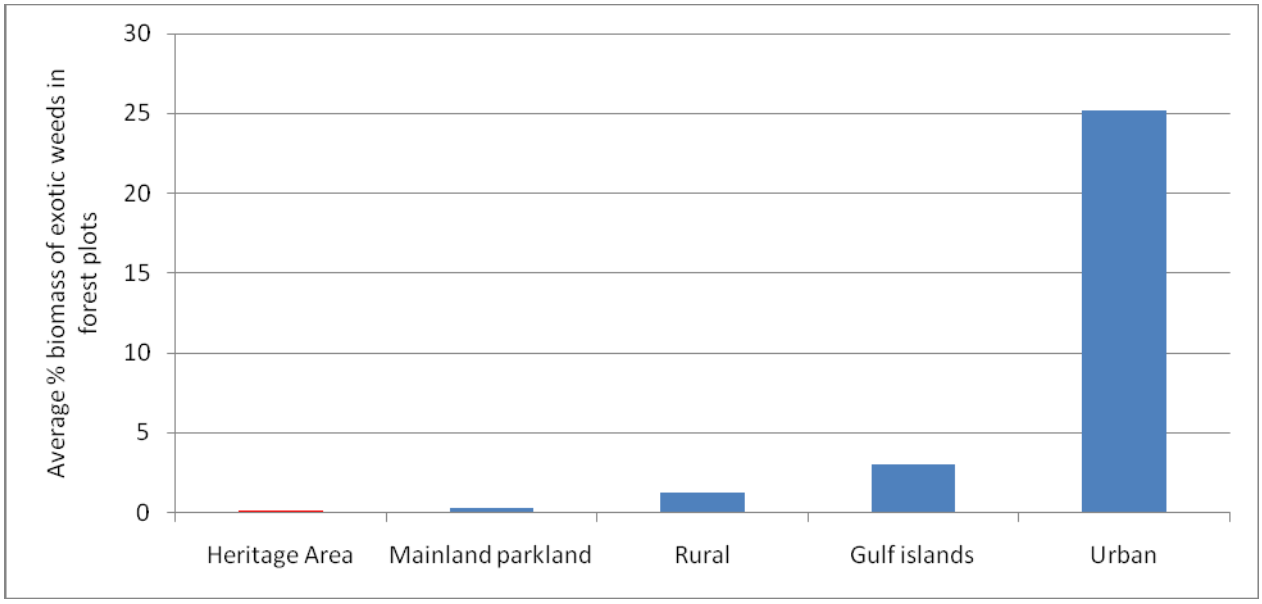

Figure 8 Average % biomass of weedy exotic tree stems in forest plots.

Change before 2008

See F3 data. All exotic woody species recorded in the forest monitoring plots were also classed as weed species. Therefore the value and interpretation of this indicator is identical to F3

Change 2008 – 2013

See F3 data. All exotic woody species recorded in the forest monitoring plots were also classed as weed species. Therefore the value and interpretation of this indicator is identical to F3

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.8 Indicator F6: Proportion of forest plots with no exotic trees or saplings

Summary

Indicators F3, F4 and F5 are all concerned with the presence and dominance (in terms of biomass) of exotic species in forest plots. Because these indicators use weed biomass the indicator result is largely controlled by the 'weediness' of forest stems within a plot. This indicator has been included to monitor the percentage plots that are completely free from the influence of weedy saplings or trees. Ecosystems beyond the influence of weeds, much like wilderness, have decreased markedly as more and more exotic species become naturalised in the New Zealand landscape. An increase in the presence of exotic saplings in the wider landscape could be seen as a negative influence, even if this increase consisted of just a few scattered individuals. This indicator is designed to detect these types of small-scale changes

The Heritage Area figure of 84% for this indicator is equal to the best results for regional forest plots (Figure 9). However the values for different landscapes (Heritage Area vs. gulf islands vs. other rural land vs. mainland conservation parks) are quite similar for this indicator. The only obvious exception is urban plots, where there are significantly fewer locations without any exotic trees or saplings compared to the other landscapes.

2008 value	2012 value	Change
No data	84%	No change data available, but see Figure 9 for regional comparisons

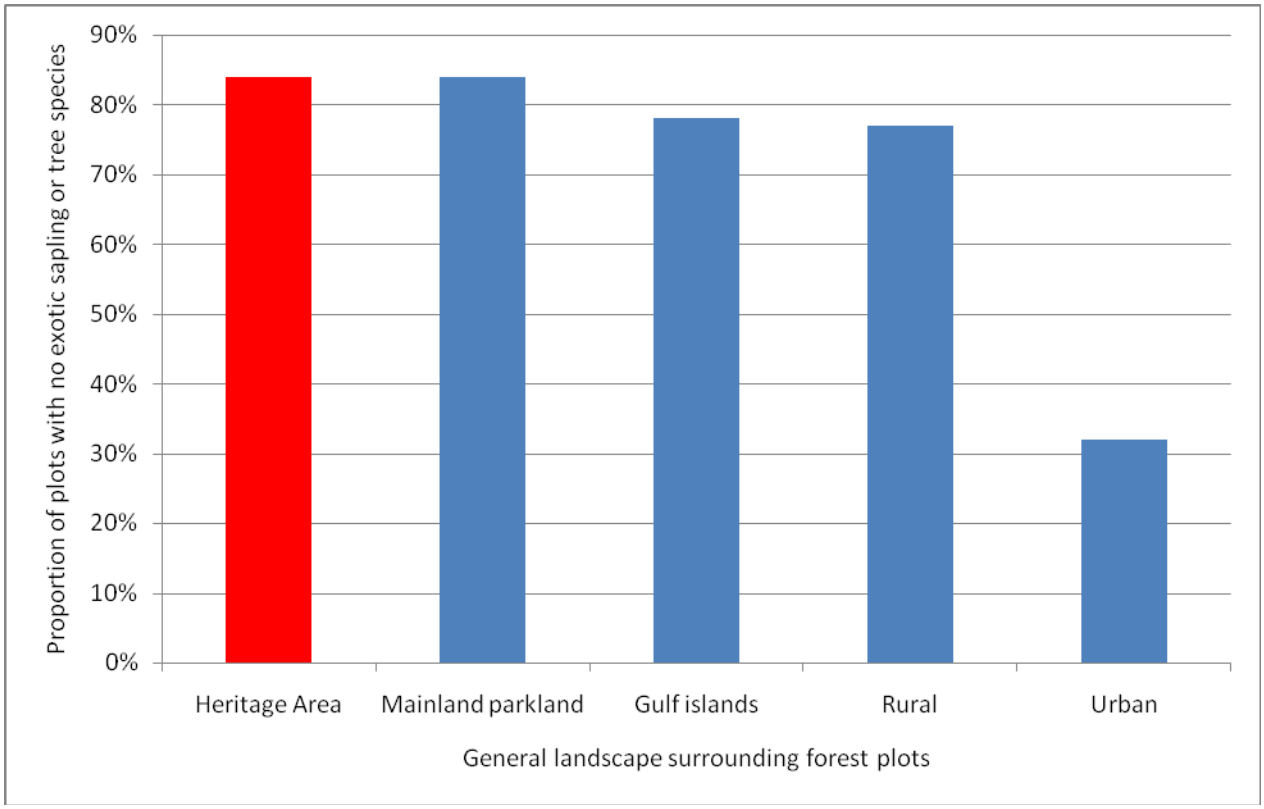

Figure 9 Proportion of forest plots with no exotic sapling or tree species recorded in the plot.

Change before 2008

The dominance of weeds in the Heritage Area has actually probably decreased over the last 50 – 100 years. Disturbance favours the establishment and growth of many weed species, and the influence of large scale disturbances associated with logging, gum extraction and early farming attempts in the early to mid 20th century is beginning to decline. This slow process occurs as indigenous forest grows and displaces lower stature weedy species (such as gorse, broom and exotic grasses) that were the first colonisers of the large clearances associated with logging and fires.

Change 2008 – 2013

Baseline data was collected throughout the period 2009 – 2011 and will continue until 2013; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to forest vegetation in general (indicators F1 and F2) and there have been no new weed incursions.

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage

Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.9 Indicator F7: Average percentage dominance of weedy exotic saplings

Summary

The 'weedy species' group includes woody plants or vines that are capable of aggressively colonizing new habitat at the expense of native plants and, in some cases actively invading and displacing native habitat. Weedy saplings are monitored to ensure the negative impact of weed invasions are recognised/highlighted at an early stage; the sapling cohort in forest ecosystems is often highly representative of the future forest composition.

In line with the results for canopy trees (F3, F4, F5 and F6) and seedlings (F8), there is a relatively low % of weedy saplings in Heritage Area forest and scrub plots, compared to other parts of the region (Figure 10). This is not unexpected, given the large tracts of intact habitat in the Heritage Area and its relative freedom from development pressures since the mid-20th century. The data suggest weedy saplings are having little impact on the regeneration of native species, and there is no need to be concerned about the invasion and displacement of native forest and scrub in the short term.

2008 value	2012 value	Change
N/A	0.3 %	No change data available, but see Figure 10 for regional comparisons

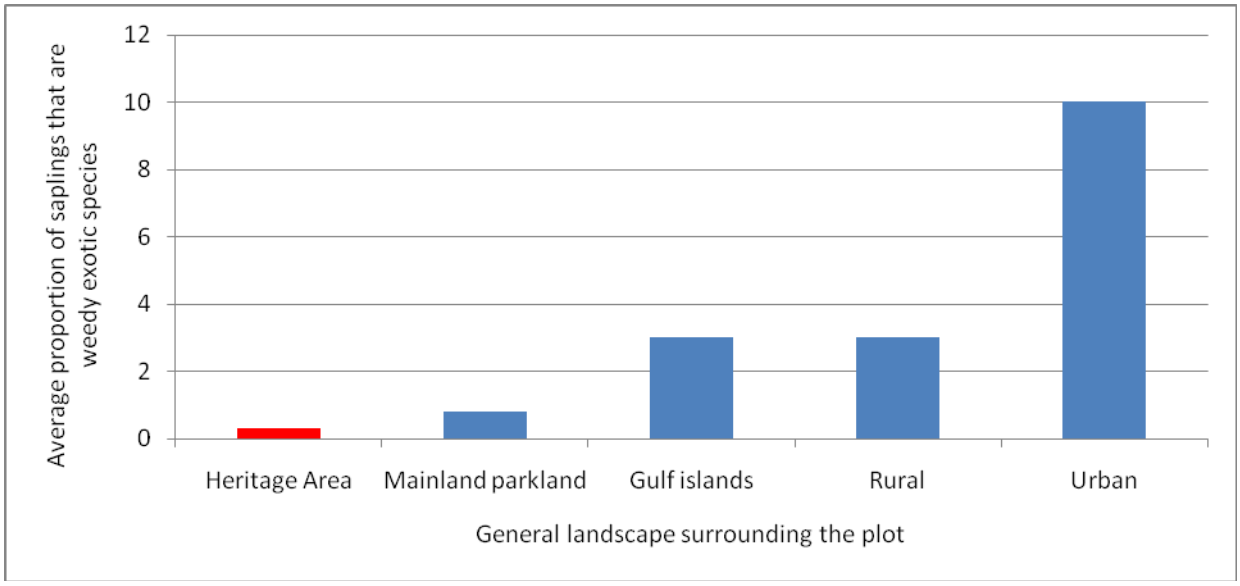

Figure 10 Average proportion of saplings that are weedy exotic species.

Change before 2008

The dominance of weeds in the Heritage Area has actually probably decreased over the last 50 – 100 years. Disturbance favours the establishment and growth of many weed species, and the influence of large scale disturbances associated with logging, gum extraction and early farming attempts in the early to mid 20th century is beginning to decline. This slow process occurs as indigenous forest grows and displaces lower stature weedy species (such as gorse, broom and exotic grasses) that were the first colonisers of the large clearances associated with logging and fires.

Change 2008 – 2013

Baseline data was collected throughout the period 2009 – 2011 and will continue until 2013; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to forest vegetation in general (indicators F1 and F2) and there have been no new weed incursions.

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.10 Indicator F8: Average percentage dominance of weedy exotic seedlings

Summary

The 'weedy species' group includes woody plants or vines that are capable of aggressively colonizing new habitat at the expense of native plants and, in some cases actively invading and displacing native habitat. Weedy seedlings are monitored to ensure the negative impact of weed invasions are recognized/highlighted at an early stage. This indicator also tracks the successful dispersal and germination of weedy seedlings throughout the large tracts of native forest and scrub that make up much of the Heritage Area. Many of these weed seedlings may not survive to be recruited into sapling and larger size classes; however the distribution and density of important weed species in the seed rain is a useful indicator of the potential for future invasions.

In line with the results for canopy trees (F3, F4, F5 and F6) and saplings (F6 and F7), there is a relatively low % of weedy seedlings in Heritage Area forest and scrub plots, compared to other parts of the region (see Figure 11). This is not unexpected, given the large tracts of intact habitat in the Heritage Area and its relative freedom from development pressures since the mid-20th century. The data suggest weedy saplings are having little impact on the regeneration of native species, and there is no need to be concerned about the invasion and displacement of native forest and scrub in the short term.

Change before 2008

The dominance of weeds in the Heritage Area has actually probably decreased over the last 50 – 100 years. Disturbance favours the establishment and growth of many weed species, and the influence of large scale disturbances associated with logging, gum extraction and early farming attempts in the early to mid 20th century is beginning to decline. This slow process occurs as indigenous forest grows and displaces lower stature weedy species (such as gorse, broom and exotic grasses) that were the first colonisers of the large clearances associated with logging and fires.

Change 2008 – 2013

2008 value	2012 value	Change
N/A	0.2%	No change data available, but see Figure 11 for regional comparisons

Baseline data was collected throughout the period 2009 – 2011 and will continue until 2013; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to forest vegetation in general (indicators F1 and F2) and there have been no new weed incursions.

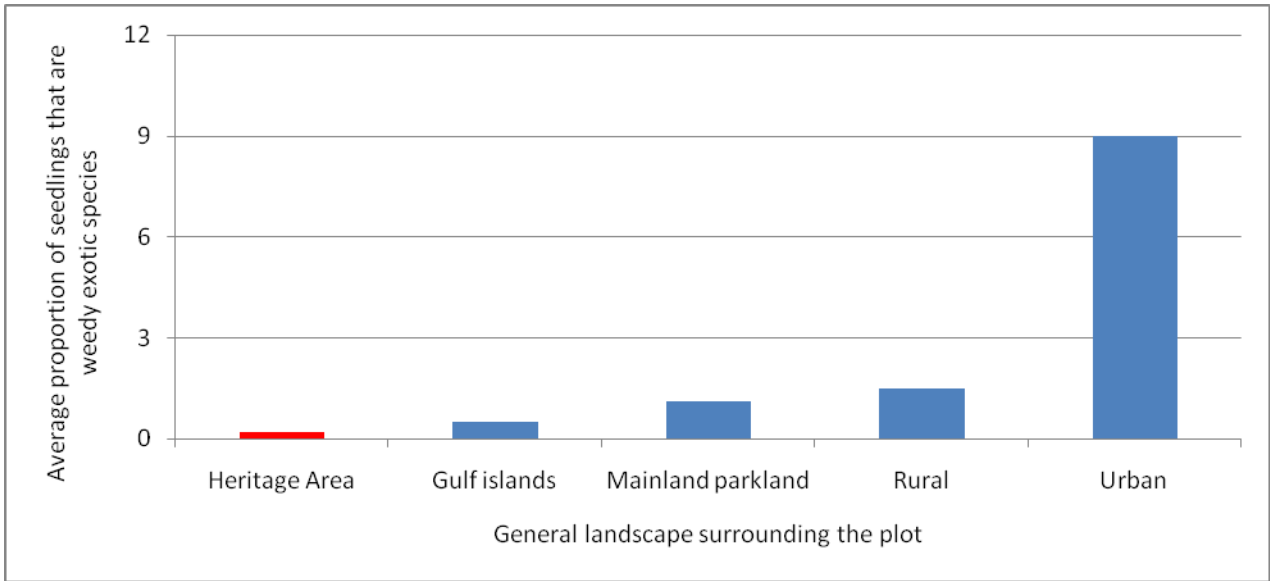

Figure 11 Average proportion of seedlings that are weedy exotic species

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.11 Indicator F9: Species diversity of indigenous plants

Summary

Total species diversity has been widely used indicator of vegetation quality in many different forest studies, both in New Zealand and overseas. High species diversity is generally seen as a positive thing. In certain situations total species diversity can be a good indicator of a mature, undisturbed forest ecosystem that has slowly accumulated biodiversity over time (i.e. all the various micro-climatic and structural niches within the plot are occupied by plant species from a range of different

guilds). For these reasons this indicator was chosen for use in the Heritage Area. However there are some problems with use of this measure, and these are summarized below.

Not all native ecosystems are species rich, and some highly natural ecosystems can actually have very low species diversity (e.g. young manuka scrub). An additional problem with using total species diversity is observer bias. Many of the smaller native species are quite cryptic, grow in places that are not easy to see and sample (e.g. up in the canopy of trees) and/or are only well known to a small group of experts (e.g. identifying moss and liverwort species). For these reasons, the total species diversity figures presented for this indicator are based on woody, native plants >15cm in height, ground ferns and tree fern species only. They do not include non-vascular plants, herbs or epiphytic species.

2008 value	2012 value	Change
N/A	144 different woody native plant species	No change data available, but see Figure 11 for regional comparisons

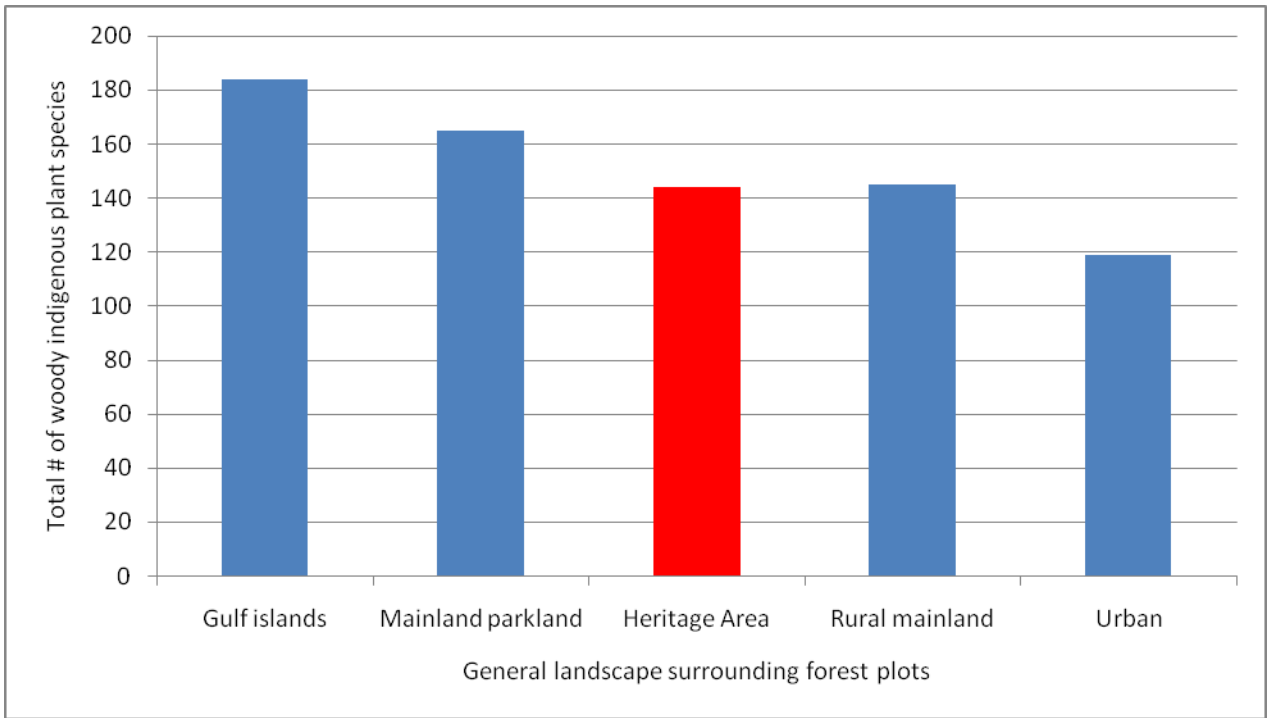

Figure 11 Total number of woody indigenous plant species recorded in all plots, by general landscape character, in the Auckland Region.

Change before 2008

The total number of indigenous woody plant species in the Heritage Area has probably remained fairly constant over the last few hundred years. This is because while many species have been dramatically reduced in coverage (e.g. kauri and associated species), they have still retained pockets of habitat throughout; this is probably true for most woody species. However, total species diversity, as measured by the plot network (had these been around in historic times), would probably have showed a decline through the 1800 – 1960 period as more species diverse forest was replaced by seral communities. Followed by an increase in diversity from 1960 onwards after cessation of logging and burning; as scrub has slowly reverted to more species rich forest.

Change 2008 – 2013

Baseline data was collected throughout the period 2009 – 2011 and will continue until 2013; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to forest vegetation in general (indicators F1 and F2) and there have been no new weed incursions.

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report.

The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.12 Indicator F10: Average species diversity of indigenous plants

Summary

Average species diversity looks at the changes in the diversity of woody plant species in individual plots, as opposed to the total of all woody species across all plots. This allows Auckland Council to track changes to species diversity that might be occurring in specific parts of the Heritage Area; these changes would not be evident in indicator F9. Interpretation of this indicator is very important, as it is possible for a plot to 'lose' indigenous woody species due to perfectly natural ecosystems changes (e.g. pioneer species are shaded out as the forest canopy grows taller and thicker).

Figure 12 presents the average number of woody native species/plot, for forest plots from a variety of locations throughout the Auckland Region. The Heritage Area forest is the most diverse of the

five groupings, with more than 10 extra species (on average) per plot than urban forest. This highlights the fact that much of the Waitakere Ranges is characterised by (relatively) more mature, species diverse and unmodified rain forest, compared with other forests in the region.

2008 value	2012 value	Change
N/A	Average of 31 different indigenous plant species/ plot	No change data available, but see Figure 12 for regional comparisons

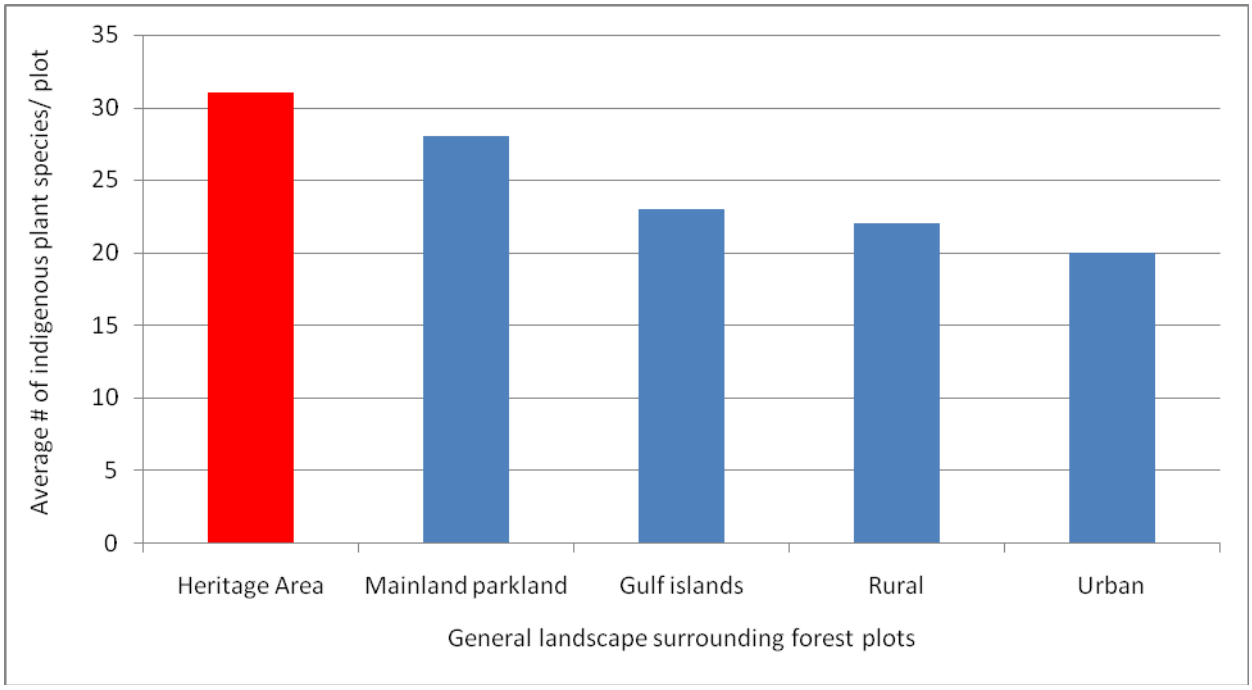

Figure 12 Average number of woody indigenous plant species recorded in forest plots, by general landscape character, in the Auckland Region.

Change before 2008

The total number of indigenous woody plant species in the Heritage Area has probably remained fairly constant over the last few hundred years. This is because while many species have been dramatically reduced in coverage (e.g. kauri and associated species or swamp forest tree species such as kahikatea and swamp maire), they have still retained pockets of habitat throughout; this is probably true for most woody species. However, average species diversity would probably have showed a decline through the 1800 – 1960 period as more species diverse forest was replaced by seral communities. Followed by an increase in diversity from 1960 onwards after cessation of logging and burning; scrub has slowly reverted to more species rich forest again.

Change 2008 – 2013

Baseline data was collected throughout the period 2009 – 2011 and will continue until 2013; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the species diversity of indigenous woody plants over period 2008 – 2012, as there were no major disturbances to forest vegetation in general (indicators F1 and F2) and there have been no new weed incursions.

How change will be monitored 2013+

This indicator will be retained, and will have a larger and more accurate dataset to draw on for the Act's 2018 monitoring report. The initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 forest plots in the Heritage Area is completed. For the 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data (i.e. change in individual plots over a five year period) for around 80% of the forest plots in the Heritage Area.

10.7.13 Indicator F11: Change in avian conspicuousness in forest and scrub habitat

Summary

The representation of birds is measured using five-minute bird counts (5MBC) (Dawson and Bull 1975) in locations throughout the Heritage Area. Five-minute bird counts are a common technique used in New Zealand to determine the relative conspicuousness of birds (Spurr and Powlesland 2000), and which may be used as an indicator of ecosystem health (Envirologic Limited 2007). The data for Indicator F11 have come from 5MBCs conducted at all the forest monitoring plots in the Heritage Area (Figure 13) as well as those counts made by Tim Lovegrove and Kevin Parker who perform 5MBCs each summer in a variety of locations throughout the forested areas of the Heritage Area (Figure 14).

2008 value	2012 value	Change
See text below	See text below	Change data unavailable (see below)

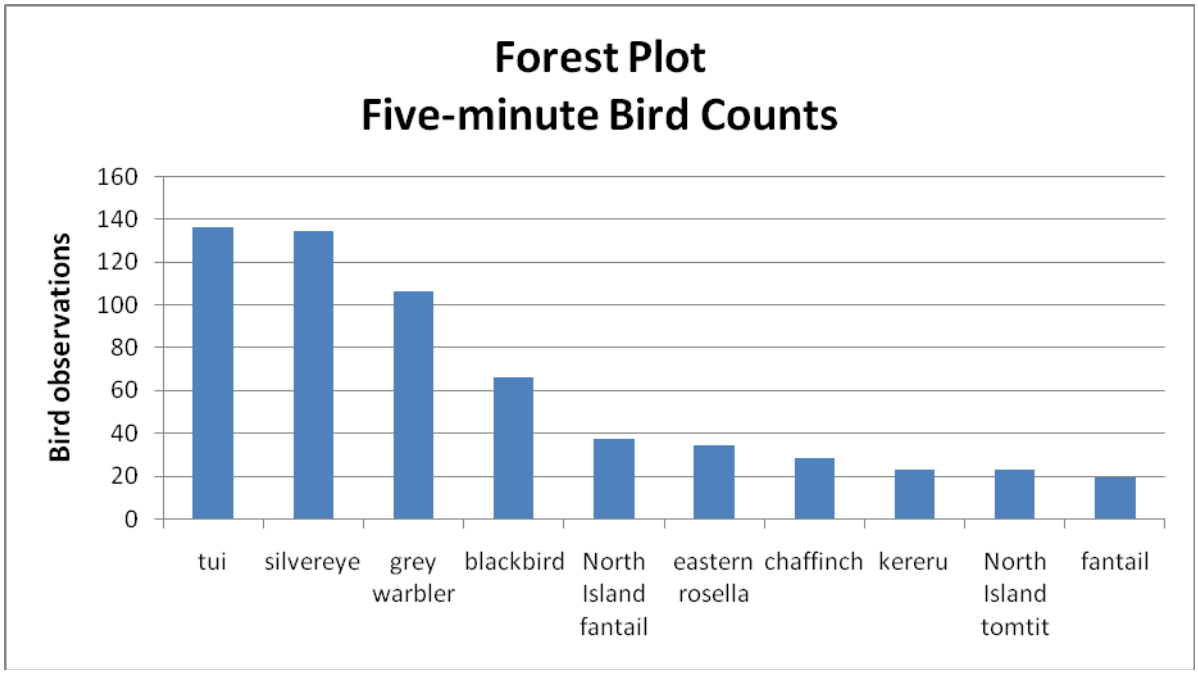

Figure 13 The ten most common bird species observed from five-minute bird counts conducted at forest plots within the Heritage Area during November to December of the years 2009-11 as part of the Auckland Council regional monitoring programme.

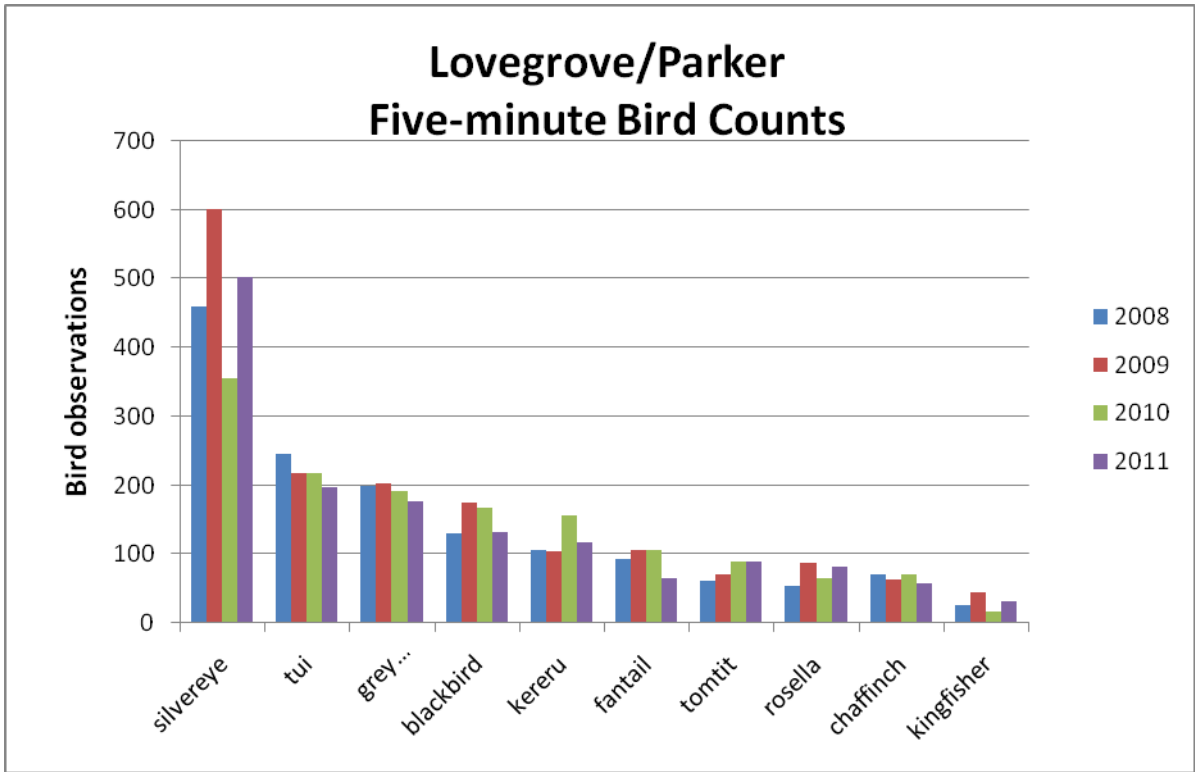

Figure 14 The ten most common bird species observed from five-minute bird counts conducted at forest areas within the Heritage Area during the summer seasons of 2008-11 by Tim Lovegrove and Kevin Parker.

Change before 2008

A described in the introduction section of this report, there have been significant vegetation changes in the Heritage Area up to the 1940's, but more recent times have seen the gradual increase in the quantity and quality of native ecosystems in the Heritage Area. The bird life would be expected to increase with the restoration of these ecosystems. Although not directly comparable to the bird data used for this indicator due to location and temporal differences in design, previous surveys in the Waitakere Ranges indicate similar trends in avian conspicuousness with high numbers of tui, silvereye, and grey warbler observed at most sites (Chapman and Alexander 2004, Envirologic Limited 2007).

Change 2008 – 2013

Bird populations are known to vary year to year (as is visible in Figure 14) in response to wide variety of environmental fluctuations and hence it is prudent to assess changes over a minimum of several years to ascertain the major trends in avian fauna. Once the full 5-year regional forest programme has been completed in 2013 and hence baseline bird data will be available, future repeat monitoring will be able to indicate what major changes in birds are occurring. It is reasonable to assume given the consistent if not increased management practices in the area (e.g. Ark in the Park, etc – Section 7 above) that avian representation would have remained relatively static during this period. The bird data in Figure 13 and Figure 14 indicate that the majority of bird observations in the Heritage Area over this time period are from indigenous species, which may reflect the high quality habitat in this area (as the forest vegetation indicators above illustrate). These results were similar to those found in a bird survey conducted in February 2010 at a number of parks a reserves in the former Waitakere City Council boundary (several which were within the Heritage Area) and who also found the top three most conspicuous species to be silvereye, tui and grey warbler (Boffa Miskell Limited 2010).

How change will be monitored 2013+

As described above, the initial establishment/measurement of forest plots in the Heritage Area will continue until the full complement of c.50 plots in the Heritage Area is completed. All forest plots will continue to have 5MBCs conducted and hence for the Act's 2018 reporting deadline Auckland Council will be able to provide initial measurement data for all plots, and re-measurement data for around 80% of the forest plots in the Heritage Area. A more comprehensive and quantitative avian assessment will be accomplishable with these new data. Auckland Council are also planning to research and explore alternative bird survey techniques throughout the regional monitoring programme, such as the use of acoustic monitoring.

10.8 Wetland ecosystem (W) indicator results

10.8.1 Introduction

Wetlands are important for the wide range of different environmental, economic, biodiversity and cultural benefits they provide. However despite this, historical loss of wetland habitat has been very high in many parts of the Auckland Region. Auckland Regional Council (2009) provided estimates of the proportion of wetlands lost to draining and clearance. Only around 4% of Auckland's freshwater wetland ecosystems remain. Their high values and history of past clearance make wetlands of particular interest to the Council and community. In recognition of this, wetlands have been given there own section and set of specific indicators in this report (Table 18).

Table 18 Wetlands in the Heritage Area.

Name Size		Brief description
Whatipu duneland wetland complex	480 ha	Large, complex and dynamic wetland system comprising a mosaic of dunelands, ephemeral, intermittent and permanent lagoons, and freshwater, brackish and saline swamps, bogs and mires. Feed by the Parahaha Valley Stream/wetland and other smaller watercourses. Plot based condition and biodiversity indicators for this wetland will be available for the Act's 2018 monitoring report.
Te Henga wetland	210 ha	The largest single wetland in the Auckland Region. Te Henga wetland occupies the flat valley bottom of the Waitakere River and one of its main tributaries. Vegetation is mostly higher fertility 'swamp' communities dominated by raupo, willow, kuta and some areas of open water
Parahaha Valley wetland	2.5 ha	'Raupo swamp' wetland surrounding the lower reaches of the Parahaha Stream caused by dune sands damming the stream exit and allowing water to pool in the valley behind the dam
Tasman View Road wetland	3.1 ha	Large, raupo dominated wetland in a shallow depression in the Holocene age sand dune country at Behtell's/Te Henga. The wetland drains into the Waiti Stream (which drains Lake Wainamu). It was probably deeper and contained more open water in the past, but has filled in and dried out over the years.
Lake Wainamu	15.2 ha	Lake Wainamu is a dune lake that formed during the last 6,500 years when the Wainamu Stream Valley was

Name	Size	Brief description
	(3.6) ha	dammed by dunes of sand blown inland. While the lake is quite large, wetland associations are confined to fringing vegetation around the margins of the lake where the water depth allows emergent wetland plants to grow. The figure in brackets is the approx amount of fringing wetland vegetation around Lake Wainamu
Coulter Road wetland	1.5 ha	Raupo dominated wetland(s) associated with two water supply dams that have been created in the upper Waimoko Stream (a tributary of Swanson Stream/Henderson Creek). The wetlands extend over several properties and have a mix of agricultural land and forest/scrub around their margins
Glenesk Road Wetland	0.8 ha	High fertility, swamp style wetland on waterlogged alluvial terraces beside the lower reaches of the Maungaroa Stream. This site would have been much larger but wetland vegetation on most of these terraces has been cleared in the past to and converted to pasture, gardens and house sites
Lake Kawaupaka	10.3 ha (0.1) ha	Dune lake similar in age and origin to Lake Wainamu, but Lake Kawaupaku is deeper, closer to the coast and wholly privately owned. There are few areas on the lake margin shallow enough to support wetland vegetation and only a small amount (c. 0.1 ha) is present at this site
Lake Waiataru	0.6 ha	Small, shallow dune lake just 300m or so from the coast at the end of Bethells Road. A few very small patches of wetland vegetation evident, mostly open water
TOTAL	701.6 ha	

10.8.2 Indicator W1: Total wetland area

Summary

There have been no significant changes in the total area of freshwater habitat – e.g. through new wetlands being created or large areas of existing wetlands cleared – between 2008 and 2012. There has been a small overall loss of wetland habitat through marginal drying and encroachment of 0.2 ha or 0.03% reduction in area. If this same rate of clearance continued for the next 100 years the total loss of wetland vegetation would still be <<1% of the total. Therefore, while the loss of any wetland vegetation is undesirable, this rate of loss is sustainable in the medium term at least.

Change before 2008

The total area of freshwater wetland habitat in the Heritage Area has almost certainly increased from its pre-human extent. This is because Whatipu wetland complex – at around 480 ha[10] the largest wetland in the Auckland Region – has largely formed as the result of land clearance in the Manukau Harbour and Waikato River catchments leading to increased sediment deposition at Whatipu.

Most of the Heritage Area is rugged and steep in nature, and therefore largely devoid of habitat suitable for wetlands. The main exception to this is Te Henga/Bethell's Wetland, a very large (in Auckland terms) swamp wetland that occupies the flat, broad floodplain of the lower Waitakere River. Unlike most similar wetland systems in other parts of the Auckland Region, Te Henga wetland is still largely intact with perhaps 85% of its original extent remaining. The fringe of coastal wetlands along the ocean and (especially) Manukau Harbour coastlines has probably also remained largely unchanged; although mangroves and saltmarsh may have increased response to increased sedimentation from the changing land use. Some of these coastal wetlands also lie outside the boundary of the Heritage Area.

No changes in the amount of wetland habitat in the Heritage Area were recorded between LCDB2 (2001) and LCDB3 (2008)

Change 2008 – 2013

Only a very small reduction (0.2 ha) in the area of wetland vegetation was recorded; see indicator W2 below for more details.

2008 value	2012 value	Change
702.2	702.0	0.2 ha (0.03% reduction)

[10] The 480 ha figure includes substantial areas of dry duneland vegetation, although there is probably over 300 ha of dune lakes, freshwater reedland, sedgeland and rushland, and saline rushland wetland vegetation at this site.

How change will be monitored 2013+

The external boundaries of all the wetlands identified in the 'Wetlands in the Heritage Area' table above have been digitized and recorded in the Council GIS system. These boundaries have been determined in the field and therefore the Auckland Council now has an accurate map of the extent of all freshwater wetland vegetation in the Heritage Area (i.e. as at summer 2012/13). Prior to the 2018 reporting deadline, the boundaries of wetlands will be re-surveyed in the field and the 2018 extend compared to the 2012/13 extent.

10.8.3 Indicator W2: Loss or gain of wetland habitat (area and %)

Summary

There has been negligible to no loss of freshwater wetland habitat, via human induced activity such as draining or active clearance, within the Heritage Area over the last five years. Tasman View Road wetland appears to have shrunk in size (c.4% reduction for this individual wetland) and the surrounding pasture appears drier. However, because this wetland is relatively small, the overall percentage loss for the Heritage Area as a whole is small. There has probably also been some additional turnover of freshwater wetland habitat (c.0.15 ha) through natural, dynamic processes.

Indicator	Area habitat lost (ha)	Percentage loss (%)
Loss of wetland habitat	0.1 ha	0.01%

Change before 2008

As outlined in the introduction to this section, the extent of wetlands has been greatly reduced throughout New Zealand over the past 150 years. However, the rugged topography and landforms of the Waitakere Ranges – which has protected them from large scale clearance for farmland and housing - mean that there has probably been a relatively low historical loss of wetland habitat within the Heritage Area, compared with other parts of the Auckland Region.

The largest amount of change is likely to have been in the two largest wetland systems; Bethells/Te Henga and Whatipu wetlands. However, most of this change is the result of natural processes and/or occurred before the middle of the 20th century. Whatipu has been rapidly accumulating 99sediment since the 1940s and the total area of wetland vegetation, ponds etc. is likely to have dramatically increased in that time. Bethells/Te Henga wetland was recently (May 2012) field surveyed, and a vegetation and weed map prepared. There were no obvious changes in grey willow distribution, wetland vegetation composition or wetland size between late 2007/early 2008 to late 2010.

The topography surrounding Tasman View Road wetland, Coulter Road wetland and Glenesk Road wetland suggests that these wetlands may have been larger in the past, but were drained to create more pasture. While it is not clear exactly when the clearance occurred, it was certainly well before 2008.

Change 2008 – 2013

Local expert knowledge and time series aerial photographs (from late 2007/early 2008 to late 2010) were used to determine of any of the wetlands identified in 0 had lost/gained wetland habitat in the first five year monitoring period of the Heritage Area (2008 – 2013). Figures for % change are based on the total wetland area indicator (W1), this information is summarized in Table 19.

Table 19 Change in size of freshwater wetlands within the Heritage Area 2008-2013.

Wetland name	Summary of change	Area of wetland habitat lost or gained (% loss, % gain)
Whatipu duneland wetland complex	This system is highly dynamic and there is likely to have been substantial turnover of different vegetation types within the wetland. However the overall extent of the wetland complex has not changed	0 ha (0%)
Te Henga wetland	No change noted	0 ha (0%)
Parahaha Valley wetland	No change noted. High level of protection as site is part of Waitakere Ranges Regional Park	0 ha (0%)
Tasman View Road wetland	A small area (approx 0.1 ha) of wet pasture and rushland on the margin of the wetland appears to have dried out somewhat – there has been a reduced dominance of rushes and an increase in pasture dominance. Pasture in the hollow that feeds this wetland has also shifted from rush/grassland to pure grassland, another indicator of drying out/habitat loss	0.1 ha (3%)
Lake Wainamu	Approx 0.15 ha of wetland vegetation that was present in 2008, is not visible in 2012 aerial. However, this loss is due to natural fluctuations in water levels, rather than habitat clearance	0.15 ha[1] (4%)[1]
Coulter Road wetland	Reduction in open water from 2008 – 2012, but no visible change in wetland extent. Lower	0 ha (0%)

Wetland name	Summary of change	Area of wetland habitat lost or gained (% loss, % gain)
	water level could be a result of silting, or just an effect of the natural water cycle here. Some of the wetland vegetation at this site may have been induced by the damming of the stream to create open water ponds.	
Glenesk Road Wetland	No major changes noted. There is the suggestion of some replacement of pasture dominated grassland with rush and reed species more typical of wetlands, but there is no other data to support this change	0 ha (0%)
Lake Kawaupaka	No change noted	0 ha (0%)
Lake Waiataru	No change noted	0 ha (0%)

1 = Change in wetland habitat due to natural fluctuations is not reported as wetland loss for the purposes of this indicator

How change will be monitored 2013+

The external boundaries of all the wetlands identified in Table 18 have been digitized and recorded in the Council GIS system. These boundaries have been determined in the field and therefore the Auckland Council now has an accurate map of the extent of all freshwater wetland vegetation in the Heritage Area (i.e. as at summer 2012/13). Prior to the Act's 2018 reporting deadline, the boundaries of wetlands will be re-surveyed in the field and the 2018 extend compared to the 2012/13 extent.

10.8.4 Indicator W3: Native: exotic plant biomass ratio in monitored wetlands

Summary

The data used for this indicator is from recently established plots and only baseline measures are available for this report. This baseline will be used to monitor future change. However, it is clear from comparing native biomass percentages of wetlands across the Auckland Region (Figure 15) that wetlands in the Heritage Area are relatively high quality in terms of their dominance of native plants (i.e. naturalness).

2008 value	2012 value	Change
N/A	81%	No change data available, but see Figure 15 for regional comparisons

The wetlands in the Heritage Area are quite varied in terms of their topography, nutrient input and hydrology, and the different types of wetlands are vulnerable to different weeds. However, the general low intensity land use through much of the WRHA (i.e. relatively little urban growth, light industrial or high input/ production farming) means that many of the wetland pressures common through the rest of the region are absent or reduced in the Heritage Area. However, the two biggest wetlands in the WRHA are vulnerable to invasion by some key pest weed species; pampas and blackberry at Whatipu, and grey willow and crack willow at Bethells - Te Henga. Use of detailed vegetation maps and a network of 15 – 20 plots in each of these two wetlands will allow weed density to be tracked and (hopefully) acted upon if the penetration of weed species begins to increase.

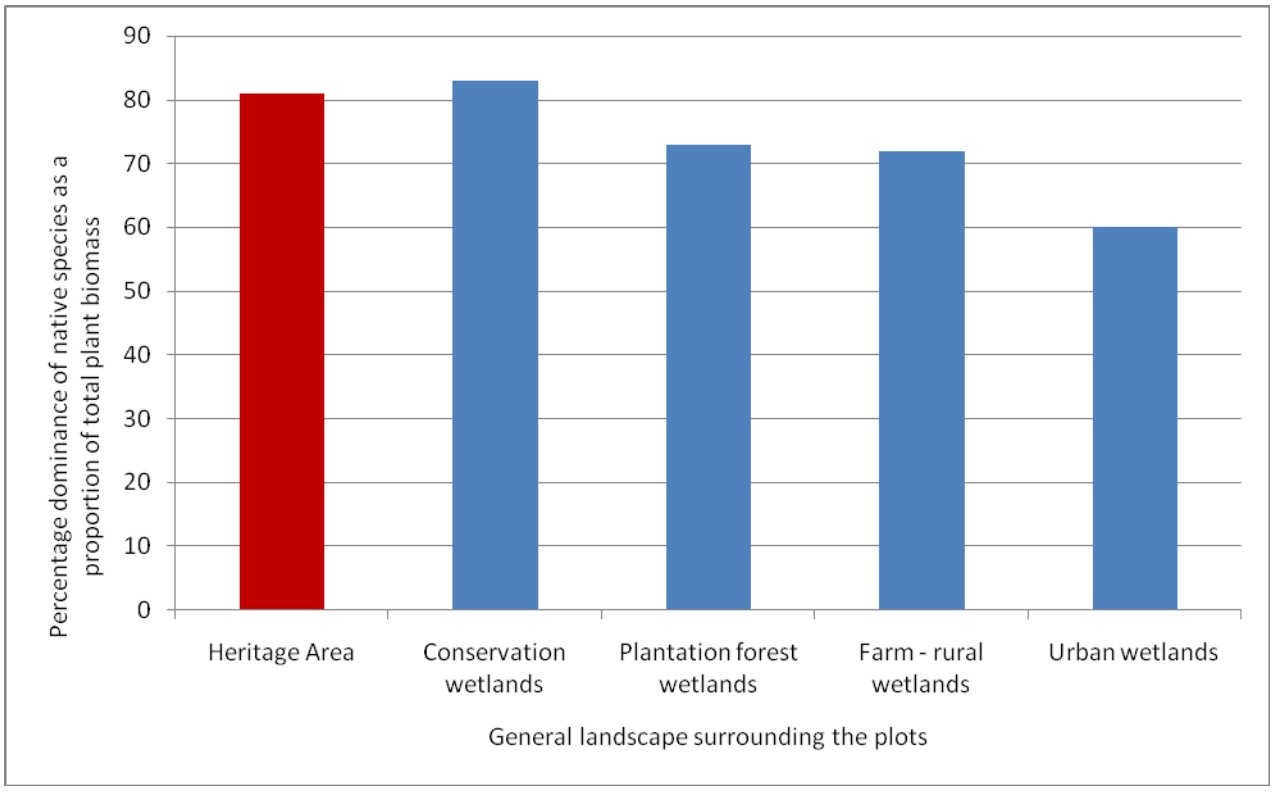

Figure 15 Percentage dominance of native plants in wetlands in the Heritage Area in comparison to wetlands in other parts of the Auckland Region.

Change before 2008

Wetland ecosystems are more vulnerable to invasion by exotic plants than forest or scrub ecosystems. It is likely that the proportion and diversity of exotic plants in Waitakere wetlands has increased through the 20th century as the presence/seed rain of exotic grasses and herbs introduced for agriculture has grown in the surrounding landscape.

Change 2008 – 2013

There is no evidence to suggest there has been an increase in the 'weediness' of wetlands in the Heritage Area over the past five years, compared with the period before 2008. The general seed rain of weeds and other exotic species into the various wetland systems from the surrounding landscape is likely to have been stable for several decades now, as land management (i.e. Regional Park vs. farm etc.) and ownership has been quite stable since the mid 1980's. There are no records of new wetland weed introductions in this period.

How change will be monitored 2013+

Data on the relative biomass of native vs. exotic plants will continue to be collected for wetland plots within the Heritage Area over summer 2013 and 2014. Once all wetland plots are completed there will be a total of c.40 wetland plots in the Heritage Area, including 14 and 20 plots in the Te Henga and Whatipu wetland complexes respectively. It is planned to measure each wetland plot at five year intervals in future. The 2018 Act monitoring report will therefore include 1st re-measurement data for around 80% of the wetland plots

10.8.5 Indicator W4: Average native: exotic plant biomass ratio in monitored wetlands

Summary

Indicator W3 summarized the total native: exotic biomass ratio across all plots. Total value indicators are more sensitive to changes in individual plots than averages because values are summed across all plots. This means that a dramatic decrease in indicator W3 (i.e. an increase in exotic plants at the expense of native ones) could be the result of an 'across the board' increase in the importance of weeds in all plots OR could be the result of a big increase in weeds in one or a handful of locations with the majority of other locations having no-change (or even small improvements) in their native: exotic balance.

This indicator (W4) provides more information about the distribution of any changes in weed dominance among the various wetland plots. Similar values for indicators W3 and W4 suggests that the negative impacts of exotic encroachment are equally shared between the various sample

locations across the network. A wide divergences between these two figures show that reductions (or improvements) in this indicator are occurring in a subset of plots.

The data used for this indicator is from recently established plots and only baseline measures are available for this report. This baseline will be used to monitor future change. However, it is clear from comparing average native biomass percentages of wetlands across the Auckland Region (0) that wetlands in the Heritage Area are relatively high quality in terms of their dominance of native plants (i.e. naturalness).

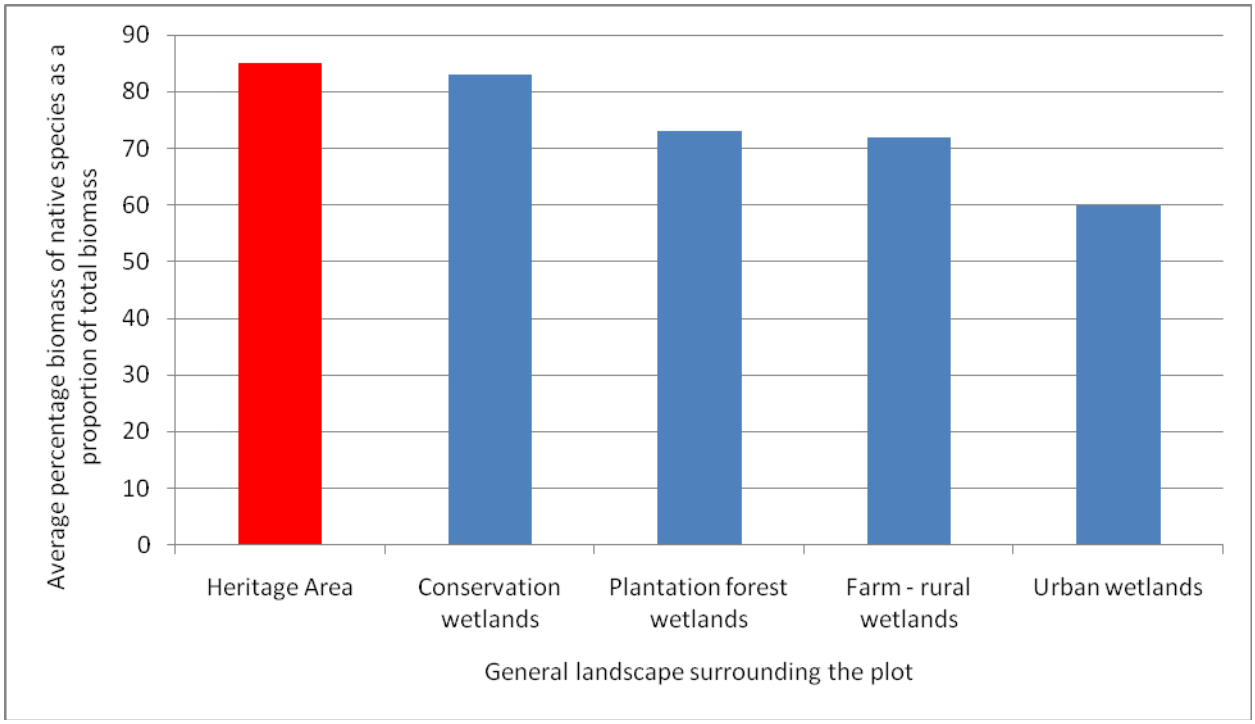

Figure 16 Average % dominance of native plants in wetlands in the Heritage Area in comparison to wetlands in other parts of the Auckland Region.

Change before 2008

Wetlands in the Heritage Area, like most wetland types in New Zealand, are quite vulnerable to invasion by exotic plants. It is interesting to contrast the average native: exotic biomass ratio for wetlands in the Heritage Area (60% - 82%, average of 81%, Figure 16), with that of forest and scrub plots (75% - 100%, average c.98%, Figure 6). Their higher light environment, and constant turnover of new surfaces etc. due to their dynamic nature, can favour exotic species over natives and provide regular sites for new invasions.

There is very little quantitative data on the native vs. exotic components of wetlands in the Heritage Area before 2008, therefore we can only really guess at likely changes in the balance between

these two groups of species. Changes within the Heritage Area are likely to have mirrored those in other parts of the region. That is, wetlands in locations where there has been a high loss of vegetation and hydrological modification in the catchment have fared worse than those where land use has left surrounding vegetation and natural hydrological processes largely intact. The native: exotic biomass ratio of Heritage Area wetlands is among the best in the Auckland Region due to a general lack of many of these external pressures.

Change 2008 – 2013

2008 value	2012 value	Change
N/A	85%	No change data available, but see Figure 16 for regional comparisons

Baseline data was collected throughout the period 2010 – 2012 and will continue until 2014; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to wetlands themselves (indicators W1 and W2) and there have been no new weed incursions.

How change will be monitored 2013+

The initial establishment/measurement of wetland plots in the Heritage Area will continue for the next two years (scheduled for Feb/Mar 2013 and 2014) until the full complement of c.40 plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data for around 60% of the wetland plots in the Heritage Area.

10.8.6 Indicator W5: Average native: exotic plant frequency in monitored wetlands

Summary

Comparing the biomass of exotic and indigenous wetland plants (c.f. indicators W3 and W4) is an important indicator of the naturalness of a wetland system. This indicator looks at the frequency of weed species from data collected in nine 2m x 2m plots nested within the larger plot at each sample location. Therefore frequency data give some information on the spatial distribution of weeds within plots. That is, are the weeds clumped in one part of the plot, or are they spread throughout. Decreases in this indicator while W4 stayed constant (or showed a smaller decrease) would imply that weed species were starting to spread at low density throughout the plot network.

The data used for this indicator is from recently established plots and only baseline measures are available for this report. This baseline will be used to monitor future change. However, it is clear from comparing the averages for this indicator from different types of wetlands across the Auckland Region (Figure 17) that wetlands in the Heritage Area are relatively high quality in terms of their dominance of native plants (i.e. naturalness). That is, more than 60% of all plants in plots are

native species. This compares to 40% in urban wetlands, where weedy wetland plants are dominant over natives.

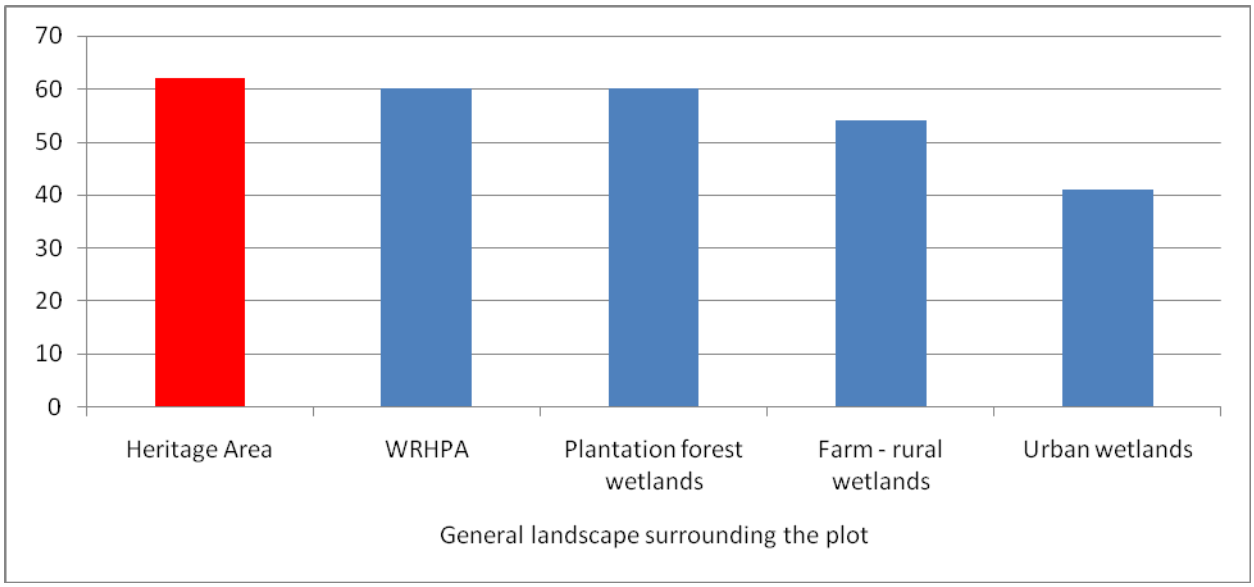

Figure 17 Average % frequency of native plants in wetlands in the Heritage Area in comparison to wetlands in other parts of the Auckland Region.

Change before 2008

See comments for indicator W4. Changes within the Heritage Area are likely to have mirrored those in other parts of the region. That is, wetlands in locations where there has been a high loss of vegetation and hydrological modification in the catchment have fared worse than those where land use has left surrounding vegetation and natural hydrological processes largely intact.

Change 2008 – 2013

2008 value	2012 value	Change
N/A	62%	No change data available, but see Figure 17 for regional comparisons

Baseline data was collected throughout the period 2010 – 2012 and will continue until 2014; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to wetlands themselves (indicators W1 and W2) and there have been no new weed incursions.

How change will be monitored 2013+

The initial establishment/measurement of wetland plots in the Heritage Area will continue until the full complement of c.40 plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data for around 60% of the wetland plots in the Heritage Area.

10.8.7 Indicator W6: Average native: exotic weed plant frequency in monitored wetlands

Summary

The exotic component of wetlands is a key component of wetland health, and indicators W3, W4 and W5 include all exotic plants in the exotic species group, irrespective of how weedy they are. Indicator W6 recognizes that some exotic plants have a much greater effect on indigenous wetland ecosystems than others. Populations of many different exotic herbs and grasses often take up space within a wetland that could be occupied by native herbs, grasses, and rushes. However, not all these exotic species are aggressively weedy. That is, they do not grow into large woody plants that are likely to grow quickly and/or suppress native plant species in lower tiers, or they do not form dense swards that spread and actively displace native wetland plants form the system.

In contrast, the invasion of important wetland weeds species such as crack willow, grey willow, pampas, Mercer grass or reed sweet grass can have a much greater impact on the indigenous component of wetlands. These species are capable of completely altering the vegetation structure (e.g. in the case of willow turning a rushland into a forest) and/or displacing native plants by smothering and out-competing them. The definition of a 'weed' for the purposes of this indicator was any exotic plant species that is a known ecological weed species of wetland ecosystems.

The data used for this indicator is from recently established plots and only baseline measures are available for this report. This baseline will be used to monitor future change. However, it is clear from comparing the averages for this indicator from different types of wetlands across the Auckland Region (Figure 18) that wetlands in the Heritage Area have a relatively low frequency of exotic wetland weed species.

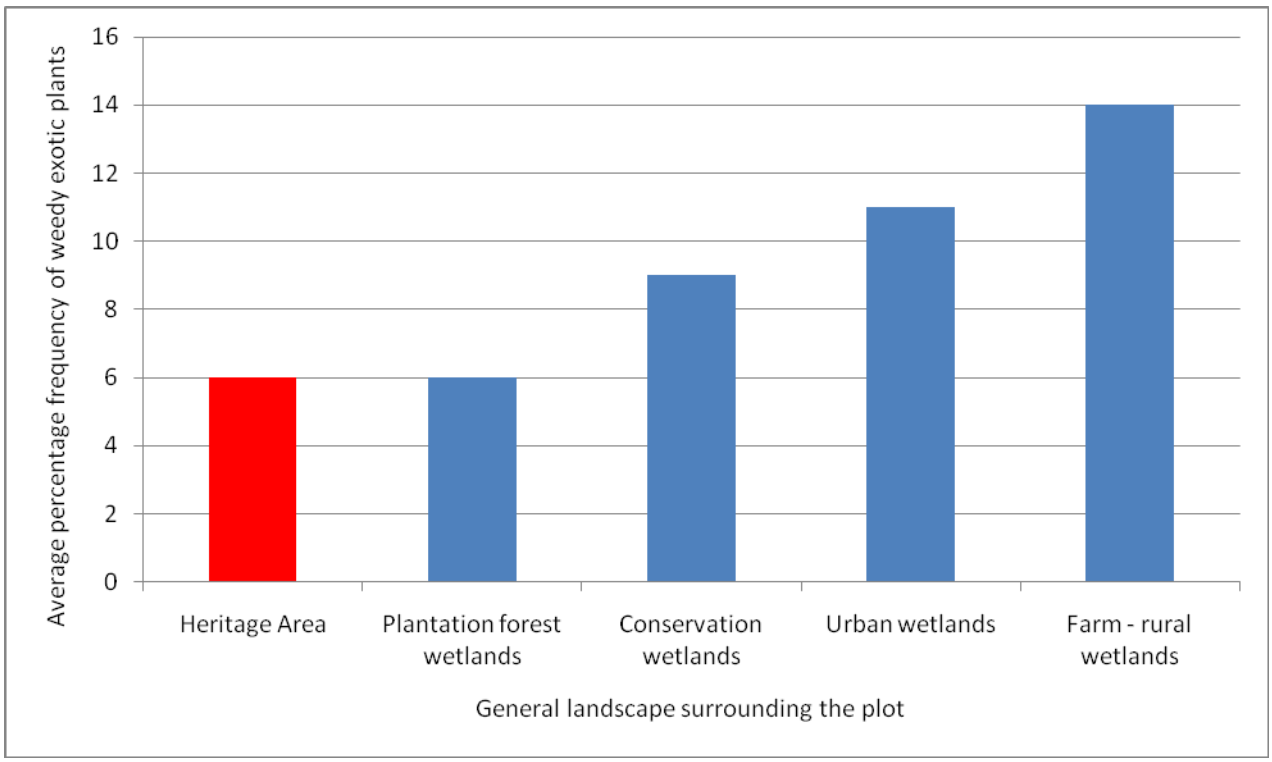

Figure 18 Average % frequency of weedy exotic plants in wetlands in the Heritage Area in comparison to other parts of the Auckland Region.

Change before 2008

There is very little quantitative data on the native vs. exotic components of wetlands in the Heritage Area before 2008, therefore we can only really guess at likely changes in the balance between these two groups of species. Changes within the Heritage Area are likely to have mirrored those in other parts of the region. That is, wetlands in locations where there has been a high loss of vegetation and hydrological modification in the catchment have fared worse than those where land use has left surrounding vegetation and natural hydrological processes largely intact. The frequency of weedy exotic species in Heritage Area wetlands is among the best in the Auckland Region (Figure 18) due to a general lack of many of these external pressures.

Change 2008 – 2013

2008 value	2012 value	Change
N/A	6%	No change data available, but see Figure 18 for regional comparisons

Baseline data was collected throughout the period 2010 – 2012 and will continue until 2014; therefore there is no change data for this period. It is unlikely that there were any dramatic changes in the period 2008 – 2012, as there were no major disturbances to wetlands themselves (indicators W1 and W2) and there have been no new weed incursions.

How change will be monitored 2013+

The initial establishment/measurement of wetland plots in the Heritage Area will continue until the full complement of c.40 plots in the Heritage Area is completed. For the Act's 2018 reporting deadline the Council will be able to provide initial measurement data for all plots, and re-measurement data for around 60% of the wetland plots in the Heritage Area.

10.8.8 Indicator W7: Change in wetland condition index

Summary

Auckland Council's regional wetland monitoring programme is based around standard national approaches/methodologies that have been developed for wetland monitoring in New Zealand. Using national protocols ensures Auckland Council data collection is a best practice approach, and means Auckland data is comparable with other regional datasets and is easily aggregated for national reporting requirements. One of these national standards is the collection wetland condition data.

Wetland condition assesses the condition/state of a specific wetland using 14 semi-independent indicators of wetland health grouped into five broad categories (Clarkson et al. 2004). The indicators are based on major threats and stress factors known to damage wetlands. Each indicator component is scored on a scale of 0 to 5, with 5 representing the unmodified or best condition and 0 representing the most degraded condition. Five categories with a 0 – 5 score in each gives a possible score range of 0 – 25 for each wetland or wetland sub-component assessed. The average score of almost 22 for WRHA wetlands is very close to the maximum value of 25.

2008 value	2012 value	Change
N/A	21.9	No change data available, but see Figure 19 for regional comparisons

Change before 2008

As outlined in the introduction to this section, the extent of wetlands has been greatly reduced throughout New Zealand over the past 150 years. However, the rugged topography and landforms

of the Waitakere Range meant that much of this area is not suitable for farming or dense urban development. This in turn has meant that wetlands within the Ranges have probably suffered less clearance and reduction in condition than wetlands in other parts of the Auckland Region

Change 2008 – 2013

There are no measurements for change in wetland condition within the Heritage Area between 2008 and 2013. Systematic regional monitoring of wetlands only commenced in 2010 and therefore only baseline/first measurement data has been collected to date. Change data will available from February 2015, when re-measurement of the plots that were established in 2010 will commence. However, the regional wetland programme now has measurements from over 100 plots throughout the wider Auckland Region, and it is possible to compare condition scores for wetlands in the WRHP area with other parts of the Region. Figure 19 compares the average wetland condition score for Heritage Area wetlands, with wetlands in landscapes dominated by different surrounding land uses (conservation, rural, plantation forestry and urban). Average wetland condition scores for the Heritage Area are amongst the highest/ best in the Auckland Region.

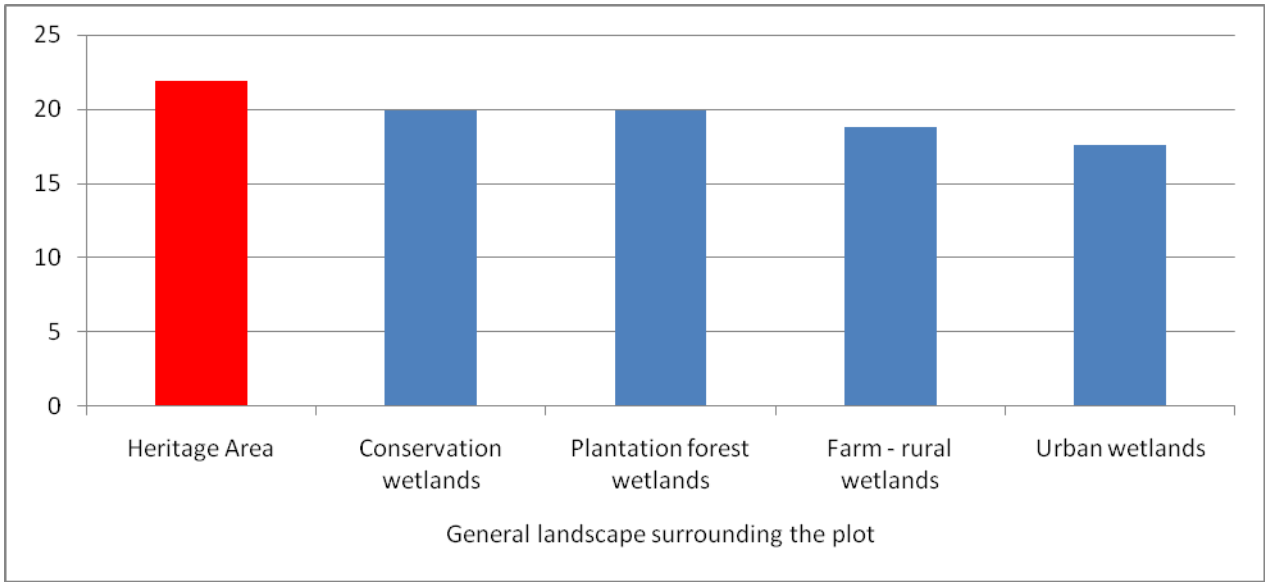

Figure 19 Average wetland condition index score (max score of 25, high scores denote better condition wetlands) for wetlands in the Heritage Area, compared with wetlands grouped by general landscape character from throughout the Auckland Region.

How change will be monitored 2013+

Data on wetland condition will continue to be collected until a total of c.40 wetland plots in the Heritage Area are complete. Including 14 and 20 plots in the Te Henga and Whatipu wetland complexes respectively. It is planned to measure each wetland plot at five year intervals in future.

The Act's 2018 monitoring report will therefore include 1st re-measurement data for around 80% of the wetland plots

10.8.9 Indicator W8: Change in wetland perimeter condition index

Standard national approaches/methodologies that have been developed for wetland monitoring in New Zealand include two main indices of wetland condition. Wetland condition index data is summarised in W9. The second main index is the wetland perimeter condition index; which looks at similar groups of threats (weeds, pests, plant dieback, stock access etc.), but assessments are targeted on the c.10m wide band of habitat around the wetland margin (i.e. the perimeter). Each indicator component is scored on a scale of 0 to 5, with 5 representing the unmodified or best condition and 0 representing the most degraded condition.

2008 value	2012 value	Change
N/A	21.7	No change data available, but see Figure 20 for regional comparisons.

Change before 2008

As outlined in the introduction to the wetland section, the extent of wetlands has been greatly reduced throughout New Zealand over the past 150 years. However, the rugged topography and landforms of the Waitakere Range meant that much of this area is not suitable for farming or dense urban development. This in turn has meant that wetlands within the Ranges have probably suffered less clearance and reduction in condition than wetlands in other parts of the Auckland Region

Change 2008 – 2013

There are no measurements for change in perimeter condition within the Heritage Area between 2008 and 2013. Systematic regional monitoring of wetlands only commenced in 2010 and therefore only baseline/first measurement data has been collected to date. Change data will available from February 2015. Figure 20 compares the average perimeter condition score for Heritage Area wetlands, with wetlands in landscapes dominated by different surrounding land uses (conservation, rural, plantation forestry and urban). Heritage Area wetlands appear to be much less affected by disturbance, weeds etc. around their perimeter, compared to wetlands in other parts of the region. This is not unsurprising given the relatively large size of Te Henga and Whatipu wetlands, and the fact that most remaining wetlands are on public reserves and are therefore surrounded by tracts of protected forest and scrub.

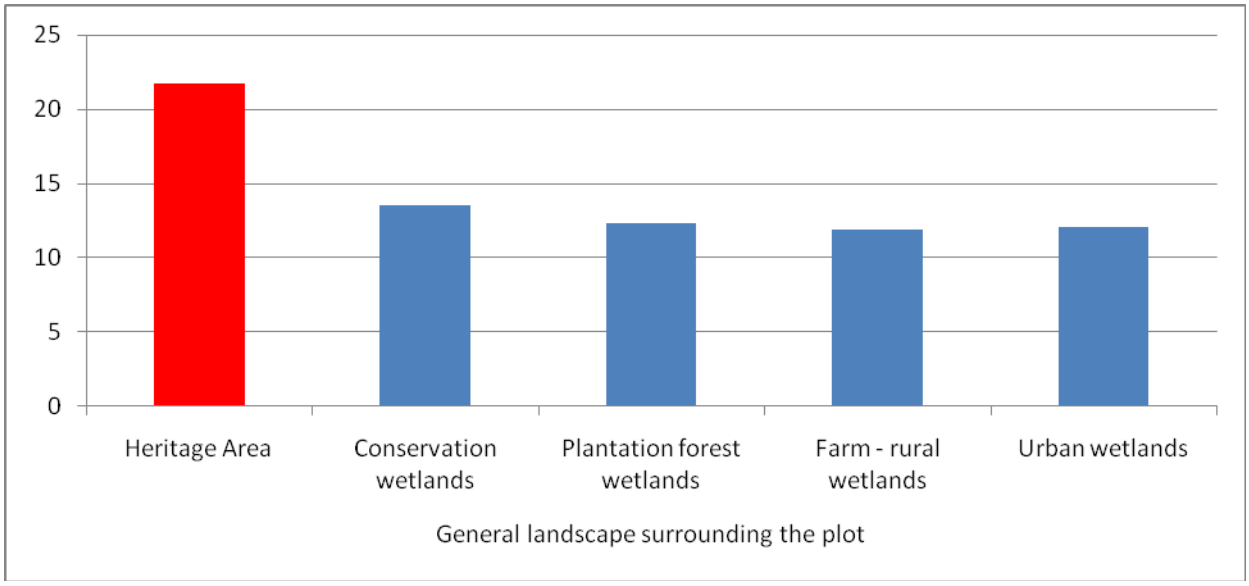

Figure 20 Average wetland perimeter condition index score (max score of 25, high scores denote better condition wetlands) for wetlands in the Heritage Area, compared with wetlands grouped by general landscape character from throughout the Auckland Region.

How change will be monitored 2013+

Data on wetland perimeter condition will continue to be collected for wetland plots within the Heritage Area over summer 2013 and 2014. Once all wetland plots are completed there will be a total of c.40 wetland plots in the Heritage Area, including 14 and 20 plots in the Te Henga and Whatipu wetland complexes respectively. It is planned to measure each wetland plot at five year intervals in future. The Act's 2018 monitoring report will therefore include 1st re-measurement data for around 80% of the wetland plots

10.8.10 Indicator W9: Change in avian conspicuousness in wetland habitat

Summary

Five-minute bird counts (5MBC) (Figure 21) and playback bird counts for three key wetland species (fernbird, spotless crake, banded rail) (Figure 22) are conducted at all regional monitoring programme wetland plots. As discussed above, these recently established plots are only baseline measures and hence no changes in avian conspicuousness in wetlands habitats are available for this report.

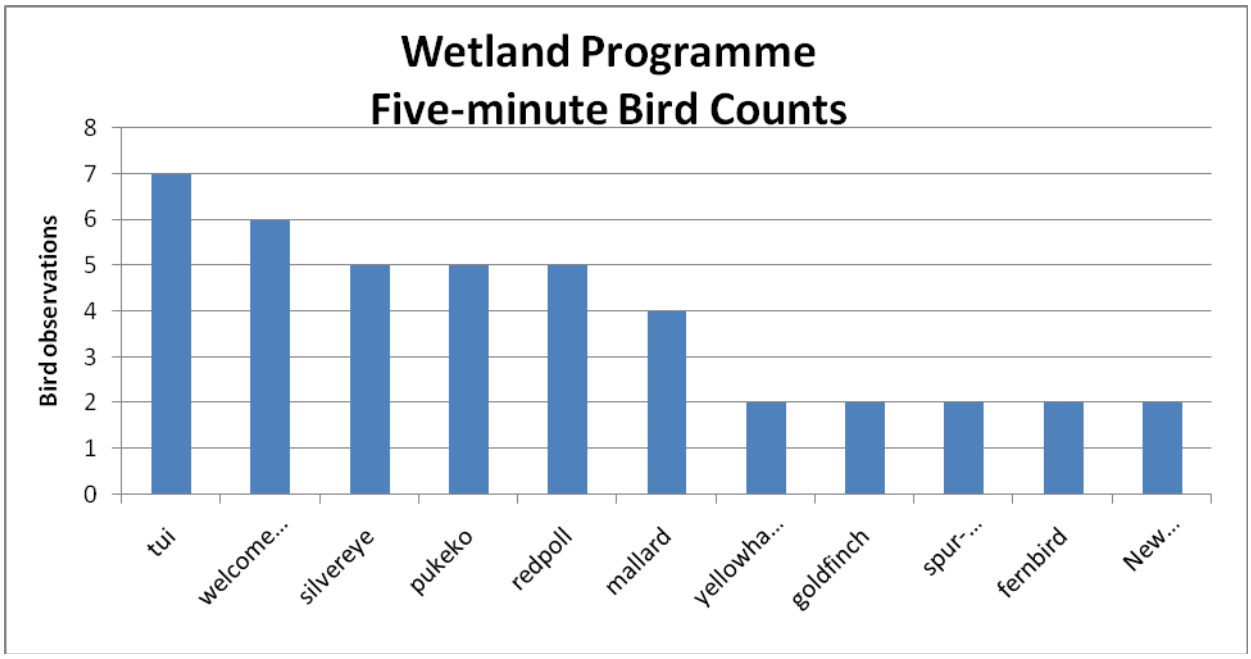

Figure 21 The eleven most common bird species observed from five-minute bird counts conducted at wetland plots within the Heritage Area during February to March of the years 2009-11 as part of the Auckland Council regional monitoring programme.

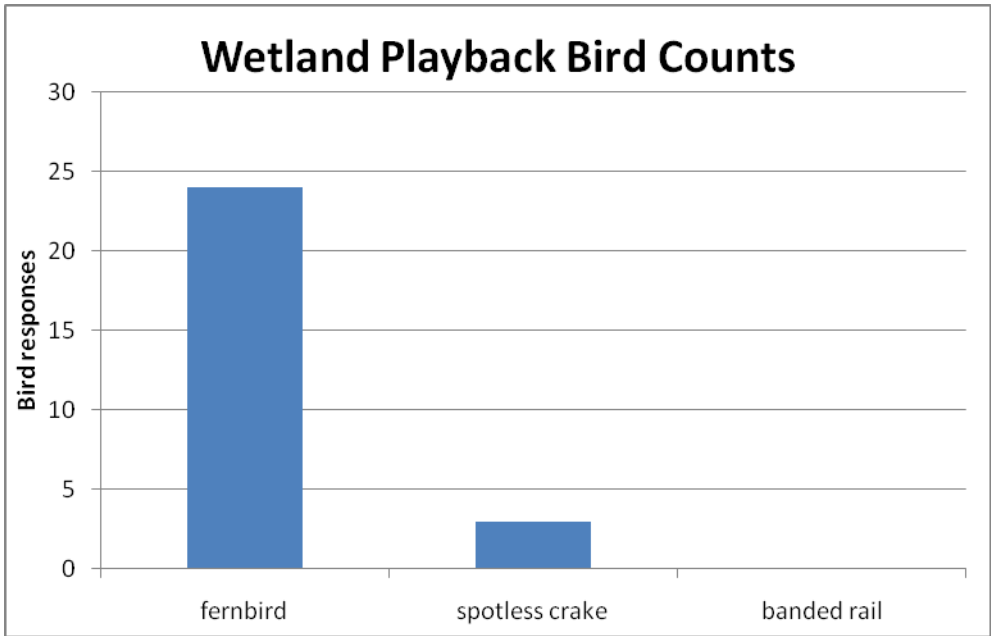

Figure 22 Presence of three key wetland bird species assessed from playback bird counts in wetlands in the Heritage Area.

Change before 2008

As mentioned above, wetland habitat in the Waitakere Ranges have remained relatively intact and hence presumably this would have been reflected in the avian fauna. No previous bird wetland

surveys are directly comparable to the bird data used for this indicator due to location and temporal differences in design, however noteworthy trends found in other bird surveys at Te Henga wetland was the similar finding of high bird conspicuousness of the native birds tui and silvereye and also the presence of fernbird and spotless crake (Alexander and Chapman 2004; Chapman and Alexander 2004).

Change 2008 – 2013

As mentioned above with regards to forest birds (Indicator F11) it is not prudent to assess bird changes over relatively short periods (i.e. several years) and hence the trends in bird conspicuousness need replication to confirm them. The five-minute bird counts conducted thus far at a subset of wetland plots planned for the full five year wetland programme (Figure 21) reveal the dominance of indigenous species (4 of the 5 most conspicuous species observed), which may reflect the high quality habitat in this area (as the wetland vegetation indicators above illustrate). The playback bird counts (Figure 22) revealed the fairly strong presence of fernbird and also some spotless crake observations. No banded rail was detected in any of the wetland plots surveyed.

How change will be monitored 2013+

All plots will continue to have 5MBCs and playback bird counts conducted and hence for the Act's 2018 reporting deadline the Auckland Council will be able to provide initial measurement data for all plots, and re-measurement data for around 80% of the wetland plots in the Heritage Area. A more comprehensive and quantitative avian assessment will be accomplishable with these new data. Auckland Council are also planning to research and explore alternative bird survey techniques throughout the regional monitoring programme, such as the use of acoustic monitoring.

10.9 Duneland ecosystem (D) indicator results

10.9.1 Introduction

Dunelands are dynamic but fragile ecosystems that form a key element of New Zealand's coastal environment/processes and provide critical buffering for inland habitat from heavy seas and wind. In the WRHA, dunes support important breeding habitat for a range of threatened bird species, including northern NZ dotterel, variable oystercatcher, NZ pipit and little blue penguin. Dunes also provide habitat for threatened plant species such as shore spurge (*Euphorbia glauca*) and sand tussock (*Poa billardierei*).

Nationwide, almost 90% of all duneland systems have been lost to a combination of residential development, forestry and agriculture (DoC & MfE 2007). Many of our remaining dunes are threatened by weeds such as marram grass, lupin and kikuyu, together with mammalian predators

and browsers. Approximately 2,577 ha of dune vegetation remain in the Auckland Region (15% of the original extent), of which around 1,806 are protected (ARC 2010).

The high ecological values of dunelands, their desirability as a place to live and play (i.e. flat land on the coast), their vulnerability to damage from a range of human impacts and their history of past clearance make dunelands of particular interest to the Council and community. Moreover, under the proposed National Policy Statement on biodiversity, local authorities are required to regard any indigenous vegetation associated with sand dunes as significant. In recognition of these factors, dunelands have been assigned their own section and set of specific indicators in this report.

The results presented in indicators D1 – D5 below are based on three main information sources:

1. A duneland habitat map for the Heritage Area. This was created as a desktop exercise (i.e. the boundaries have not been field checked) using aerial photographs, LIDAR contour data and soil and geological maps to map the extent of duneland habitat. Duneland habitat includes all areas with underlying sand dune geology, and therefore included areas of highly modified duneland that might have been covered in houses or exotic pasture. Duneland boundaries were digitized in GIS;

2. Vegetation cover of duneland habitat. Aerial photographs were used to classify duneland habitat into one of the following vegetation cover classes: native dune vegetation (largely intact dunes dominated by native species); degraded dune vegetation (dune invaded by weeds and/or coastal development); grassland with scattered shrubs/trees (highly modified areas of dunes that are managed for amenity); grassland with residential dwellings (highly modified areas characterized by mown grass and houses); pine (dunes planted in radiata pine forest). Vegetation boundaries were digitized in GIS.

3. Change in cover of vegetation, buildings and impermeable surfaces between 2008 and more recent (2012) aerial photography. Time series aerial photographs were compared to detect changes in built structures (removal and new construction), impermeable surface cover, and vegetation (clearance and regeneration of new habitat). Change and the type of change were digitized in GIS for later analysis.

10.9.2 Indicator D1: Total duneland area

Summary

The total duneland area of the WRHA comprises areas of indigenous dune vegetation, degraded dune vegetation (included residential dwellings within dune vegetation), grassland and scattered trees/shrubs, and pine plantation. In addition, freshwater wetlands at Whatipu and Pararaha have been included given they occur on a dune substrate. In total there are approximately 925 ha of

duneland habitat in the Heritage Area (Table 20). The overwhelming majority of this (c.80%) is found at Whatipu, where aggregation of sand over the last 60+ years has formed an extensive dunefield and wetland complex. The main secondary area of dunes is at Te Henga/Bethell's Beach (c.15%) with the remaining <5% of habitat scattered amongst a further ten much smaller patches of duneland along the exposed western coastline.

Table 20 Duneland habitat in Heritage Area.

Name	Approx size	Brief description
Whatipu duneland and wetland complex	735 ha	Whatipu comprises an expansive and largely intact mosaic of dunes, brackish and freshwater wetlands that are contiguous with terrestrial forest and shrubland.
Karekare Beach and duneland	14 ha	A moderate-sized area of largely intact dunes with scattered dwellings, bounded by steep coastal slopes and cliffs.
Piha Beach and duneland (north and south)	12.0 + 5.5 ha	Most of the dune habitat is highly modified by coastal development and weeds. The foredunes are the most intact part of the Piha duneland system, and are characterized by abundant spinifix and smaller amounts of pingao. Dune planting and weeding is carried out by a local community group.
Whites Beach	1.5 ha	A small isolated beach north of Piha with an area of unmodified duneland (some of which is privately owned) buffered by steep coastal slopes.
Anawhata	3.5 ha	This isolated beach contains a largely unmodified dune system bisected by a major watercourse. It is semi-contiguous with dunes at Parera Bay to the north.
Parera Bay	1.5 ha	Lies just to the north of Anawhata and contains a small area of unmodified dunes bounded by steep coastal slopes.
Wahirua Bay	1.5 ha	A very small, isolated beach south of Wigmore Bay that contains a small, unmodified area of duneland bounded by steep coastal slopes and cliffs.
Wigmore Bay	2.5 ha	An isolated beach south of Te Henga that contains a small, unmodified area of duneland bounded by steep coastal slopes and cliffs.

Name Approx	size	Brief description
Bethells Beach/Te Henga	140 ha	The site is characterized by extensive foredunes, two dune lakes, dune forest (indigenous and pine), residential dwellings, open grassland, and a large area of inland dunes within the Te Henga Scenic Reserve.
O'Neill Bay	5 ha	A small, but largely intact indigenous dune system.
TOTAL	922 ha	

Change before 2008

As outlined in the introduction to this section, dunelands have been greatly reduced throughout New Zealand over the past 150 years. However, the rugged terrain and exposed coastal conditions of the Heritage Area (which would have been formidable barriers to the establishment of agriculture), have most likely resulted in a relatively low historical loss of dunelands compared with other parts of the Auckland Region (particularly the east coast).

Change 2008 – 2013

Desktop analysis of time series aerial photographs revealed there had been some changes to landcover on duneland habitat between 2008 – 2013; including vegetation clearance (see indicator D3) and construction of new structures and roads (see indicators D4 – D5). However, none of these changes were judged to have destroyed the underlying dune geology and geomorphology. That is, the duneland habitat could be 'regenerated' by removing the structure, path etc. and re-planting native vegetation.

2008 value	2012 value	Change
921.5 ha	921.5 ha	0%

How change will be monitored 2013+

The external boundaries of all the dunelands identified in Table 21 have been digitized and recorded in the Council GIS system. These boundaries will be checked in the field at some point over the next five years, which will ensure Auckland Council has an accurate map of the extent of all duneland habitat in the Heritage Area (i.e. as at summer 2013/14). Prior to the 2018 reporting

deadline, the areas of duneland habitat will be re-surveyed in the field and the 2018 extent compared to the 2012/13 extent.

10.9.3 Indicator D2: Loss or gain of duneland habitat (area and %)

Change for this indicator is summarised in D1. The purpose of separating D1 and D2 is that future measurements D1 will allow the total area of duneland habitat at that time to be compared with the 2008 baseline, and therefore calculate cumulative change. Whereas D2 will assess the change in vegetation cover over the preceding five year period. For this initial five year reporting period, comparison back to a 2008 baseline and change over the preceding five years are the same figures.

10.9.4 Indicator D3: Proportion of duneland area with a landcover of indigenous ecosystems

Summary

Indigenous vegetation is the preferred vegetation cover for duneland in the Heritage Area as it preserves the natural features of the system and provides habitat for the maximum amount of indigenous plants and animals. Indigenous duneland ecosystems in the Heritage Area are characterized by extensive spinifex grassland on foredunes and mid-dunes, locally common karo-dominant dune forest and shrubland, and sedge-dominant freshwater wetland systems.

The overall vegetation composition of the duneland in the Heritage Area is outlined in Table 21. The large size and naturalness of the Whatipu wetland system means that the overall proportion of duneland habitat in the Heritage Area characterised by indigenous dominant or 'natural'[11] vegetation cover is relatively high (>80%). However, the much smaller patches of duneland habitat associated with the beaches north of Whatipu have been more severely affected by built structures and replacement of native with exotic vegetation. The dunelands at Piha and Te Henga/Bethell's are the most highly modified sites.

Table 21 General vegetation cover of duneland habitat in the Heritage Area.

Vegetation/landcover type	Area in ha (% of total)

[11] Natural vegetation cover includes non-vegetated ecosystems (e.g. open water or bare sand) that are bare/non-vegetated because of natural physical processes (such as accumulation of rainwater in dune hollows or the constant movement of new sand preventing the establishment of native sand binding plant species.

Indigenous dune vegetation	750
Degraded dune vegetation	89.4
Exotic grassland and scattered shrubs	38.7
Exotic pine forest and treeland	29.7
Exotic grassland and residential buildings	13.7
TOTAL	921.5

Change before 2008

As outlined in the introduction to this section, dunelands have been greatly reduced throughout New Zealand over the past 150 years. However, the rugged terrain and exposed coastal conditions of the Heritage Area (which would have been formidable barriers to the establishment of agriculture), have most likely resulted in a relatively low historical loss of dunelands compared with other parts of the Auckland Region (particularly the east coast).

The greatest losses (i.e. replacement of indigenous vegetation with exotic vegetation or buildings) have occurred at Piha and Bethell's/Te Henga and are associated with construction of residential dwellings and their gardens, driveways etc. Karekare has also been subjected to a smaller amount of this type of modification. The remaining small areas of habitat at Wigmore, Parera, Wahirua, Anawhata and Whites beaches have been largely unaffected by construction, although there has been some invasion of common exotic duneland plants.

Change 2008 – 2013

2008 value	2012 value	Change
749.35 ha/81% (estimate)	750.00 ha /81%	0.65 ha/+0.071% (estimate)

A desktop comparison of 2007 and 2010 high resolution aerial photography was used to detect any changes in duneland landcover. Changes detected included vegetation clearance, regeneration of new vegetation, construction and/or removal of structures, and construction or removal of impervious surfaces. There was only a very small amount of clearance of native vegetation, c.0.05 ha of total loss scattered across three different dune systems (0.007 ha, 0.004 ha and 0.041 ha for Karekare, Piha and Te Henga respectively). However, this 0.05 ha loss was balanced by a c.0.7 ha increase/re-growth of indigenous dune vegetation in the Te Henga dune system

Note that the data given for 2008 in the table above is based on change between the 2008 and more recent aerials; rather than independently mapping dune vegetation using 2008 aerials.

How change will be monitored 2013+

The external boundaries of all indigenous dune ecosystems have been digitized and recorded in the Council GIS system. These boundaries have been determined through a combination of fieldwork and the use of geological GIS layers, and as such as, the Council now has an accurate map of the extent of all indigenous duneland ecosystems in the Heritage Area.

10.9.5 Indicator D4: Proportion of duneland area with 'non – natural' landcover

Summary

This indicator assesses the naturalness of the dune systems in the Heritage Area. For the purpose of this indicator natural dune vegetation includes both indigenous dominated ecosystems (i.e. those mapped for indicator D3) and degraded dune vegetation. This degraded vegetation is often dominated by exotic herbs and grasses, perhaps with patches of native vegetation, open sand and erosion, but the natural landform and general 'wildness' of the dunes remain. Non – natural vegetation cover includes urban cover (buildings amongst scattered shrubs and grassland), pine forest and dense swards of exotic grass (i.e. lawn) with scattered shrubs. Intensive agriculture is included in this category as the switch to new grass species, high inputs of nutrients and physical damage to the soil structure from compaction by stock means that many of the natural values associated with dunelands converted to intensive agriculture are lost.

Urban landcover on duneland is mostly restricted to Piha and Bethells Beach/Te Henga, and equates to approximately 52.4 ha (Table 22). There also some smaller areas at Anawhata and Whatipu. Small blocks of pine plantation (29.7 ha) are present at Bethells Beach/Te Henga. No dunelands within the Heritage Area are currently being used for any intensive agricultural activity. However, grassland on dune substrate at Te Henga and Whatipu has probably been subjected to low density stock grazing in the past.

Table 22 Residential and agricultural land on duneland substrate in the Heritage Area.

Name	Approx size
Te Henga - urban	33.4 ha
Piha/Karekare - urban	13.7 ha
Whatipu – exotic grassland & some buildings	5.1 ha

Anawhata – small area of grass and several built structures	0.2 ha
Te Henga – pine forest	29.7 ha
TOTAL	82.1 ha

Change before 2008

As outlined in the introduction to this section, dunelands have been greatly reduced throughout New Zealand over the past 150 years. However, the rugged terrain and exposed coastal conditions of the Heritage Area (which would have been formidable barriers to the establishment of agriculture), have most likely resulted in a relatively low historical loss of dunelands compared with other parts of the Auckland Region (particularly the east coast).

Construction of costal properties has increased in more recent decades, and with much of the Heritage Area dunelands protected in reserves, urban expansion is likely to be the main source of duneland habitat displacement. There is negligible pressure from expansion of agricultural production into Heritage Area dunelands.

Change 2008 – 2013

2008 value	2012 value	Change
81.63 ha/8.86% (estimate)	82.15 ha/8.91%	+ 0.52 ha/0.05% (estimate)

Only a very small (c. 0.5 ha) increase in the amount of duneland covered by non-natural vegetation was detected using aerial photograph analysis of change over three years (2007 – 2010) that overlap with the first 5 year monitoring period of the Act. This small increase amounted to around 0.05% of the total area of dune habitat being 'converted' from indigenous or degraded indigenous vegetation to buildings/exotic grassland. The 2008 value presented in the Table above is an estimate, based on the change recorded in 2010 aerials.

Continuing the current rate of dune conversion (c.0.01% per annum) into the future would require c.100 years to produce a 1% increase in the proportion of duneland within the Heritage Area covered in non-natural vegetation. This level of change is almost certainly sustainable in the long term, particularly if a sensitive approach is taken to future buildings (e.g. requiring landscaping/gardens for new dwellings to use appropriate duneland plants and recreate typical duneland ecosystems).

How change will be monitored 2013+

The external boundaries of all dune ecosystems have been digitized and recorded in the Council GIS system, along with the total the parts of this duneland area that are covered by houses, exotic grassland and pine forest etc.. The Auckland Council now has an accurate map of the extent of buildings from which to measure future change.

10.9.6 Indicator D5: Building and impervious cover on duneland area (area and %)

Summary

Exotic and other 'non-natural' dune vegetation has lower biodiversity values than an equivalent indigenous community. However, exotic ecosystems still provide habitat for indigenous animals and (some) plants, and in many cases they also protect the natural physical structure of the dunes, retain ecosystem processes in upper soil layers. In contrast, the construction of buildings, roads and other impervious structures can result in substantial modification of dune morphology (e.g. cut and fill, removal of topsoil, paving over with concrete etc.) that means all their natural values are lost, and it becomes very difficult or impossible to recreate indigenous duneland ecosystems on the site without extensive rehabilitation efforts.

Buildings, roads and carparks and other impervious surfaces are concentrated in the coastal villages of Piha and Bethells Beach/Te Henga. Manmade structures are largely absent from smaller beaches such as Whites Beach, Anawhata, Wahirua Bay and Wigmore Bay. This indicator looks at changes in the area and overall proportion of duneland in the Heritage Area covered by impervious surfaces. There are no figures for the total area of impervious habitat on duneland for this indicator. Change in the cover of impervious surfaces was assessed by comparing 2007 and 2010 aerial photographs, but we were unable to calculate the total percentage impervious cover for either 2008 or 2012 because the GIS layers we had available for this report were not in the correct format to provide accurate data. However, this data will be available for (and included in) the Act's 2018 monitoring report.

Change before 2008

As outlined in the introduction to this section, dunelands have been greatly reduced throughout New Zealand over the past 150 years. However, the rugged terrain and exposed coastal conditions of the Heritage Area (which would have been formidable barriers to the establishment of agriculture), have most likely resulted in a relatively low historical loss of dunelands compared with other parts of the Auckland Region (particularly the east coast).

Construction of costal properties has increased in more recent decades, and with much of the Heritage Area dunelands protected in reserves, urban expansion is likely to be the main source of duneland habitat displacement. There is negligible pressure from expansion of agricultural (and associated impervious infrastructure) into Heritage Area dunelands.

Change 2008 – 2013

2008 value	2012 value	Change
No data	No data	+0.34 ha (+ 0.5%)[12]

The aerial photograph analysis detected a small increase in the amount of duneland covered by impervious surfaces (=buildings, driveways, roads etc.). However, the lack of an accurate figure[12] for the overall cover of impervious surfaces on duneland in the Heritage Area means we are not able to provide proportional change data for this indicator at this time. This will be rectified in the next monitoring progress report.

Even this relatively small increase of 0.34 ha might amount to a 5% increase in the proportion of duneland, or 1%/year over the 4 -5 years time period between the 2007 and 2010 aerial photographs. A 1%/annum increase in impermeable surface on duneland is likely to produce cumulative environmental and biodiversity effects on the medium term (10 – 30 year) time scale, and this indicator should be watched closely. We recommend that an interim report, focused on changes in this indicator, is prepared once the technical issues with impervious layer in GIS are sorted and before the Act's 2018 monitoring report. We think that March 2014 would be an appropriate due date for this interim report.

How change will be monitored 2013+

The external boundaries of all dune ecosystems have been digitized and recorded in the Council GIS system and therefore the Auckland Council now has an accurate map of the extent of buildings from which to measure future change. Technical issues with the impermeable surface layer in GIS will be addressed over the next year, and this will become the main tool for calculating this indicator for future measures.

10.9.7 Indicator D6: Proportion of indigenous duneland habitat under active conservation management

[12] Percentage change can be roughly estimated from the vegetation map data. *A priori* defining a percentage impervious cover of 50% for urban areas, 8% for pine forest, 5% for degraded dune vegetation and 1% for indigenous dune vegetation gives an estimate of c.33 ha (3.6% of total area) impervious surface across all the duneland in the WRHAA. The figure of +0.34 ha therefore amounts to a 5% increase in impermeable surfaces on duneland. However, we would like to stress that this is an estimate only.

Summary

Dunelands are dynamic but fragile ecosystems, and are subjected to a range of different stresses that can affect their natural values. Nationwide, approximately 90% of all duneland systems have been lost to a combination of residential development, forestry and agriculture (DoC & MfE 2007). Unfortunately, many of the remaining dunes systems within the Heritage Area are vulnerable to threats such as weed infestations, damage from mammalian predators and browsers, and physical damage through recreational use (foot and vehicle traffic). Active management of dunelands is likely to significantly lower the risks and damage from environmental pressures. For example, signage and watchful locals can provide significant protection against damage from recreational users, and active weeding and replanting with appropriate native species reduces the impact of exotic weeds.

This indicator assess the response of the Council and local community to pressures on the dune system by looking at what percentage of dunelands are actively managed, and what level of resources are being put into management. This indicator requires the collation of information from a wide variety of sources, many of which are not immediately accessible. For this reason the dataset for this indicator is incomplete and is not presented in this report. Collection of this data is ongoing, and we recommend that this is presented in an interim report, in March 2014, with the full indicator to be included with the other data from 2018 onwards.

Change before 2008

Not applicable.

Change 2008 – 2013

Not applicable.

How change will be monitored 2013+

The final indicator will include much better defined measures of what ‘active management’ is, based on what and how much the restoration and conservation activities the Council, community groups, private landowners and/or the Department of Conservation carry out on each site. This means the indicator will be responsive to both the coverage of active management and the success of the actions.

10.10 Freshwater indicator results (FW)

10.10.1 Introduction

The Waitakere Ranges receives plentiful supplies of rainfall throughout the year, sustaining a wide variety of freshwater environments including rivers, lakes and wetlands on the surface, as well as groundwater in aquifers below the surface. These freshwater environments are important habitats for a variety of plants, insects, invertebrates, fish and amphibians. Freshwater is a vital resource to all forms of life, and no less to humans as well for social, cultural and economic reasons. It is important to monitor the quality and quantity of freshwater, and hence the Auckland Council operates a regional freshwater monitoring network, which includes lakes, rivers and streams throughout the Heritage Area as well as groundwater monitoring from the wider Waitemata Group aquifers (Figure 5). The network contains a variety of sites which are monitored for ecological quality, native fish, water quality, and groundwater quality, and hence a variety of freshwater indicators are presented below.

The lake Water Quality programme data for lakes within the Heritage Area is currently being processed and hence will be presented in the Act's 2018 monitoring report. Freshwater indicators specifically pertaining to water supply reservoirs are presented in a separate section below "Water supply indicator results."

10.10.2 Indicator FW1: Ecological quality (rivers): Macroinvertebrate community index (MCI)

Summary

The macroinvertebrate communities of streams are frequently sampled to provide an assessment of the ecological condition of the stream because they are ubiquitous, relatively easy to sample and identify and sensitive to a wide range of disturbances. The complex taxonomic information and biological data resulting from macroinvertebrate surveys is often required to provide information for non-scientist audiences, thus such data are condensed into a biological index to aid interpretation. In New Zealand, the Macroinvertebrate Community Index (MCI) was developed for this purpose (Stark & Maxted 2007). Each of the commonly encountered taxa is assigned a "score" between 1 and 10 based on their tolerance to environmental stress. Taxa sensitive to environmental stress are assigned scores at the upper end of this range, whereas taxa tolerant of stress are assigned scores at the lower end. The scores of all the taxa recorded at a site are summarised into an

overall MCI score for that site, which is a function of the mean score of all the recorded taxa. The MCI score can then be used to assign a site to a quality class.

There are five macroinvertebrate sites in the following streams/rivers within the Heritage Area that are monitored on a regular basis: Cascades Stream, Opanuku Stream, Waitakere River, Marawhara Stream, Wekatahi Stream (Figure 5). The MCI scores and quality classes for these five sites are summarised below (Figure 23).

The length of the data record for the time frame since the Act's inception precludes the analysis of trends, therefore the information presented below should be used to assess and report the current state of the sites sampled and not any change over time.

2008 value	2012 value	Change
Cascades = 105.4 (GOOD) Opanuku = 84.0 (FAIR) Waitakere = 101.8 (GOOD) Marawhara = 121.0 (EXCELLENT) Wekatahi = 126.8 (EXCELLENT)	Cascades = 115.9 (GOOD) Opanuku = 83.6 (FAIR) Waitakere = 114.7 (GOOD) Marawhara = 125.6 (EXCELLENT) Wekatahi = 128.9 (EXCELLENT)	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

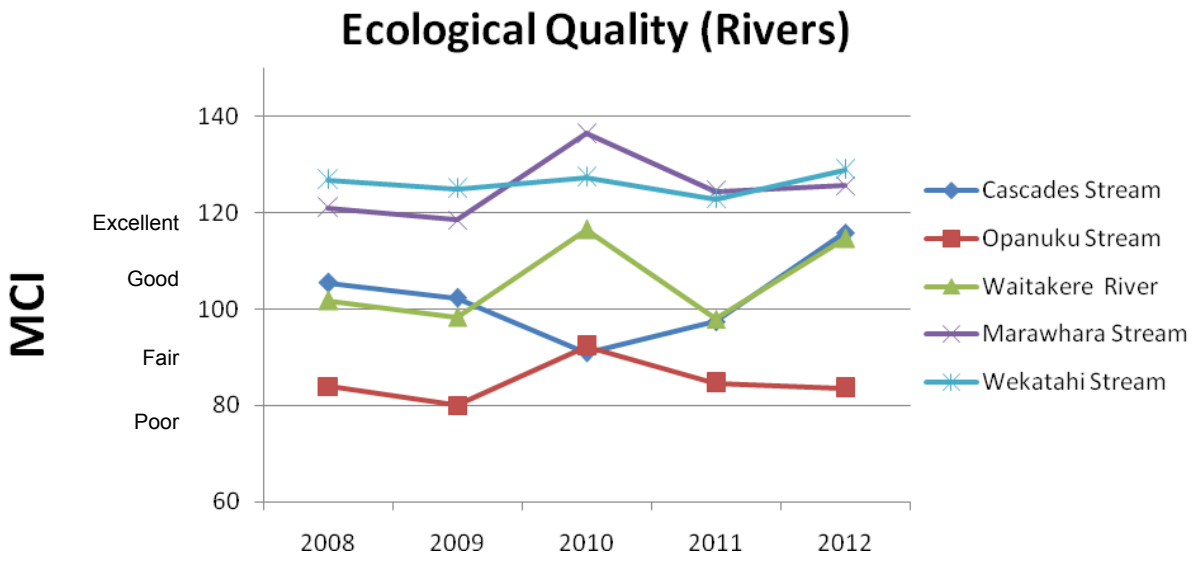

Figure 23 Macroinvertebrate Community Index (MCI) ecological quality data from river sites in the Heritage Area.

Change before 2008

Although no data is available, we anticipate MCI values would not have changed a great deal over the last few decades. The Heritage Area has remained relatively intact in regards to forest extent.

Change 2008 – 2013

Although changes over this short of time cannot be accurately detected for the Ecological Quality indicator, the general trend appears to remain fairly constant for each of the five watercourses monitored with most in the GOOD to EXCELLENT range. Future data collection will allow this pattern to be robustly tested.

How change will be monitored 2013+

Data on the ecological quality (MCI) of rivers and streams will continue to be collected annually as part of the Auckland Council regional freshwater monitoring programme. By the time of the Act's 2018 monitoring report there will likely be adequate data to assess for changes since the Act's inception in 2008.

10.10.3 Indicator FW2: Native fish monitoring: Index of biotic integrity (IBI)

Summary

Fish monitoring is carried out at all five of the river/stream sites where macroinvertebrates are sampled in the Heritage Area (Indicator FW1) to assess the health of native fish communities. Sites were sampled once since the Act's inception in 2009 and hence these data act as a baseline for a future survey which should take place before the Act's next monitoring report in 2018. The results (Table 23) are reported using the Index of biotic integrity (IBI) which was originally developed in the USA and subsequently adapted for New Zealand conditions by Joy & Death (2004). The IBI tool outputs scores which are then assigned to narrative classes.

Table 23 Native fish monitoring in the Heritage Area.

Site name	Year sampled	Fish species found	IBI score	IBI class
Waitakere River	2009	Longfin eel, Crans bully, common bully, perch	32	Fair

Cascades Stream	2009	Longfin eel, koaro, Crans bully, redfin bully	48	Very good
Opanuku Stream	2009	Longfin eel, torrentfish, banded kokopu, inanga, common bully, redfin bully	52	Excellent
Marawhara Stream	2009	Banded kokopu, redfin bully	46	Very good
Wekatahi Stream	2009	Longfin eel, koaro, banded kokopu, redfin bully	52	Excellent

As the fish monitoring has only taken place in 2009 and thus precludes any change analyses since the Act's inception in 2008, these data act as baseline information which will be reassessed in future monitoring work and of which should be available for incorporation into the Act's 2018 monitoring report.

Change before 2008

No historic data is available.

Change 2008 – 2013

No changes are available as fish monitoring has only occurred once over this time period. The results show that all four streams sampled were in 'Very good' to 'Excellent' condition with only the Waitakere River having a lower score placing it in the 'Fair' class.

How change will be monitored 2013+

Another round of fish monitoring should take place within the next five years and hence these data will be able to be compared in the Act's 2018 monitoring report providing some indication of trends in native fish communities within the Heritage Area. In addition to the above native fish monitoring, lamprey (*Geotria australis*) is monitored at a number of sites within the Heritage Area (Waitakere River, Marawhara Stream, Glen Esk Stream, Karekare Stream, and Karamatura Stream) using in-stream passive pheromone samplers. The sample analysis revealed that only the Glen Esk site tested positive for the presence of lamprey, and even then only in very low concentrations, and

hence it is likely that there is only a small population of lamprey within this stream. Future surveys will be able to confirm this.

10.10.4 Indicator FW3: Water quality (rivers)

Summary

The freshwater water quality monitoring programme initially began with the monitoring of 6 sites in 1977. The programme in its current form began with 16 sites in 1986. The basics of the programme have remained essentially unchanged since, although sites have subsequently been added (currently 34) and formal quality control measures introduced in 1992. The programme generates monthly data for a range of water quality parameters. There are two water quality monitoring sites within the Heritage Area (Cascades Stream and Opanuku Stream; Figure 5) and both of the sites were included in the most recent status and trends analysis carried out on 1995-2005 data record. Since 2007, the water quality data has been summarised into a Water Quality Index (WQI) to facilitate the communication of the complex water quality data. The physical and chemical water quality data is used to produce a WQI that scores each site on a scale of 0 to 100 (the higher the index the better the water quality). The data for the two Waitakere Ranges Regional Park sites are presented below (Figure 24).

The length of the data record for the time frame since the Act's inception precludes the analysis of trends, therefore the information presented below should be used to assess and report the current state of the sites sampled and not any change over time.

2008 value	2012 value	Change
Cascades = 83.4 (GOOD) Opanuku = 100.0 (EXCELLENT)	Not available	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

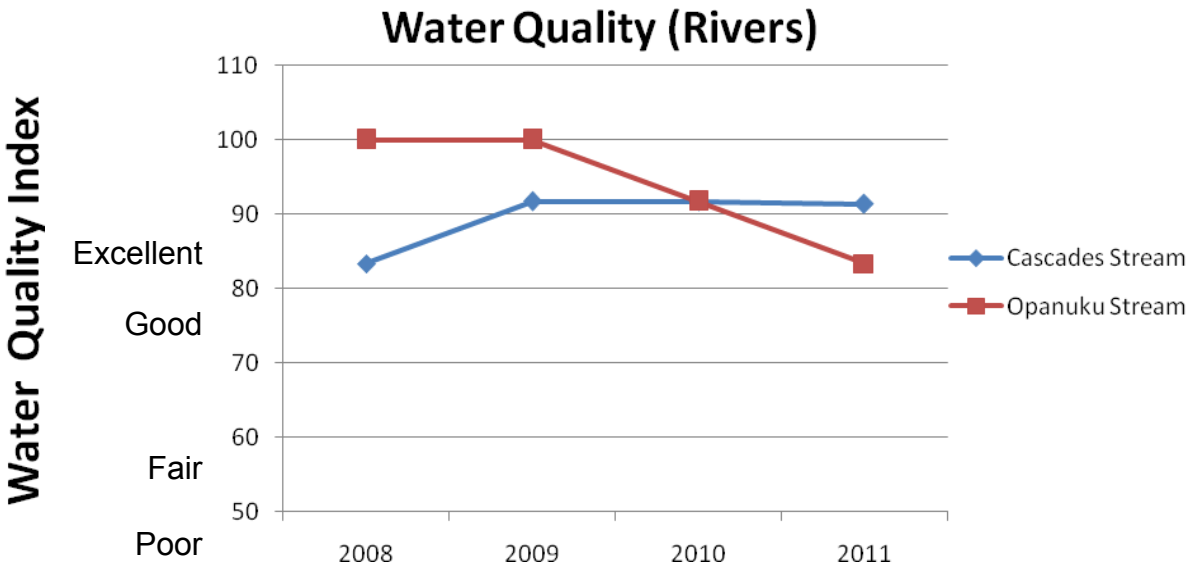

Figure 24 Water Quality Index data from river sites in the Heritage Area.

Change before 2008

Of the 25 sites throughout the Auckland region that were included in the status and trends analysis, the Cascades Stream site was ranked 1st and the Opanuku Stream site 5th, indicating that these sites have above average water quality when compared with the sites in the monitoring programme. This is likely to have been the trend for some time.

Change 2008 – 2013

Although changes over this short of time cannot be accurately detected for the Water Quality indicator, the general trend appears to remain in the GOOD to EXCELLENT water quality range. Future data collection will allow this pattern to be robustly tested.

How change will be monitored 2013+

Data on the Water Quality (WQI) of rivers and streams will continue to be collected annually as part of the Auckland Council regional freshwater monitoring programme. By the time of the Act's 2018 monitoring report there will likely be adequate data to assess for changes since the Act's inception in 2008.

10.10.5 Indicator FW4: Ecological quality (lakes): Rotifer index

Summary

Rotifers are natural components of lake zooplankton communities and useful indicators of ecological quality due to their high abundance, diversity, and sensitivity to environmental impacts. The output data from rotifer sampling is rather complex and hence for ease of communication and interpretation it is summarised into a rotifer index where the lower the score equates to better the lake quality. The rotifer community of Lake Wainamu in the Heritage Area is sampled several times each year (Figure 25).

2008 value	2012 value	Change
~3.7 (Mesotrophic)	Not available	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

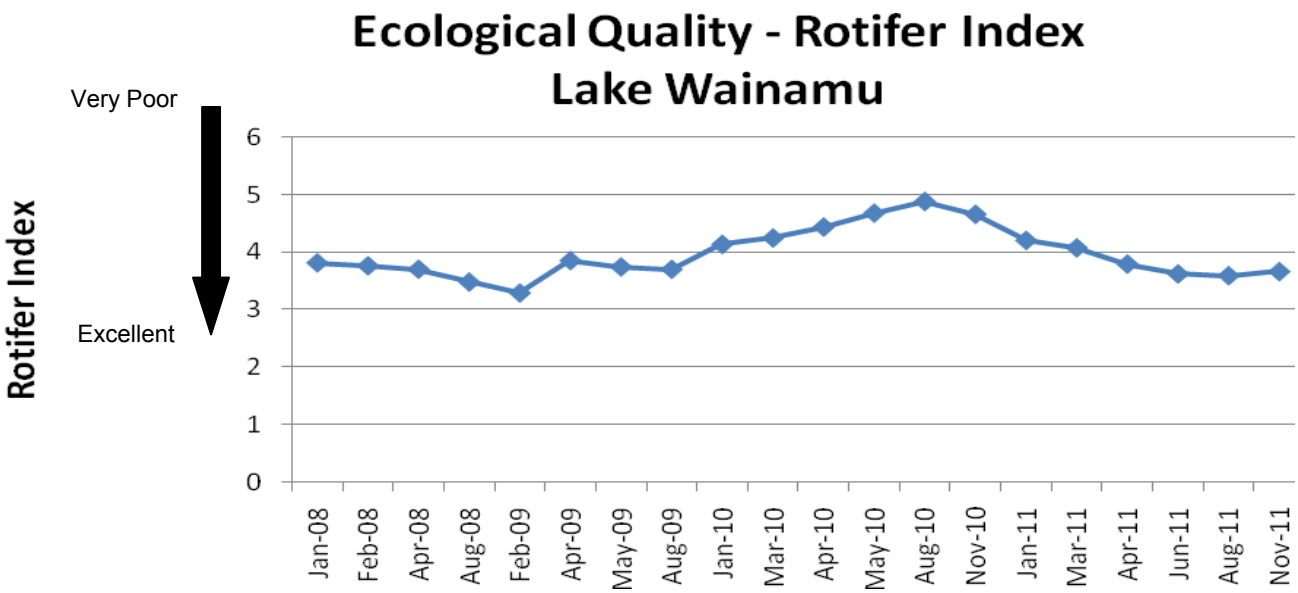

Figure 25 Ecological Quality Rotifer Index data from Lake Wainamu in the Heritage Area.

Change before 2008

The State of the Environment report published in 2008 indicated that of the seven lakes monitored in the Auckland Region, Lake Wainamu's rotifer index is one of the lowest, second to only Lake Ototoa in the Rodney District. The inferred quality class is Mesotrophic.

Change 2008 – 2013

This time period is too short to reliably detect changes in ecological quality using the Rotifer Index. The general trend appears to remain in the Mesotrophic range however future data collection are required to valid this pattern.

How change will be monitored 2013+

Data on the ecological quality using the Rotifer Index of Lake Wainamu will continue to be collected several times each year as part of the Auckland Council regional freshwater monitoring programme. By the time of the Act's 2018 monitoring report there will likely be adequate data to assess for changes since the Act's inception in 2008.

10.10.6 Indicator FW5: Ecological quality (lakes): Macrophytes (LakeSPI)

Summary

Pristine lakes in Auckland are home to a variety of native macrophytes, which are submerged plant species. The area and coverage of these plants depends upon the water clarity and/or the maximum depth of the lake. Many of Auckland's lakes have been degraded by invasive species and reduced water clarity, and hence the quality and extent of macrophytes have been reduced.

Macrophytes are valuable indicators of lake ecological quality due to their size, ease of identification and perennial nature. Twenty-nine lakes throughout the Auckland region, including Waimamu and Kawaupaku in the Heritage Area, are monitored for ecological quality using macrophytes. A number of key features of the macrophyte community structure and composition are measured and used to generate a LakeSPI (Submerged Plant Indicators) index where the higher the score, the better the lake ecological quality of the lake (Figure 26).

2008 value	2012 value	Change
n/a	Lake Kawaupaku 10% (POOR) Lake Wainamu 0% (POOR)	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

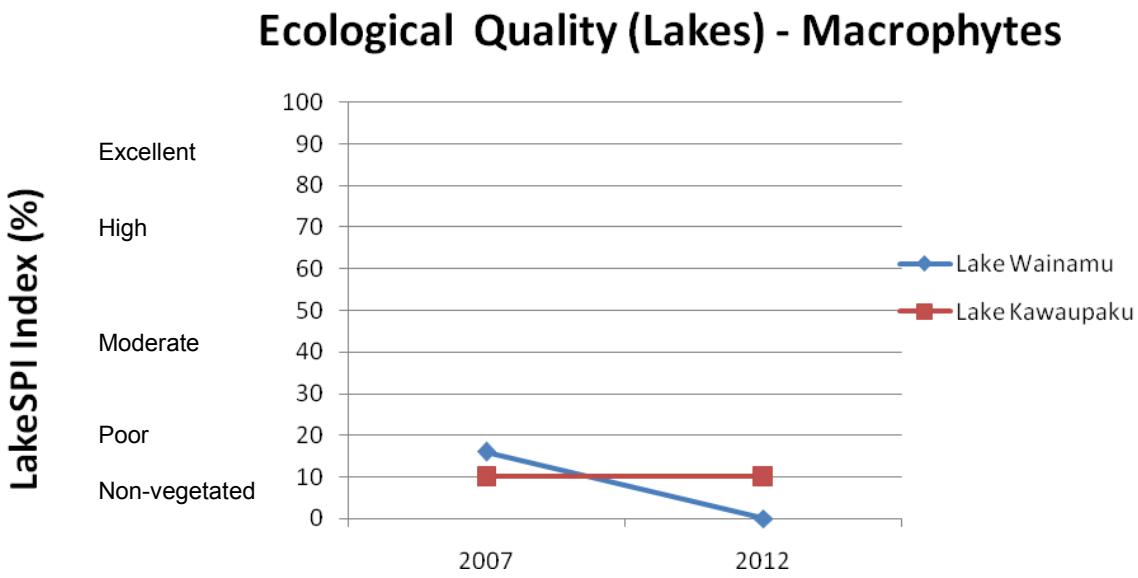

Figure 26 Ecological Quality LakeSPI (macrophyte) Index data from lake Wainamu and Kawaupaku in the Heritage Area.

Change before 2008

Lake Wainamu has gone through a lot of change in the last couple of decades, from a pristine state with dominant native macrophytes, and then degrading with the weed egeria occupying almost all available habitat in the lake down to 4 m. Similarly Lake Kawaupaku was primarily composed of native macrophytes in the 1970s but declined after due to an invasion of egeria.

Change 2008 – 2013

This time period is too short to reliably detect changes in ecological quality using the Macrophye LakeSPI Index. Note that the non-vegetated state detected in Lake Wainamu in 2012 is directly the result of the introduction of grass carp (*Ctenopharyngodon idella*) in 2009, and consequently the 2012 LakeSPI score is not indicative of lake ecological condition. The general trend for the two monitored lakes in the Heritage Area is in the 'Poor' range however future data collection are required to valid this pattern.

How change will be monitored 2013+

Data on the ecological quality of lake Wainamu and Kawaupaku using the LakeSPI Index (Macrophytes) will continue to be collected as part of the Auckland Council regional freshwater monitoring programme. By the time of the Act's 2018 monitoring report there will likely be adequate data to assess for changes since the Act's inception in 2008.

10.10.7 Indicator FW6: Groundwater quality (for discharge to rivers)

Summary

Groundwater from the Heritage Area includes water flow from the Waitakere Group Volcanics and Waitemata Group Sandstones/Mudstones aquifers. No groundwater monitoring takes place for any of Auckland's volcanics, however a 78-150m borehole located at 7 Waitakere Road (Figure 5) is monitored regularly (quarterly), which although is located outside of the Heritage Area, is deemed to be representative of the deep, confined groundwater of the wider Waitemata Group aquifer. The shallow, more vulnerable aquifers within the Heritage Area are not monitored, and hence we do not know the impact of local land-use impact on these aquifers.

Groundwater quality has been summarised into the same Water Quality Index (WQI) described above (see Indicator FW3 above).

The length of the data record for the time frame since the Act's inception precludes the analysis of trends, therefore the information presented below should be used to assess and report the current state of the sites sampled and not any change over time.

2008 value	2012 value	Change
Excellent	Data not available	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

Change before 2008

Data from 1998 -2009 (reported in the 2009 State of the Auckland Region) rated the Waitemata Group aquifer as EXCELLENT.

Change 2008 – 2013

Although changes over this short of time cannot be accurately detected for the Groundwater Quality indicator, the available data from 1998-2009 revealing an EXCELLENT water quality range is likely to have persisted for the Waitemata Group aquifer, however future data collection is necessary to confirm this.

How change will be monitored 2013+

Data on the Water Quality (WQI) of groundwater will continue to be collected quarterly as part of the Auckland Council regional groundwater monitoring programme. By the time of the Act's 2018 monitoring report there will likely be adequate data to assess for changes since the Act's inception in 2008.

10.11 Water supply (S) indicator results

10.11.1 Introduction

Water is a vital resource for humans used for domestic consumption, agricultural production, commercial and industrial needs. Within the Heritage Area there are five major water supply reservoirs operated by Watercare Service Ltd (Watercare): Waitakere, Upper and Lower Huia (Huia), Upper and Lower Nihotupu (Figure 5). As part of the resource consent conditions for the operation of these freshwater reservoirs Watercare undertake freshwater monitoring at locations in the rivers and streams which reflect the reservoir water supply quality. For the purposes of this report the following two indicators are detailed below which are based on the analyses and results presented in Watercare's annual reports (Tonkin & Taylor Ltd 2008, 2008b, 2008c, 2012, 2012b, 2012c): ecological quality (Indicator S1) and water quality (Indicator S2). Note that Watercare also undertake Periphyton (aquatic mixture of various biomass) and fish monitoring which although are not used as indicators in this report may be useful for future reporting and hence should be investigated for the 2018 monitoring report.

10.11.2 Indicator S1: Ecological quality (water supply) – Macroinvertebrates

Summary

Macroinvertebrate samples were collected on 15 January and 8 July each year at a number of sites downstream from each of the reservoirs being monitored. Several variables and indices are analysed (similar to the regional monitoring programme; Indicator FW1 above), however for the purposes of this report, and due to the short time period since the Act's inception, only broad qualitative ecological quality trends are reported using the Index of Biological Integrity (IBI) scoring criteria (Plafkin et al. 1989; modified for New Zealand by Quinn et al. 2009). The degree of habitat impairment attributed to the effect of each of the dams is assessed by comparing IBI scores calculated from downstream sites to a reference upstream site of the dam. The output of this analysis places each of the downstream sites into one of the following four categories (from positive to negative): non-impaired, slightly impaired, moderately impaired, and severely impaired.

2008 value	2012 value	Change
Waitakere - NI to SI Huia - NI Nihotupu - most NI	Waitakere – most NI Huia – NI to SI Nihotupu - SI to MI	There must be far greater than 5 years (potentially up to 10 years) of data to interpret any changes.

NI = non-impairment; SI = slightly impaired; MI = moderately impaired.

Change before 2008

Data unavailable.

Change 2008 – 2013

As mentioned above, five years is an inadequate time period to robustly assess how ecological quality has changed. In general it appears that each of the dams has remained fairly consistent in level of impairment, with most reservoir dams falling into the non-impairment category, and no reservoir receiving the lowest impairment score 'severely impaired'. A common trend found was an increase in the number of macroinvertebrate diversity between summer and winter which appears to explain a slight decrease in indices for the Upper Nihotupu Dam. These seasonal effects and trends will be assessed in future analyses.

How change will be monitored 2013+

Data on the ecological quality for the four reservoirs within the Heritage Area will continue to be collected as part of Watercare's resource consent requirements, and hence a more thorough quantitative analysis of water quality will be available for the Act's 2018 monitoring report.

10.11.3 Indicator S2: Water quality (water supply)

Summary

Water quality samples were collected on a monthly basis from December until May each year. Several variables are analysed such as temperature, dissolved oxygen, conductivity, and pH. For the purposes of this report, and due to the short time period since the Act's inception, only broad qualitative water quality trends are reported based on comparison to the Auckland Council's reference site on the Cascade Stream in the Waitakere River Catchment (a regional reference site).

2008 value	2012 value	Change
Waitakere - GOOD	Waitakere - GOOD	There must be far greater than 5

Huia - GOOD Nihotupu - GOOD	Huia - GOOD Nihotupu - GOOD	years (potentially up to 10 years) of data to interpret any changes.

Change before 2008

Data unavailable.

Change 2008 – 2013

Although changes over this short of time cannot be accurately detected for the water quality indicator, the general trend for all four reservoirs appears to be “GOOD” and hence overall water quality in the reservoirs in the Heritage Area have high water quality (similar to the findings from the regional freshwater monitoring programme - Indicator FW3 above).

How change will be monitored 2013+

Data on the water quality for the four reservoirs within the Heritage Area will continue to be collected as part of Watercare’s resource consent requirements, and hence a more thorough and quantitative analysis of water quality will be available for the Act’s 2018 monitoring report.

11.0 Appendix three: Threatened species of the WRHA

Threatened plant species known in the Heritage Area. National threat rankings are taken from de Lange et al. (2009) and regional threat rankings are taken from Stanley et al. (2005). Regional threat rankings are italicized under the 'Threat status' column.

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Daucus glochidiatus	NZ carrot	Dicot herb	Threatened-Nationally Critical, *Critical*	Likely that competition from faster growing, and taller weeds, particularly rats tail grass a key factor in the species' decline (NZPCN 2012).
Epilobium hirtigerum	Hairy willowherb	Dicot herb	Threatened-Nationally Critical, *Critical*	Competition from weeds (NZPCN 2012).
Lindbergia maritima		Moss	Threatened-Nationally Critical	Unknown
Ophioglossum petiolatum	Stalked adder's tongue fern	Fern	Threatened-Nationally Critical, *Critical*	Intolerant of competition from taller faster growing plants and very vulnerable to slug and snail browsing (NZPCN 2012).
Myosotis petiolata var. *pansa*	Forget-me-not	Dicot herb	Threatened-Nationally Endangered, *Endangered*	Loss of habitat through coastal development; susceptible to goat, deer and pig impacts; competition from weeds, especially Mexican daisy and Mexican devil (NZPCN 2012).
Picris burbidgeae	Native oxtongue	Dicot herb	Threatened-Nationally Endangered, *Serious Decline*	Habitat loss through coastal development, succession, displacement by weed invasion, it is also prone to accidental eradication because of its weedy appearance (NZPCN 2012).
Plumatichilos tasmanicum	Plumed greenhood	Orchid	Threatened-Nationally Endangered, *Critical*	Lack of fires, competition from weeds (gorse) and over-collection by orchid enthusiasts (NZPCN 2012).
Schoenus carsei		Sedge	Threatened-Nationally Endangered, *Critical*	Threatened by wetland drainage, eutrophication, modification and the spread of naturalised wetland weeds (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Utricularia australis	Yellow bladderwort	Dicot herb	Threatened-Nationally Endangered. *Critical*	Competition from the introduced *Utricularia gibba,* which occupies the same habitat and has a more aggressive growth form. Threatened by other introduced aquatic weeds. It is also vulnerable to habitat loss through modification and drainage (NZPCN 2012).
Dactylanthus taylorii	Wood rose, pua o te reinga	Dicot herb	Threatened-Nationally Vulnerable, *Critical*	Habitat destruction, collectors of wood roses and browsing animal such as possums, rats and pigs. Cattle destroy plants through trampling.
Dichelachne micrantha	Purple plume grass	Grass	Threatened-Nationally Vulnerable, *Data Deficient*	Progressive loss of the open, coastal shrublands and clay pans it favours. Competition from weeds (NZPCN 2012).
Geranium retrorsum	Turnip-rooted geranium	Dicot herb	Threatened-Nationally Vulnerable, *Gradual Decline*	Appears to be threatened by browsing animals such as rabbits. The open habitats it prefers are also now largely dominated by taller growing weeds (NZPCN 2012).
Hebe bishopiana	Waitakere rock koromiko	Dicot shrub	Threatened-Nationally Vulnerable, *Vulnerable*	A very localised species common in only a few stream catchments and rock outcrops of the Waitakere Range. At most sites it is threatened by the spread of pampas grass and Mexican daisy (NZPCN 2012).
Lepidium oleraceum	Cook's scurvy grass	Dicot herb	Threatened-Nationally Vulnerable, *Endangered*	Seriously threatened by loss of indigenous sea bird nesting. It is susceptible to a range of introduced pests and diseases, and is browsed by cattle and other livestock. A fungus-like disease is also a problem; and the plant has been and continues to be over-collected by people (NZPCN 2012).
Brachyglottis kirkii var. *kirkii*	Kirk's daisy	Dicot epiphyte	At Risk-Declining, *Serious Decline*	This plant is intolerant of browse and is targeted by possums, goats and deer (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Carex litorosa	Sea sedge	Sedge	At Risk-Declining, *Critical*	Habitat loss through coastal development, encroachment by weeds.
Coprosma acerosa	Sand coprosma	Dicot shrub	At Risk-Declining, *Serious Decline*	Rapidly becoming scarce in large parts of its range. Seems to represent dune reclamation and competition from marram grass (NZPCN 2012).
Eleocharis neozelandica	Sand spike sedge	Sedge	At Risk-Declining, *Critical*	Vulnerable through natural perturbations of its sand flat habitat. Some populations have been lost due to coastal development and through the spread of weeds (NZPCN 2012).
Euphorbia glauca	Shore spurge	Dicot herb	At Risk-Declining, *Critical*	Domestic and feral cattle, sheep, pigs and possums are the major threats mainly through browse and trampling. Competition from taller vegetation is significant at many sites. Coastal development and erosion are further common threats (NZPCN 2012).
Ficinia spiralis	Pingao	Sedge	At Risk-Declining	Weeds such as marram grass, rabbit browse.
Juncus pauciflorus	Leafless rush	Rush	At Risk-Declining, *Endangered*	Drainage of wetlands, competition from weeds, and coastal developments in dune habitat.
Leptinella tenella		Dicot herb	At Risk-Declining, *Sparse*	Naturally uncommon species of sporadic distribution. Some populations have declined due to spread of weeds and associated wetland drainage (NZPCN 2012).
Myriophyllum robustum	Stout water milfoil	Dicot herb	At Risk-Declining, *Range Restricted*	Threatened by wetland drainage, eutrophication, and the spread of naturalised wetland weeds (NZPCN 2012).
Paspalum orbiculare	Native paspalum	Grass	At Risk-Declining, *Serious Decline*	It seems to be threatened by other taller, faster growing grass and shrub species, though exact data on the nature or mechanism of its decline is not available (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Peraxilla tetrapetala	Red mistletoe	Dicot epiphyte	At Risk-Declining	Possum browse is the most serious threat.
Pittosporum kirkii	Kirk's kohuhu	Dicot shrub	At Risk-Declining, *Vulnerable*	Forest clearance, possum browse.
Poa billardierei	Sand grass	Grass	At Risk-Declining, *Critical*	Mammalian grazing and browsing. Competition from marram grass. Coastal development and use of vehicles (NZPCN 2012).
Ptisania salicina	King fern	Fern	At Risk-Declining, *Gradual Decline*	Feral and domestic stock, wild pig and goat browse are serious threats. Fern collectors also pose a threat (NZPCN 2012).
Scandia rosifolia	Koheriki	Dicot herb	At Risk-Declining, *Serious Decline*	This species is extremely palatable and it is greedily consumed wherever plants are accessible to browsing animals (NZPCN 2012).
Thelypteris confluens		Fern	At Risk-Declining, *Coloniser*	The main threat seems to come from wetland drainage, eutrophication and the often associated spread of faster, taller growing weeds. The species is also popular with fern collectors (NZPCN 2012).
Tupeia antarctica	White mistletoe, tupia	Dicot liane	At Risk-Declining, *Critical*	Possum browse is the primary threat to this species. Insect browse, habitat destruction, loss of pollinating and seed-dispersing native birds, collectors, vandalism and fungal disease also threaten this species (NZPCN 2012).
Adelopetalum tuberculatum		Orchid	At Risk-Naturally Uncommon, *Sparse*	Plant collectors pose a minor threat (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Calystegia marginata	Small-flowered white bindweed	Dicot liane	At Risk-Naturally Uncommon, *Critical*	Ignorance seems to be the main threat. Because it is frequently mistaken as a convolvulus, it is sprayed. Also its preference for succession habitats and along road margins tend to make it especially vulnerable to routine, roadside weed spraying (NZPCN 2012).
Centipeda aotearoana	New Zealand sneezewort	Dicot herb	At Risk-Naturally Uncommon, *Data Deficient*	Weeds.
Corunastylis nuda	Red leek orchid	Orchid	At Risk-Naturally Uncommon	Much of the habitat this species favours has been destroyed over the last 100 or so years and it is quite likely that this orchid has undergone a massive range reduction (NZPCN 2012).
Corunastylis pumila	Yellow gumland leek orchid	Orchid	At Risk-Naturally Uncommon, *Gradual Decline*	The open clay pans and gumland scrub it flourishes in have been reduced to tiny, effectively non-functional units now given over to natural succession to taller vegetation (NZPCN 2012).
Danhatchia australis	Danhatchia	Orchid	At Risk-Naturally Uncommon, *Sparse*	Not threatened in New Zealand, but not very common either, and at risk from orchid collectors (NZPCN 2012).
Doodia mollis	Mokimoki, mukimuki	Fern	At Risk-Naturally Uncommon, *Sparse*	Although some populations have been lost through land development the species remains rather widespread (NZPCN 2012).
Doodia squarrosa		Fern	At Risk-Naturally Uncommon	Vulnerable to the spread of aggressive weeds (NZPCN 2012).
Hebe obtusata	hebe	Dicot shrub	At Risk-Naturally Uncommon, *Range Restricted*	None known.
Hypolepis dicksonioides	Giant hypolepis	Fern	At Risk-Naturally Uncommon, *Sparse*	None known, but biologically sparse (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Korthalsella salicornioides	Dwarf mistletoe, leafless mistletoe	Hemiparasitic dicot epiphyte	At Risk-Naturally Uncommon, *Sparse*	An apparently naturally uncommon and biologically sparse species. In some parts of its range it is seriously at risk due to the felling of its main host species for firewood and also to clear land for farming or pine plantations (NZPCN 2012).
Libocedrus plumosa	Kawaka	Conifer	At Risk-Naturally Uncommon, *Sparse*	This species may even have benefited from past logging because it is at its most abundant in places that were once heavily logged, and/or burned. Field evidence suggests that *Libocedrus plumosa* needs regular disturbance to maintain itself (NZPCN 2102).
Lindsaea viridis		Fern	At Risk-Naturally Uncommon, *Sparse*	Extremely vulnerable to over collection at some sites (NZPCN 2012).
Myriophyllum votschii		Dicot herb	At Risk-Naturally Uncommon, *Range Restricted*	None known.
Olearia angulata		Dicot shrub	At Risk-Naturally Uncommon, *Data Deficient*	Probably not threatened (NZPCN 2012).
Petalochilus alatus		Orchid	At Risk-Naturally Uncommon, *Data Deficient*	Not considered threatened (NZPCN 2012).
Pittosporum ellipticum		Dicot shrub	At Risk-Naturally Uncommon, *Sparse*	Not directly threatened though it is generally very uncommon throughout its range, and where found it is often known from one or two trees (NZPCN 2012).
Schizaea dichotoma	Fan fern	Fern	At Risk-Naturally Uncommon, *Sparse*	Not threatened at a national level. A naturally uncommon, biologically sparse species (NZPCN 2012).
Sophora fulvida		Dicot tree	At Risk-Naturally Uncommon, *Range Restricted*	Competition from weeds, especially on rocky outcrops; animal browse and loss of habitat (NZPCN 2012).

Scientific name	Common name	Type of organism	Threat status (National, *Regional*)	Current threats
Stegostyla atradenia		Orchid	At Risk-Naturally Uncommon, *Sparse*	Some populations have been lost due to weed invasions and land development (NZPCN).
Tetragonia tetragonoides	NZ spinach	Dicot herb	At Risk-Naturally Uncommon, *Critical*	It is threatened by disturbance of coastal sands and stony beaches (NZPCN 2012).
Pellaea falcata	Sickle fern	Fern	At Risk-Relict, *Critical*	Many mainland sites are threatened by weeds and coastal development. In some places it is or has recently been threatened by over-collection (NZPCN 2012).
Pisonia brunonia	Parapara	Dicot shrub	At Risk-Relict, *Endangered*	Within the mainland part of its range, parapara is virtually extinct. Its large leaves are especially palatable to browsing animals such as possums, goats and other feral livestock. However, the main threat to accessible mainland populations is the irresponsible behaviour of ignorant people who have cut down trees because of their ability to trap small passerines (NZPCN 2012).
Sonchus kirkii	NZ sow thistle	Dicot herb	At Risk-Relict, *Critical*	The main threat seems to be from competition by faster growing weed species (NZPCN 2012).
Streblus banksii	Large-leaved milk tree	Dicot tree	At Risk-Relict, *Critical*	Rodents, possums and goats (NZPCN 2012).
Nematoceras rivulare		Orchid	Data Deficient	Seems to be genuinely uncommon but not threatened (NZPCN 2012).
Pimelea longifolia		Dicot shrub	Data Deficient, *Endangered*	Probably not threatened at a national level (NZPCN 2012).
Ranunculus macropus	Swamp buttercup	Dicot herb	Deficient, *Critical*	Threatened by wetland drainage, modification and the spread of weeds. In large parts of its former range hybrids are now more commonly encountered than the actual species

Table 24 Threatened bird species known in the Heritage Area. Current threat rankings are taken from Miskelly et al. (2008).

Scientific name	Common name	Threat status	Current threats
Anas superciliosa superciliosa	Grey duck	Threatened-Nationally Critical	Hybridisation with mallard, mammalian predators, duck shooting
Botaurus poiciloptilus	Australasian bittern	Threatened-Nationally Endangered	Mammalian predators, loss of wetland habitat through clearance and drainage
Callaeas wilsoni	Kokako	Threatened-Nationally Vulnerable	Mammalian predators
Larus bulleri	Black-billed gull	Threatened-Nationally Endangered	Mammalian predators, human disturbance, loss of breeding habitat
Anarhynchus frontalis	Wrybill	Threatened-Nationally Vulnerable	Mammalian predators at South Island riverbed breeding sites, loss of riverbed breeding grounds to weed invasion, human disturbance and mammalian predators at North Island wintering grounds
Charadrius bicinctus bicinctus	Banded dotterel	Threatened-Nationally Vulnerable	Mammalian and avian predators at breeding sites, human disturbance and mammalian predators at roosts
Charadrius obscurus aquilonius	NZ dotterel	Threatened-Nationally Vulnerable	Mammalian and avian predators and human disturbance at breeding sites, human and domestic dog disturbance at roosts
Egretta sacra sacra	Reef heron	Threatened-Nationally Vulnerable	Mammalian predators and human disturbance at breeding sites
Hydropogne caspia	Caspian tern	Threatened-Nationally Vulnerable	Mammalian predators and human disturbance at breeding sites
Larus novaehollandiae scopulinus	Red billed gull	Threatened-Nationally Vulnerable	Impacts of fisheries on pelagic food supplies near offshore breeding islands

Scientific name	Common name	Threat status	Current threats
Nestor meridionalis septentrionalis	North Island kaka	Threatened-Nationally Vulnerable	Mammalian predators (particularly stoats), possible competition for nesting sites with the Australian rosella
Phalacrocorax varius varius	Pied shag	Threatened-Nationally Vulnerable	Fishing set nets
Poliocephalus rufopectus	NZ dabchick	Threatened-Nationally Vulnerable	Mammalian predators, loss of wetland habitat, nests vulnerable to wash from recreational boating
Anthus novaeseelandiae novaeseelandiae	NZ pipit	At Risk-Declining	Mammalian predators, loss of habitat due to coastal development.
Bowdleria punctata vealeae	North Island fernbird	At Risk-Declining	Mammalian predators, loss of scrubland and wetland habitat
Eudyptula minor iredalei	Northern little blue penguin	At Risk-Declining	Mammalian predators, fishing set nets, human disturbance and domestic dog predation at breeding sites
Himantopus himantopus	Pied stilt	At Risk-Declining	Mammalian predators, loss of habitat
Puffinus carneipes	Flesh footed shearwater	At Risk-Declining	Mammalian predators, bycatch by recreational fishers
Puffinus griseus	Sooty shearwater	At Risk-Declining	Mammalian predators, bycatch in North Pacific longline fisheries
Sterna striata	White-fronted tern	At Risk-Declining	Impacts of fisheries on food supplies, human disturbance of breeding colonies
Eudynamys taitensis	Long-tailed cuckoo	At Risk-Naturally Uncommon	Mammalian predators causing decline in host species (whitehead).
Gallirallus philippensis assimilis	Banded rail	At Risk-Naturally Uncommon	Mammalian predators, clearance of mangroves and saltmarsh
Phalacrocorax	Black shag	At Risk-	Wetland drainage and degradation, ,

Scientific name	Common name	Threat status	Current threats
carbo novaehollandiae		Naturally Uncommon	fishing set nets, disturbance from recreational boats
Phalacrocorax melanoleucos brevirostris	Little shag	At Risk-Naturally Uncommon	Wetland drainage and degradation, fishing set nets disturbance from recreational boats
Phalacrocorax sulcirostris	Little black shag	At Risk-Naturally Uncommon	Wetland drainage and degradation, fishing set nets, disturbance from recreational boats
Porzana pusilla affinis	Marsh crake	At Risk-Relict	Mammalian predators, loss of wetland habitat
Porzana tabuensis plumbea	Spotless crake	At Risk-Relict	Mammalian predators, loss of wetland habitat

Table 25 Threatened bat species known in the Heritage Area. Current threat rankings are taken from O'Donnell et al. (2010).

Scientific name	Common name	Type of organism	Threat status	Current threats
Chalinolobus tuberculata	Long-tailed bat	Bat	Threatened-Vulnerable	Mammalian predators, vegetation clearance (particularly large, old trees).

Table 26 Threatened reptile and frog species known in the Heritage Area. Current threat rankings are taken from Hitchmough et al. (2010) for reptiles and Newman et al. (2009) for frogs.

Scientific name	Common name	Type of organism	Threat status	Current threats
Dactylocnemis pacificus	Pacific gecko	Reptile	At Risk-Declining	Mammalian predators, clearance/fragmentation of habitat.
Naultinus elegans elegans	Auckland green gecko	Reptile	At Risk-Declining	Mammalian predators, clearance/fragmentation of habitat.
Oligosoma	Ornate skink	Reptile	At Risk-	Mammalian predators.

Scientific name	Common name	Type of organism	Threat status	Current threats
ornatum			Declining	
Leiopelma hochstetteri	Hochstetter's frog	Amphibian	At Risk-Relict	Mammalian predators, fungal disease.

Table 27 Threatened fish species known in the Heritage Area. Current threat rankings are taken from Allibone et al. (2009).

Scientific name	Common name	Type of organism	Threat status	Current threats
Anguilla dieffenbachii	Longfin eel	Freshwater fish	At Risk-Declining	Over-fishing, pollution, dams.
Galaxias argenteus	Giant kokopu	Freshwater fish	At Risk-Declining	Pollution, loss of habitat.
Galaxias postvectis	Short-jawed kokopu	Freshwater fish	At Risk-Naturally Uncommon	Pollution, loss of habitat.

Table 28 Threatened invertebrate species known in the Heritage Area. Current threat rankings are taken from Hitchmough et al. (2007).

Scientific name	Common name	Type of organism	Threat status	Current threats
Paranephrops planifrons	koura	Aquatic crustacean	At Risk-Declining	Over-harvesting, pollution, sedimentation.
Peripatus	Velvet worm	Onychophora	At Risk-Declining	Rodents.
Paraphanta busbyii	kauri snail	Snail	At Risk-Naturally Uncommon	Predation by possums, pigs, and rodents.

12.0 Appendix four: Vegetation survey methodology

The study investigated the patterns of vegetation cover and land use in the Waitakere Ranges as part of the Waitakere Heritage Protection Report. Five broad landscape units were identified in the Waitakere area:

1. Dense bush living
2. Bush living
3. Rural living
4. Coastal living
5. Parkland

Each landscape type was divided into a series of smaller, discrete parcels based on catchment and topography. ArcGIS version 9.3.1 was used to inspect aerial photography captured in two summer periods: (1) November 2007 to April 2008, and (2) November 2010. Before and after comparisons were made in order to determine changes in land cover and use over ~3 years.

Landscape units

1. 'Dense bush living' comprises privately owned land characterized by a low number of dwellings within contiguous, intact indigenous forest and shrubland. Most such areas are scattered around the periphery of the 'Parkland'.

2. 'Bush living' comprises land situated predominantly on the foothills of the Waitakere Ranges. The land is characterized by a greater number of residential dwellings and small lifestyle blocks surrounded by large, contiguous areas of indigenous vegetation together with small, fragmented mixed indigenous-exotic shrubland.

3. 'Rural living' includes land on the lower foothills of the ranges, largely situated in Henderson Valley and around the town of Waitakere. The land is used for a range of uses, including grazing, viticulture and other mixed horticultural activities. Small, isolated patches of indigenous shrubland occur frequently across this land type.

4. 'Coastal living' comprises built-up residential areas at Muriwai, Piha, Little Huia, Huia, and Parau. They are largely buffered by 'Dense bush living' and 'Parkland'.

5. 'Parkland' comprises all public land administered by Auckland Council within the Waitakere Ranges. It is dominated by indigenous forest and includes a range of other ecosystem types such as dunes, freshwater wetlands and shrubland. For the purposes of the project, 'Parkland' was not included in the analysis.

Analysis

The analysis included five general categories of land change:

1. **Construction** – includes the construction of new dwellings, the construction of small utility structures such as sheds and garages, the extension of existing dwellings (e.g. new deck, new room or wing), swimming pools, and new water tanks.

2. **Clearance of Vegetation** – includes the removal of all types of vegetation (both indigenous and exotic). It was noted in the attribute table if the vegetation cleared was contiguous with a larger area of forest and/or shrubland. Where possible, the vegetation was noted as being indigenous, exotic, or mixed.

3. **Regeneration** – includes previously cleared, disturbed or managed areas that have regenerated into shrubland. The assumption was that the majority of observations made related to regeneration of indigenous shrubland, although it is likely that in some cases it may have been exclusively exotic species, e.g. gorse, woolly nightshade and rank grassland.

4. **Impervious Surfaces –** includes areas that have been covered by tar-seal, concrete and bricks, e.g. new driveways and courtyards.

5. **Removal of structure** – includes any type of structure that has been dismantled and removed, which in most cases resulted in a net gain of permeable surfaces.

All changes were recorded and described in an attribute table in ArcGIS. The level of confidence of each change observed was recorded as either 'Low', 'Moderate' or 'High'. Occasionally, factors such as poor photo resolution and shading effects made it difficult to discern the type and extent of change that had occurred. Often an observed change would incorporate two types of changes, e.g. vegetation cleared to build a new dwelling would be labelled as 'Clearance of Vegetation' and 'Construction'.