Key Ecological Sites of Hamilton City

Volume I

CBER Contract Report 121

Client report prepared for

Hamilton City Council

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May 31st 2012

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Executive Summary

Ecological sites of significance previously identified in 2000 were reviewed in 2011. Natural vegetation in areas acquired by the city since 2000 was also surveyed to identify any new key sites. In total seventy key sites that met the Waikato Regional Council Regional Policy Statement criteria for ecological significance were identified across Hamilton City.

Of the original key sites, the total area covered by sites, average site size and overall quality of sites had increased between the 2000 and 2011 surveys. This was due to restoration efforts across the city by Hamilton City Council and the community. Vegetation restoration efforts have had other biodiversity and ecological benefits such as providing additional habitat for the city's increasing tui population.

Key sites are not spread evenly across the city or across landform types. Most key sites are either in gullies or adjoining the Waikato River. Less than 1% of urban alluvial plains and peat bogs are key sites. Two sites on private land have degraded and no longer meet the ecological significance criteria in 2011.

The current survey utilised a standard methodology focused on vegetation types. There will be other significant sites not identified including sites with significant fauna values but a detailed and costly survey would be required to identify all such sites.

The 1.5% of the city area covered by key sites is well below the 10% minimum recommended to prevent biodiversity decline in urban areas. Areas where vegetation restoration has begun in the city have the potential to expand existing key sites or develop new sites if council and community efforts continue in the future. The Council and its restoration partners should continue to seek ways of increasing native vegetation cover in Hamilton City and restoration of the distinctive gully landform remains the best option.

Report Context and Overview

Overview

In December 2010 the University of Waikato's Centre for Biodiversity and Ecology Research was contracted by Hamilton City Council to review the significant natural areas (henceforth known as "key sites") previously identified within the city boundaries. Any additional key sites in Hamilton City as a result of remediation work or extension of Hamilton City boundaries were also to be included. As with past reports, the significance of a site was based largely on the ecological significance of vegetation and there was no systematic attempt to identify significant fauna habitat or cultural values of a site.

The identification of Key Sites fulfils part of Hamilton City's obligation under section 6 of the Resource Management Act 1991 (RMA) to "recognise and provide for the following matters of national importance: The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna". The Waikato Regional Policy Statement (RPS) outlines a strategy for implementing the RMA in the Waikato Region, including the need to maintain and enhance indigenous biodiversity. The city could meet its obligations with district plans taking indigenous biodiversity into account when developing a local biodiversity strategy; creating reserves along the banks of lakes and water ways to provide linkages and enhance biodiversity; re-creating and restoring natural habitats in the district and managing activities e.g. subdivisions. Local biodiversity plans need to recognise indigenous biodiversity in their districts by identifying opportunities and priorities for re-creating, restoring and linking habitats. Key sites in the district need to be mapped, given a biodiversity value and have any protection or enhancement needs identified. To map, prioritize and develop strategies to enhance Hamilton City's indigenous biodiversity, key sites inside the city boundary have been identified previously within three reports across four years. Those reports are described below.

In the Downs et al. (2000) report information was provided on the ecological character of Hamilton City, focusing on terrestrial ecosystems. The result of the corresponding survey identified 67 key sites within the Hamilton City boundary. A description of each of these sites was given with information on ecological characteristics, condition and spatial distribution in the contexts of both citywide and regional scale. Recommendations on management strategies and policy responses were also given.

Due to development in the north of Hamilton City, Stevens et al. (2002) produced a report on the vegetation of the Te Awa o Katapaki Gully and the adjoining river terrace. This report identified sites and features of ecological and environmental value in the study area, including the key sites identified by Downs et al. (2000).

Due to its proposed inclusion within Hamilton City the village of Temple View was surveyed by McQueen (2004) for areas of ecological significance, following the method of Downs et al. (2000). This resulted in one key site being identified.

The review of Hamilton's District Plan triggers the need for a review of key sites to document any changes to area, quantity, vegetation type, biodiversity and quality of the sites of Hamilton City.

Hamilton City Boundaries

Since 2000 the boundaries of Hamilton City have been extended to include new areas in the west, north and east of the city (Figure 1). Temple View village was transferred to Hamilton City from the Waipa district in July 2004. This area is bounded by Tuhikaramea Road and Wallace Road, extends around the campus of the now defunct Church College of New Zealand and up to Koromatua Road, enclosing the village of Temple View and some farmland. In 2011 two areas were transferred over from the Waikato District to Hamilton City (Hamilton City Council & Waikato District Council 2005). These areas were Ruakura in the south east and Te Rapa North in the north. Ruakura comprises of 730 hectares of land that includes Innovation Park and surrounding farmland. Ruakura is bounded by Greenhill Road in the north, the Mangaonua Gully on the west and the planned Waikato Expressway on the east. Te Rapa North is 240 hectares bounded by the Waikato River, Horotiu, and the planned Te Rapa bypass. Adding the 2011 boundary extensions to the 2004 city area increases Hamilton City from 9860 hectares to 11080 hectares (Hamilton City Council 2011).

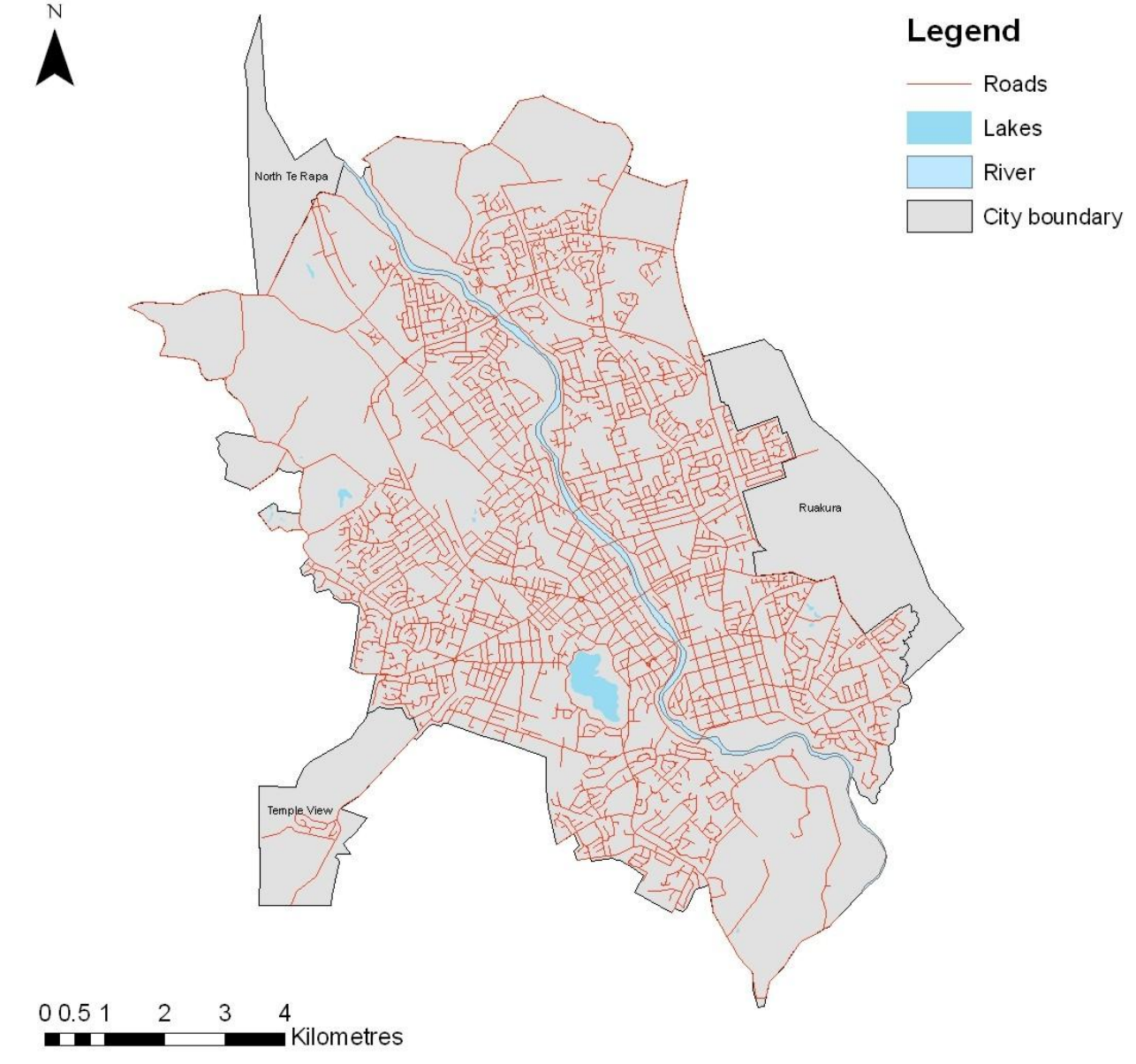

Figure 1: Hamilton City boundary with post 2003 additions

Ecology of Hamilton

Climate

Due to the sheltered inland location of the Waikato basin seasons consist of mild winters, warm, humid summers and frequent fog (Environment Waikato 2010). At the Hamilton Airport monitoring station in 2009 the average temperature was 13.2 ˚C, with 1088 mm of rainfall, and 2120 sunshine hours (National Institute of Water and Atmospheric Research 2010).

Although Hamilton City does not usually suffer extreme climatic events, in the summer/autumn of 2008 the whole Waikato Region suffered a severe drought, with rainfall the lowest it had been in approximately 100 years. This resulted in increased plant mortality across the city. Losses were seen in key ecological sites such as Claudelands Bush and Horseshoe Lake (Cornes et al. 2008; Cornes & Clarkson 2010).

Geology

The bedrock of the Hamilton basin is comprised of greywacke basement rock that was eroded to a plain about 100 million years ago (mya). Peat swamps began to form as the surface warped and created depressions about 50 mya. By 30 mya the area that is now the Hamilton basin was submerged under the advancing sea, depositing sandstones and limestones on the seafloor. Differential uplift created the basins and uplands that now form the Waikato Region. Volcanic activity distributed ignimbrite and volcanic material across the Hamilton Basin, which was then shaped by the action of the Waikato River and its associated streams to create the hilly landscape that characterises the current Hamilton Basin (McCraw in Clarkson et al. 2002).

Landforms and Vegetation Types

Hamilton City is comprised of four main landform units: hills, alluvial plains, gullies, and peatlands. In the past most of these areas were dominated by indigenous forest.

Low rolling hills and the foothills (9.5%) of ranges at the edge of Hamilton are generally comprised of late Quaternary parent material that used to be dominated by rimu-tawa forest and kauri-hard beech forest. On the footslopes of the low rolling hills the parent material is represented by poorly drained colluvium from Hamilton Ash and other deposits. The main vegetation type supported by this landform was pukatea-kahikatea forest (Clarkson et al. 2007).

Low mounds or ridges of alluvial plains (58.6%) are characterised by moderately to well-drained alluvium from the Hinuera formation which predominantly supported mixed conifer-broadleaf forest. In shallow depressions or swales the alluvium has more silt and clay, and hence drains less readily. This created the boggy areas that were dominated by kahikatea semi-swamp forests. In lower terraces (2.4%) beside the Waikato River (3.1%) the alluvium has more sand and gravel and is better drained. This well drained area suited totara-matai-kowhai forest (Clarkson et al. 2007).

Gullies (7.0%) were formed about 15,000 years ago through a process called spring sapping. As the Waikato River cut down creating steep banks, aquifers were exposed. These eroded steep-sided troughs back from the river bank, which eventually became Hamilton's gully system. Gullies have two main land units: the steep gully sides, and the gully floor. On the sides, soil material is well-drained, generally from the Hinuera formation and supported totara-matai-kowhai forest. The

gully floors are more poorly drained and were dominated by kahikatea-pukatea-swamp maire forest (Clarkson et al. 2007).

Peatlands include peat lakes (0.5%) and peat bogs (19.0%), all of which are generally very wet and poorly drained areas. These areas hosted a range of vegetation types including submerged vegetation, swamp forest, sedgelands, shrublands and restiad bogs (Clarkson et al. 2007).

Fauna of Hamilton City

Gully Systems

Sprawling over approximately 770 hectares (7.0%) of Hamilton City is a series of gully systems. They include the four major gully systems of Kirikiriroa, Mangakotukutuku, Mangaonua and Waitawhiriwhiri, and numerous minor systems.

Collier et al. (2009) surveyed and assessed the value of these streams and gully systems in Hamilton's Urban environment. Indigenous species found included the shortfin eel, longfin eel, banded kōkopu, giant kōkopu, inanga, common smelt, common bully, and torrentfish. Exotic species included koi carp, gambusia, catfish, and indeterminate trout. Many of the indigenous species found are rare or in decline and their presence in these urban environments lends great value to these gully systems.

Smith (2007) surveyed three gully streams within Hamilton City for mayflies, stoneflies and caddisflies. Twenty six species were found. Due to the sampling method this figure is likely to under-represent actual species diversity. Mangakotukutuku Gully had the highest diversity with 13 species found. Kirikiriroa Gully and Waitawhiriwhiri Gully had eleven and six respectively. In the Mangaiti section of Kirikiriroa Gully a new species of *Oxyethira* was discovered. It was suggested that the high species diversity for an urban area was due to the large number of vegetated gullies with riparian cover, which increases habitat complexity.

New Zealand's Long-Tailed Bat is an endemic mammal that has persisted in Hamilton City, despite its disappearance from other cities in New Zealand. These bats are seriously threatened by habitat loss and rat predation. Echo-location detection has allowed surviving pockets of bats to be identified, particularly in Mangaonua Gully, Mangakotukutuku Gully, Hammond Bush and surrounding areas (Figure 2). Bats play an important role in ecosystems as aerial insectivores (Le Roux 2010). Echo-location studies have shown that populations of bats roosting outside the city use the gully systems of Hamilton to migrate to the Waikato River. This is an indicator of the importance of these gully systems for wildlife corridors in Hamilton City (Parsons & Dekrout in Collier et al. 2010; LeRoux & LeRoux, 2012).

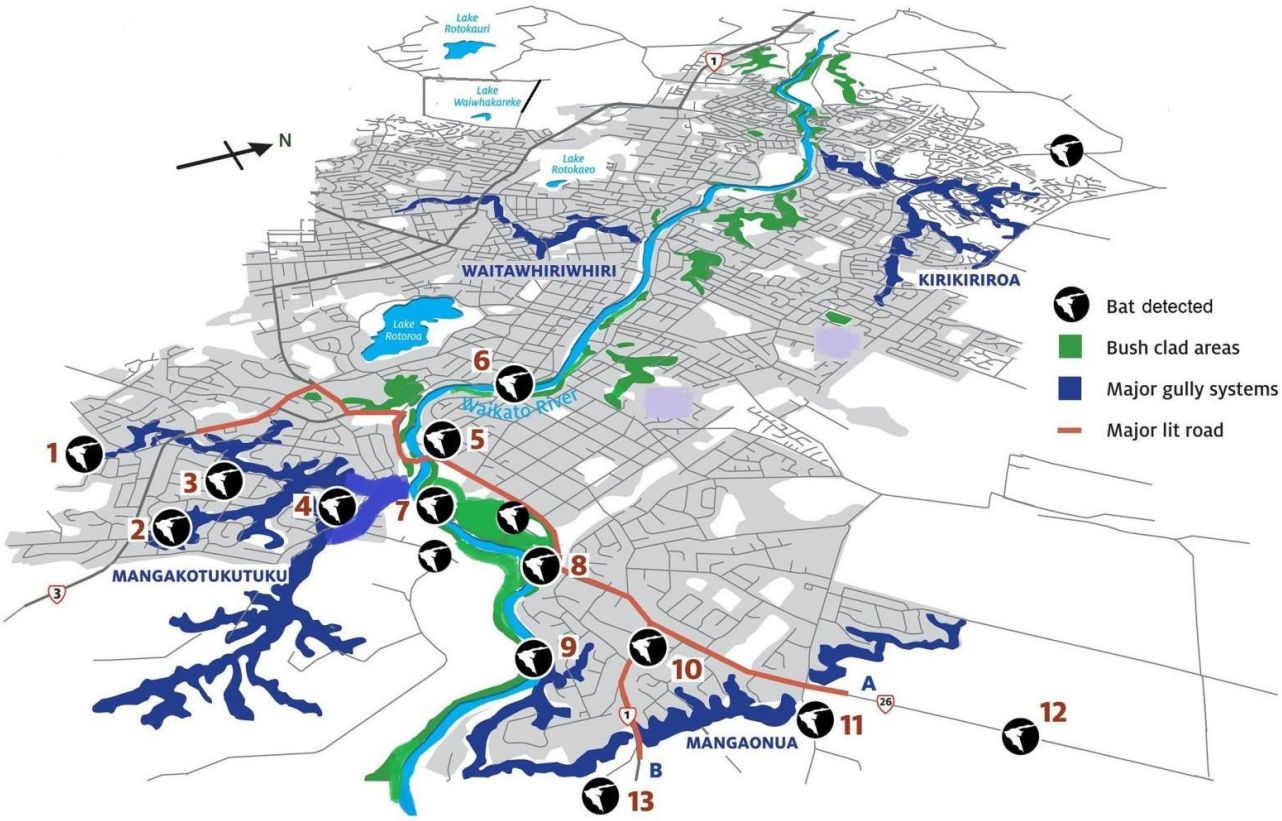

Figure 2: Long-tailed bat distribution for Hamilton City: Confirmed bat activity with numbers while confirmed sightings are unnumbered (Waikato Regional Council (2010); LeRoux & LeRoux, (2012))

Waikato River

New Zealand's longest river is a key feature of Hamilton City. This wide single-path river cuts Hamilton City in two with its deep channel and provides an ecological corridor for the movement of both indigenous and exotic wildlife.

A survey by Hicks et al. (2005) of four locations on the Waikato River just south of Hamilton City showed the presence of brown trout, common bully, goldfish, inanga, koi carp, grey mullet, rudd, shortfin eel, and smelt.

Peat Lakes

Hamilton is home to a number of peat lakes including Lake Rotoroa, Horseshoe Lake (within Waiwhakareke Natural Heritage Park), and Lake Rotokaeo. Lake Rotoroa is near the city centre and has a surface area of approximately 55 ha. It is relatively young, forming 16,000 years ago when the Waikato River changed its path. Horseshoe Lake (Lake Waiwhakareke) is a small peat lake located near the corner of Brymer and Baverstock Roads. It is the focus of a restoration project that is intended to span the next few centuries with the aim of improving the lake's water quality and recreating the historic vegetation types that were once present in this area. In the future this lake could become suitable for the introduction of native mudfish, a species that is currently threatened in New Zealand waterways (Parks and Gardens Unit, Hamilton City Council 2010). Lake Rotokaeo (Forest Lake) is a shallow peat lake located in Minogue Park off Forest Lake Road. Eleven fish species have been found in these peat lakes, including natives and exotics (Table 1).

Table 1: Fish recorded in Lake Rotoroa, Horseshoe Lake, and Lake Rotokaeo

Common Name	Lake Rotoroa (Hicks 2003)	Horseshoe Lake(Hicks, Osborne et al. 2005)	Lake Rotokaeo (Hicks, Brijs et al. 2009)
Brown bullhead catfish	•	•	•
Common bully	•	•	
Gambusia	•	•	•
Goldfish	•		•
Longfin eel	•	•	
Perch	•		
Rudd	•	•	
Shortfin eel	•	•	•
Tench	•		
Brown Trout	•	•	
Giant Kokopu	•	•	
Frog tadpoles	•	•	

Birdlife

The Ornithological Society of New Zealand regularly conducts a census of the bird species seen in different areas around the country. Monthly censuses are conducted at Hamilton Lake and Horseshoe Lake. Between January 2010 and January 2011 both land bird species and waterfowl were identified. Land bird species included Australasian harrier, blackbird, chaffinch, fantail, feral rock pigeon, goldfinch, grey warbler, magpie, mynah, silvereye, skylark, song thrush, sparrow, spur-winged plover, starling, welcome swallow and white doves. Water fowl included Australian coot, black shag, black swan, black teal, Canada goose, domestic duck, domestic white goose, farmyard duck, grey duck, grey teal, hybrid duck, kingfisher, little black shag, little shag, mallard duck, Muscovy duck, New Zealand dabchick, paradise shelduck, pied shag, pied stilt, pukeko, and white faced heron (Ornithological Society of New Zealand 2010a, 2010b, 2010c, 2011).

Other species known to be found in Hamilton include the Australasian shoveller, shining cuckoo, yellowhammer, white headed stilt, little pied cormorant, Caspian tern and notably, tui and bellbird (Fitzgerald & Innes 2009).

Local council, regional council and research institutions have combined efforts to increase native bird numbers within the city. Before 2007 tui had been regularly sighted in the city but none were known to permanently lived or bred there. Hamilton Halo was started in 2007 with the aim of re-establishing a population of tui within Hamilton City. It was intended that by increasing tui numbers outside the city using focused pest control in forest close to Hamilton visits of tui to Hamilton would increase leading to birds again nesting in Hamilton and becoming permanent residents. This operation has been successful in reducing predator numbers in selected forests and increasing tui with the city. Fifty bellbirds were reintroduced to Hamilton city in May 2010. In 2011 a bellbird fledgling was sighted, suggesting bellbirds may be successfully breeding in Hamilton (Waikato Regional Council, 2011).

Methodology

Identification of Potential Sites

To identify ecologically significant sites within Hamilton City boundaries satellite images were obtained and the updated boundaries overlaid using a Geographic Information System. Within these boundaries, potential sites were identified by vegetation cover. These sites along with those identified in previous reports were visited and assessed using a set of significance criteria as outlined in the Waikato Regional Policy Statement (2007) (Table 2).

Table 2: Ecological significance criteria (Sourced from http://www.ew.govt.nz/PageFiles/6777/rpsdecember07.pdf, pages 216-217). Examples adapted for a Hamilton City context.

Criteria	Example
Criteria 1 - Protected or Preserved	Queen Elizabeth II National Trust
Criteria 2 - Recommended for Protection	Identified by DoC (1993) as being worthy of protection
Criteria 3 - Threatened or Endemic Species Habitat	Bat feeding site
Criteria 4 - Under Represented	A patch of wetland which is under-represented (or rare) in the Hamilton Ecological District
Criteria 5 - Uncommon Before Settlement	River islands
Criteria 6 - Indigenous Wetland Habitat	Contains (or is likely to contain) a natural wetland.
Criteria 7 - Large Indigenous Habitat	c. 3 ha podocarp forest remnant in Hamilton City
Criteria 8 - Critical Aquatic Habitat	Wetland with potential mudfish habitat
Criteria 9 - Healthy Indigenous Vegetation	Representative remnants of moderately dense podocarp forest
Criteria 10 - Rare or Exceptional Representation	Nationally rare Sporadanthus-Empodisma bog habitat
Criteria 11 - Ecological Buffer Linkage or Corridor	Indigenous forest connected with a gully system

Field Assessment

Once dominance of native vegetation or abundance of native plants of the site was established, a detailed assessment was conducted using the significant natural area (SNA) form given in Appendix one. The key points of the assessment are explained in the following paragraphs.

General Information

General information for identified sites included tenure, protection status, fencing, and matrix land-use. Each of these was given a number ranking between 1 and 4, 5, or 9 that corresponded to a particular criterion. For example, fencing can be ranked: (1) secure, intact fencing around the entire perimeter; (2) mostly fenced, areas where stock access is likely; (3) some fencing, one side, or large breaks; (4) no fencing. Owner details were also recorded including name, address, contact numbers, and email if available.

Description of the Site

These included but were not limited to: aspect, slope, condition (canopy, understorey, leaf-litter), unusual (or common) characteristics, surrounding land use, dominant vegetation communities, uncommon species, history of site/landowner's comments.

Habitat and Vegetation Description

Habitat and vegetation descriptions were taken for each of the individual land units within each site. These descriptions included the unit number, hydrological regime, category, code, character, area, and vegetation description. Criteria for the classification of hydrological regimes are given in Table 2. Category and code were used to describe the vegetation of the unit. Each unit was classified into category A, B, C, or D, which correlate to wooded/treefern habitats (e.g. podocarp forest), grass/herb/moss habitats (e.g. sedgeland), bare habitats (e.g. rocky coast), and other habitats (e.g. roads/railways) respectively. Character refers to whether the unit is indigenous or exotic based on an estimate of the abundance of indigenous and exotic species. A proportion of greater than 50% qualifies the unit for classification into either one of these categories. The area of each unit was estimated and given a corresponding code (Table 3). Vegetation descriptions were based on Atkinson (1985) to give an indication of abundance, and presence or absence of tiers.

Table 3: Hydrological regime classification criteria

Code	Character	Explanation
1	Terrestrial	All dry areas of land not covered by a wetland hydroclass (see below)
2	Estuarine	Coastal waters semi-enclosed by land and partially diluted with fresh water
3	Riverine	Flowing waters contained within a channel: rivers, streams, and their margins.
4	Lacustrine	Lakes or dammed rivers with open water
5	Palustrine	All other non-tidal wetlands, small open water bodies, and vegetated wet ground.

Table 4: Area estimation codes

Code	Area Estimation
Q	< 5 x 5 m
R	5 x 5 m
S	10 x 10 m (100 m^2)
T	20 x 50 m (0.1 ha)
U	>0.1 < 1 ha
V	>1 < 5 ha
W	> 5 < 10 ha
X	> 10 < 25 ha
Y	> 25 < 100 ha
Z	> 100 ha

Flora and Fauna

Lists were made of the flora and fauna at the site, identified either by observations during the survey or from landowner's previous observations. Special note was made of rare, threatened, or distinctive species at each site. Vegetation was described in more detail, with particular reference to the condition of each tier.

Threats

This referred particularly to pest plants (e.g. vine weeds) and animals (e.g. stock) which are, or have the potential to become, significant threats in the area. For each unit a rating of one to four was given for the abundance or cover of ground cover weeds, vine weeds, and shrub or tree weeds. A rating of one indicates a very common weed with over 50% ground cover. A rating of four indicates none present. Dominant species were noted and comments or suggestions for potential management were given. The main animal pests concerned in this survey were stock. Again, a one to four rating was given for each unit, describing the abundance and frequency of stock presence in the area. Management suggestions were also given.

Human Associated Activities

Evidence of human associated activities was recorded and given a rating for impact of the activity, and for the attitude of the involved parties toward remediation. Activity examples include: rubbish dumping, stock grazing, drainage, earth works, erosion, top dressing, fire, vegetation clearing, herbicide application, harvest/vegetation clearing, planting, animal pest control, domestic pets, and fencing. Recommendations for mitigation were given.

Climatic Conditions during Survey

An indication of humidity, cloud cover, wind and temperature was recorded for the time of the site survey in each location.

Context/Nearby Site Information

If applicable, scrub, forest, or wetland areas that were close to each surveyed site were recorded with information about dominant vegetation types, size and the condition.

Management Recommendations

Management recommendations follow Downs et al. (2000) but are limited because the survey is predominantly focussed on vegetation. Recommendations follow a canopy manipulation method with inter-planting of indigenous species where necessary. This method is recommended with consideration of the cost of weed removal, the benefits of canopy protection to native plants, and bank stability from plant retention on steep sites. Recommendations to increase native animal populations have not been given.

On the SNA sheets under Management Recommendations the management technique code (see below) is given followed by the species that needs removal and possible indigenous species to plant. For example a grey willow dominant forest would have M1: Grey willow. Planting: mahoe, pate, kahikatea.

Forests and Scrub

Management action one (M1): Exotic dominant canopy

Retain canopy dominant exotics until indigenous species in the understorey have developed enough to form a replacement canopy. When this occurs (and if safe to do so) canopy exotics can be poisoned and left to die where they stand. This means the structure of the canopy is still providing protection for the layer beneath. If the understorey is sparse or indigenous species are not dominant remove understorey exotics and plant natives.

Management action two (M2): Native dominant canopy

Exotics in the canopy can be left to naturally senesce, while exotics under the canopy need removal. If exotics form dense patches in the canopy follow M1 method.

Management action three (M3): Exotics in the understorey

Remove exotic weeds from the understorey, targeting species which could develop into canopy trees. If understorey has few indigenous species, undertake planting.

Management action four (M4): Exotic groundcover

Remove invasive exotic groundcover and invasive exotic seedlings.

Shrubland

Management action five (M5): Exotic species

As no understorey exists in a shrubland exotic species should be removed. If this forms large gaps in the canopy, indigenous species should be planted within gaps.

Open Wetlands

Management action six (M6): Exotic trees

Invasive exotic trees need to be removed or poisoned and left to decay.

Management action seven (M7): Other exotics

Remove invasive exotics from the wetland and plant indigenous species in any large gaps.

Exotic Vines over all vegetation types

Management action eight (M8): Exotic vines

Where possible remove the exotic vines or stop their spread by cutting and pasting stems in mature canopy or if vines form self-supporting tangles or are growing with other exotics, spray and mechanical remove.

Ecological Rankings

Using all information gathered from the survey an ecological ranking was determined for each site. Rankings followed the scale and criteria set out in Downs et al (2000), which comprised of a three point scale. Key sites were ranked 1, 2 and 3 for sites of very high, high and moderate ecological value.

Results

City-wide Extent of Key Sites

Of the 67 Key Ecological Sites identified in Downs et al. (2000) 65 still fit the criteria. Two new key sites were located in the current survey within the 2000 city boundary. Three new key sites were found in the 2011 boundary extensions of Temple View and Te Rapa North. No sites were located in the 2011 Ruakura extension, although two existing key sites within Ruakura had their size increased due to the boundary change. SNA site sheets for each key site are given in Volume II. In Volume II some sites are grouped together due to site connectivity. A summary of all key sites is given in Appendix two and the justification for their inclusion is provided in Appendix three. A list of species noted in key sites is given in Appendix four.

The total area covered by key sites within the city has increased since 2000 due to new sites being added and area increases of previous sites resulting from restoration work (Table 5). The average size of key sites increased by 0.4ha (peat lakes excluded). In 2011 approximately 1.5% of the city is covered by key sites. When the 55.9ha of peat lakes within the sites is excluded this is adjusted to 1.0%. This gives a 0.2% increase in area of the city covered by key sites between 2000 and 2011.

Two key sites were removed from the list (totalling 1 ha) and five were added (totalling 7 ha). Only one site had a decrease in total area while 27 sites had an increase.

Table 5: City-wide extent of key sites

	2000	2011
Total Area All Sites (ha)	126.9	163.8
Total Area All Sites (excl peat lakes) (ha)	71.0	107.9
Average Site Area (ha)	1.9	2.3
Average Site Area (excl peat lakes) (ha)	1.1	1.5
Total Area of Hamilton City (ha)	9427	11080
% City Area occupied by Key Sites (ha)	1.3	1.5
% City Area occupied by Key Sites (excl peat lakes) (ha)	0.8	1.0

Extent of the Key Sites by Land Unit

Seventy key sites were located in Hamilton City. The majority of key sites were in gully systems (47%), which equates to 27% of the total area of key sites (Table 6). Peat lakes made up the largest area (34%) of key sites. River islands made up the lowest number of sites and smallest land area (Figure 2). As with the last survey, no river sites were included. Some key sites such as Waiwhakareke Natural Heritage Park include more than one landform.

Table 6: Frequency and Extent of the Key Sites by Land Unit

Land Unit	% No. of Sites	Area of Sites (ha)	% Total Site Area
Alluvial Plain	14	19.9	12
Gully	47	44.7	27
Hillslope	7	10.9	7
Peat bog	3	7.3	5
Peat Lake	2	55.9	34
River Island	3	0.3	<1
Riverbank	24	24.8	15
TOTAL	100	163.8	100

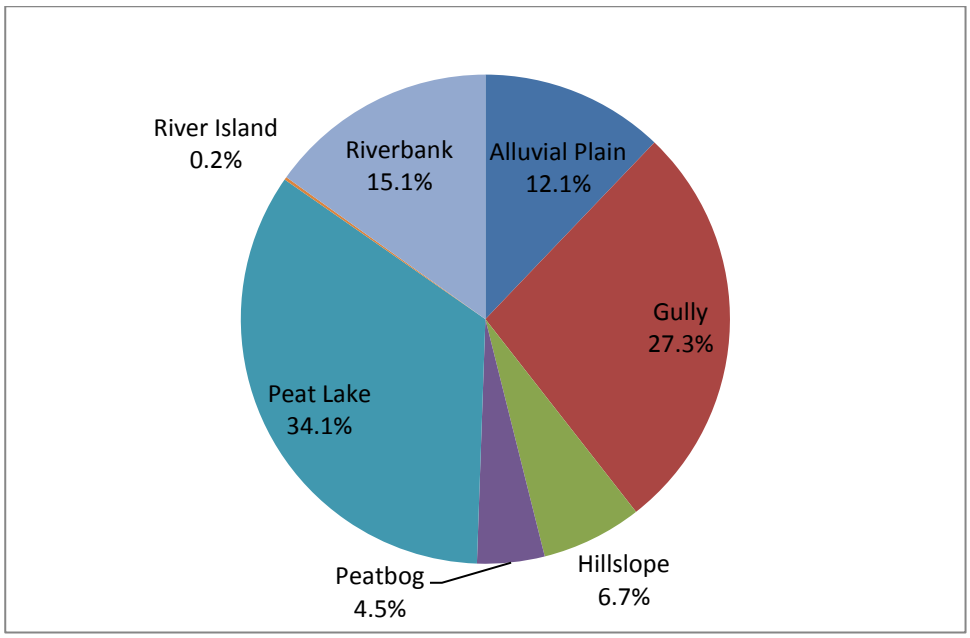

Figure 3: Extent of the Key Site Area by Land Unit

Analysis of Representativeness

Alluvial plains are the dominant landform of Hamilton City (approximately 59%). Despite this only 0.30% of the landform was occupied by key sites (Table 7, Figure 3). This was the lowest coverage for a landform with key sites present. The two smallest landforms in Hamilton City, peat lakes and river islands, had 100% cover of key sites, while all others had below 10% cover.

Table 7: Representation of Key Sites by Land Unit

Land Unit	Area of Key Sites (ha)	% City Area occupied by Key Sites	Est % City Area occupied by Land Unit	% Land Unit occupied by Key Sites
Alluvial Plain	19.9	0.18	59.7	0.30
Gully	44.7	0.40	7.1	5.79
Hillslope	10.9	0.10	9.7	1.04
Peat bog	7.3	0.07	19.3	0.35
Peat Lake	55.9	0.50	0.5	100
River Island	0.3	<0.01	<0.1	100
Riverbank	24.8	0.22	2.4	9.35
River	0	0	3.1	0
TOTAL	163.8	1.48	100	

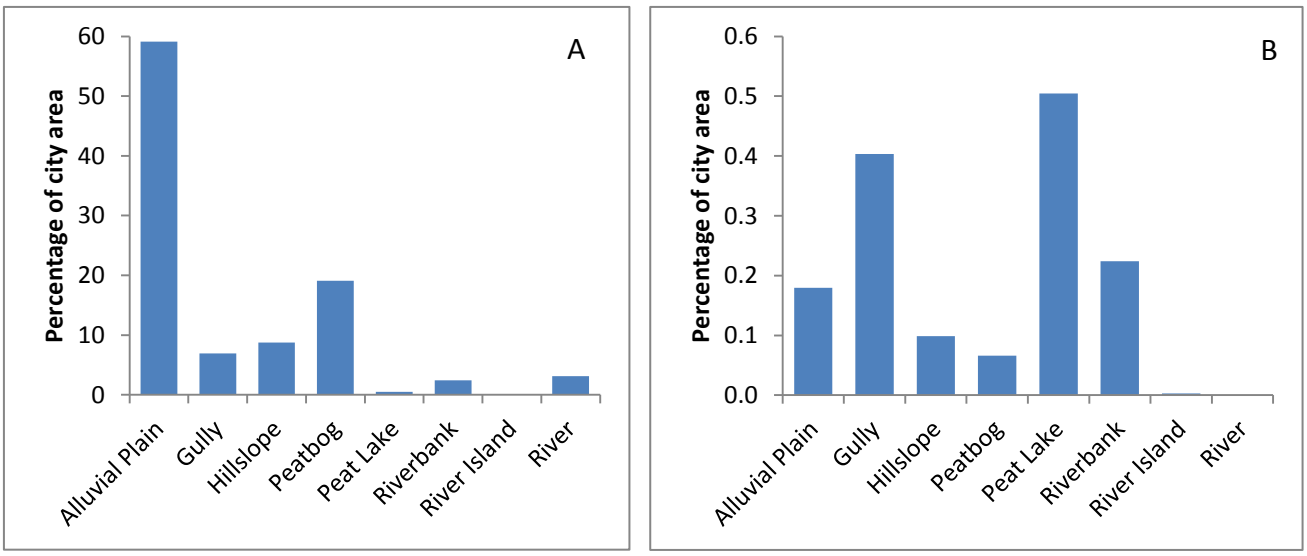

Figure 4: Representativeness of land units within A: the entire city and B: Key sites of the city

Analysis of Ecological Rankings

An increase in area across all ecological rankings has occurred from 2000 to 2011 (Table 8). The majority of sites are ranked 2 (Figure 4). Sites with an ecological ranking of 3 cover the least area. Fewer sites have an ecological ranking of 1 than in 2000. Although the total number of sites ranked 1 is the lowest of all three they make up 31% of the area covered by key sites. Sites with an ecological ranking of 2 also cover the largest area (Figure 5).

Table 8: Frequency and Area of Key Sites by Ecological Ranking

Ecological Ranking	Number		Area		Area (excl. peat lakes) (ha)	
	2000	2011	2000	2011	2000	2011
1	10	8	22.6	36.1	20.2	31
2	29	36	85.7	106.4	32.2	55.6
3	28	26	18.6	21.33	18.6	21.33
TOTAL	67	70	126.9	163.83	71.0	107.93

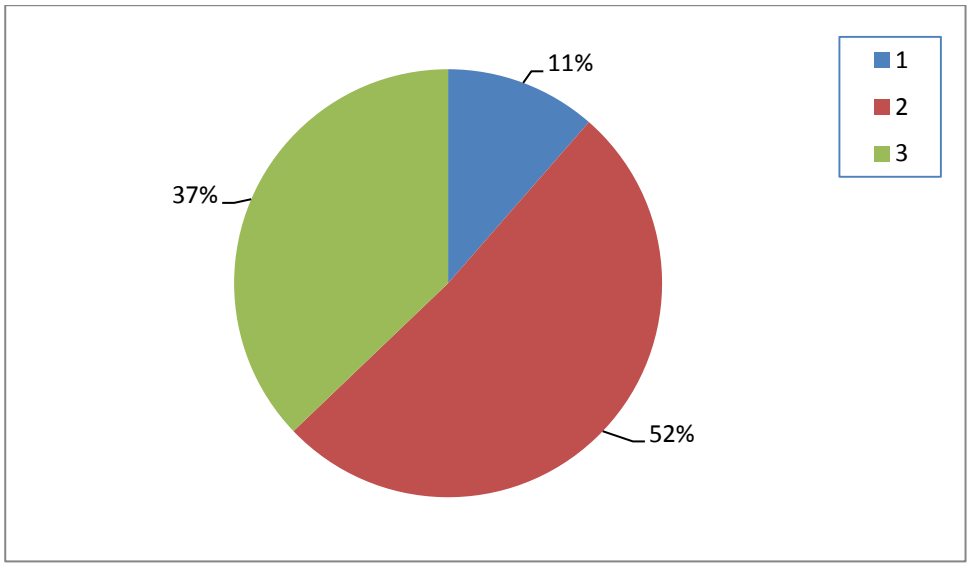

Figure 5: Frequency of Key Sites with each Ecological Ranking 2011

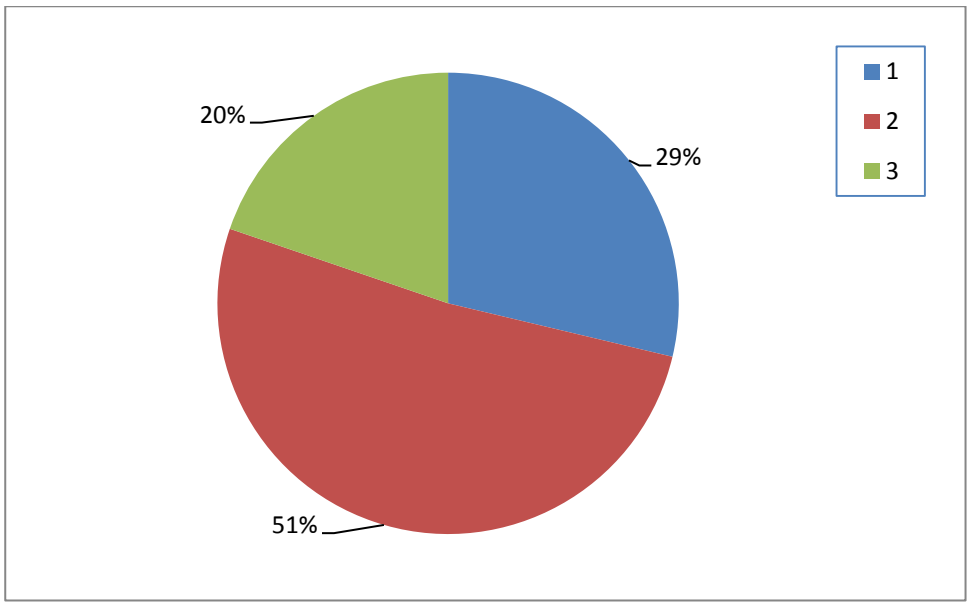

Figure 6: Area of Key Sites (excl. peat lakes) with each Ecological Ranking

Spatial Distribution of Key Sites

The majority of key sites are located on the banks of the Waikato River or in the Mangaonua Gully. Although the key sites are spread across the city from north to south and east to west, large areas of the city have no key sites within them (Figure 6). Areas with the fewest key sites are north-east of the city in north Rototuna; the eastern areas of Fairview Downs and Ruakura; north-west of the city in Burbush and Avalon; western areas such as Dinsdale and Frankton; and south of the city in Deanwell, Melville and southern Peacockes. The western side of the city has the fewest key sites, but all the peat lakes are found on this side of the city.

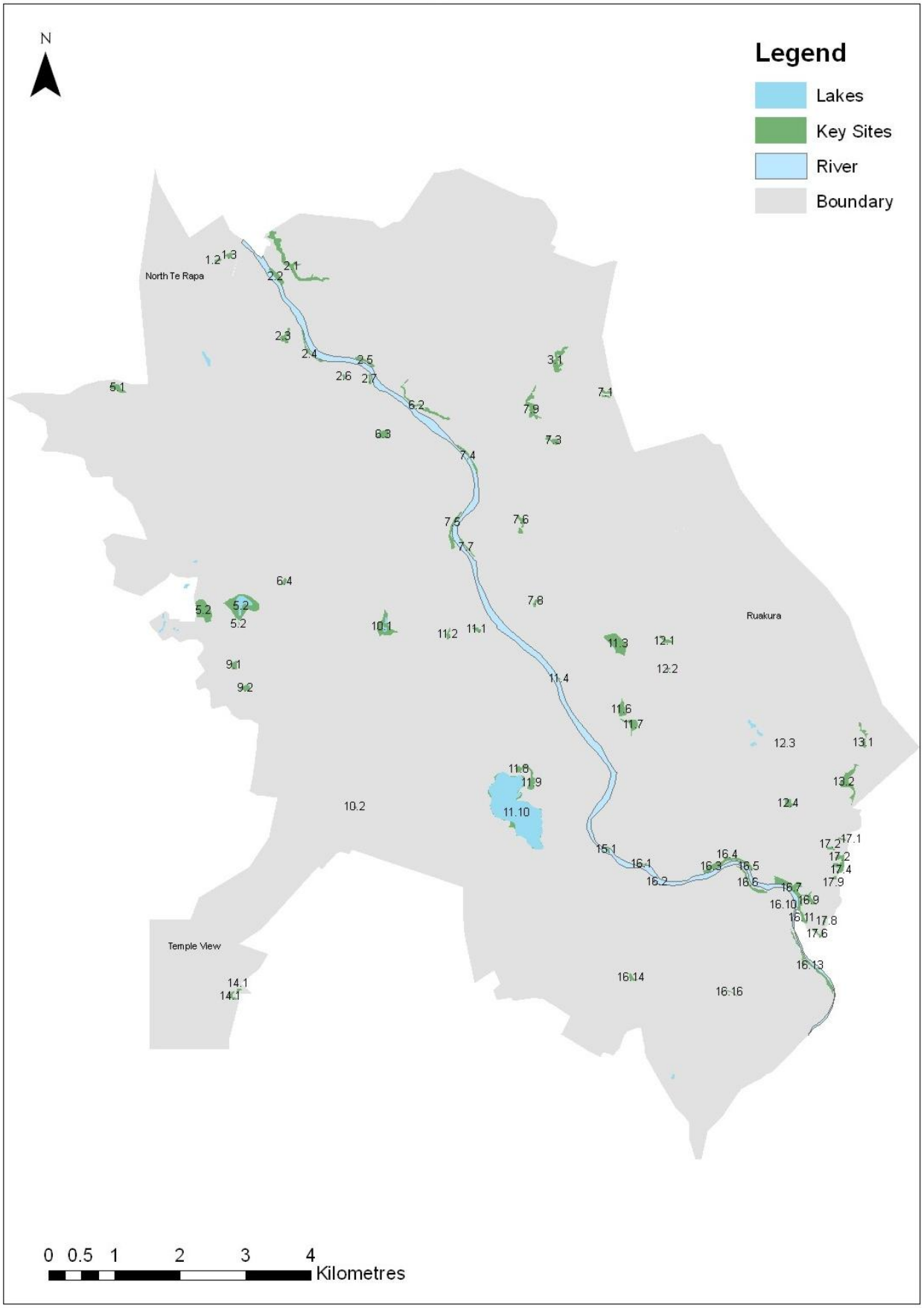

Figure 7: Location of key sites within Hamilton City

Discussion

Overview

Seventy key sites are found in Hamilton City. Five sites have been added since 2000 as a result of restoration efforts within the city and boundary changes. Twenty seven of the original sites had an increase in the area covered, with only one having a reduction. The original key sites have increased in area by a total of 49.3 ha. Losses to key site cover were due to property development, subdivisions and degradation from weed invasion. Increases in number and area of key sites can attributed to council, community groups and private residents' efforts to restore natural areas of Hamilton City. This has been helped by initiatives such as the Gully Restoration Programme and Waiwhakareke Natural Heritage Park. Sites under council or residential ownership were more likely to be improved than sites under industrial ownership.

Only 1.5% of the city is covered by ecologically significant land. In time it is possible other areas being restored around the city will meet the significance criteria outlined in Table 2. This takes place when planted vegetation matures, native trees regenerate and other native species colonise the area, as seen at Seeley's Gully in eastern Hamilton.

Spatial Distribution of Key sites

Gully Systems

Most Hamilton City gullies are undeveloped and provide a unique natural landscape feature to the city. These areas provide the greatest opportunity to expand natural areas within Hamilton City and connect adjoining landowners to the natural environment on their doorsteps. Along with the ecological benefits of gullies, these areas form part of the stormwater drainage network of Hamilton City. Vegetated areas of scrub or forest also provide these gullies with structure for bank stabilization. Five major and seven minor gullies within the city boundary contain key sites. Of these gullies, the majority have been partially or completely disconnected from the Waikato River. This is due to preparations for development such as earthworks, road construction and vegetation removal. A management plan including six gully systems was published in 2007 (Craig 2007), while Donny Park has its own management plan (Parks and Gardens Unit, Hamilton City Council 2004). These plans only cover publically owned land. When deciding how to manage key sites within a gully, the whole gully system should be taken into account due to the vegetation connectivity and buffering. The main gullies and their key sites are discussed below.

Te Awa O Katapaki

This is the city's most northern gully system. Although it contains only one key site it is the largest site within a gully. In the 2000 survey this gully was located within farmland but since 2001 residential development has been occurring and will continue around the majority of the gully. Farmland now only borders the north eastern section. Development has led to both positive and negative modification of the gully and its stream.

Hicks et al. (2001) surveyed the gully stream and found that while it was unpolluted, the stream had very high nutrient concentrations. Short finned eels were the dominant fish, with mosquito

fish and common smelt also present. They also found the stream had a relatively diverse macro-invertebrate fauna. Despite short term increases in sediment flow from development, it was hypothesized that the water quality would improve with the removal of cattle access to the stream.

Stevens et al. (2002) surveyed the vegetation of Te Awa O Katapaki gully. It was noted that this gully is a good candidate for restoration due to the large size of native dominant vegetation present, low weed species diversity, easy access, connectivity to the river, stream water quality and habitat diversity. Since then some of the recommendations have been put in place including putting part of the gully in public ownership, re-vegetating areas of wetland with indigenous species and the installation of some paths.

The current survey found cattle have now been excluded from the key site. Plantings have been installed partially around the edge of the kanuka forest and along the stream within the subdivision.

Kirikiriroa

Kirikiriroa gully and its tributaries run from Pukete Bridge to Gordonton Road and north to Somerset Heights. In the past the catchment was within a matrix of residential and farmland; it is now residential and parkland. This survey found six key sites located in the gully system, one more site than in 2000. Most of the sites are found either at the mouth or in the central part of the gully. For naturally establishing vegetation grey willow and cabbage tree are dominant canopy species on gully floors, while mahoe and wheki are dominant on the gully sides within many of this gully's key sites. The area covered by these sites increased from 5.1 ha in 2000 to 11.7 ha due to vegetation restoration efforts in the area. These efforts have resulted in the mouth of the gully being connected to the Waikato River and the adjoining riverbank key site by indigenous vegetation. Planting has led to an increase in native dominant wetland and native scrub habitat in the gully.

Mangakotukutuku

Located in the south west of Hamilton, this is the city's largest gully. Unfortunately it has the lowest key site cover of all the major gullies. All sites are under 1 ha in size and are the only sites found in the south west of the city away from the river. Both stream and vegetation restoration efforts are taking place within the gully system to improve indigenous biodiversity. As plantings are young they cannot yet be considered ecologically significant. It is clear that when these plantings do develop, they will significantly increase indigenous species habitat along the stream and improve ecological function of both terrestrial and aquatic systems.

Mangaonua

Located predominantly at the south-eastern boundary of the city this gully system contains the highest proportion of indigenous vegetation, the highest number of key sites and covers the largest total area (excluding peat lakes). Key site vegetation is directly connected to Hammond Bush vegetation at the mouth of the gully. There are four main sections of key sites on this gully; two found at the mouth, four in the Riverlea suburb, five in the Berkley suburb and two in the

Silverdale suburb. As in Kirikiriroa Gully, the naturally established canopy vegetation on the gully floor is dominated mainly by willow species, while on the gully sides mahoe and treeferns are dominant. Unlike the other sections of the gully the Riverlea section (industrial zone) seems to lack restoration efforts. Restoration efforts have increased the size of key sites within the gully system by approximately two hectares.

Waitawhiriwhiri

Located on the western side of the city, this is a long, highly fragmented gully close to Hamilton's CBD. Two key sites are located in the gully within two kilometres of each other. Restoration is taking place within the cabbage tree-land dominant section of the Edgecumbe site. This gully provides an excellent opportunity to increase the indigenous vegetation cover in an area of Hamilton city where very few key ecological sites exist.

Other gullies

Apart from Gibbons Creek Gully, which has two key sites, the rest of the gully key sites are located across different gully systems within the city. These sites include Ranfurly Gully, Bankwood Gully and three Pukete gully sites. The gullies with the highest modification within Hamilton are in the Pukete/St Andrews area as many of the gullies and tributaries were filled by residential development decades ago.

Peat lakes

The three peat lakes are all represented in the five largest key sites within Hamilton City. The majority of larger indigenous vegetation species around peat lakes in Hamilton City has been planted but there are many apparent survivors among the marginal plants and ground cover, e.g. around Rotokaeo (Forest Lake). All of these lakes are shallow and eutrophic, which has caused problems with water quality and weed invasions. The main management goals for all of Hamilton's lakes are to improve lake water quality and enhance indigenous vegetation within the lake's catchment to levels that are representative of pre human settlement; this objective is constrained by a recognition that Rotoroa (Hamilton Lake) has an important recreational and amenity function, and all the lakes exist within an urban, modified environment.

Waiwhakareke Natural Heritage Park (Horseshoe Lake)

A large restoration effort has taken place at this site increasing the indigenous vegetation from 3ha to 16ha in size between 2004 and 2011. This accounts for almost all the increases in key site area on peatland, alluvial plain and hillslope landforms. When completed the majority of the lake's catchment will be in indigenous forest. The objective of the Waiwharareke Natural Heritage Park is to create a self-sustaining, pest-free habitat sanctuary that represents the original ecosystem diversity of the Hamilton Basin within the 60ha. All plantings at this key site are under ten years old, with the majority under five (Parks and Gardens Unit, Hamilton City Council, 2010b).

Lake Rotokaeo (Forest Lake)

Plantings around this lake have continued to improve the habitats and condition of the ecosystem. Since 2002 the invasive weed Mexican water lily has been controlled and is no longer dominant in

the lake. The management plan states that pest plants need to be monitored and in some cases controlled. There are future plans to increase plantings of indigenous wetland species both in and around the lake (Parks and Gardens Unit, Hamilton City Council, 2009).

Lake Rotoroa (Hamilton Lake)

Three key sites are found at Hamilton Lake. At 54 ha the lake and its surrounds are Hamilton's largest key site. Native riparian plantings have been increased around the lake since 2000. The largest increase in indigenous vegetation has been at the south side of the lake with the other sides having limited plantings but still having weed control. Invasive species Yellow flag iris and *Egeria densa* have been removed in the past. Monitoring and eradication of these species and other possible problem species such as water lilies will continue at this site (Parks and Gardens Unit, Hamilton City Council, 2010).

The 2010 Hamilton Lake Domain management plan includes priorities for management of the riparian vegetation. Key aims are; retain vegetation for wildlife habitat; increase riparian planting with eco-sourced plants; increase lake bank stabilisation by planting the margins; investigate the possibility of small scale artificial wetlands for stormwater control. There will still be some exotic amenity plants installed around the lake but the majority of new plantings will be native.

Riverbanks

No new sites were located on the banks of the Waikato River. The area covered has been extended by restoration planting and management. These riverbank areas help to provide ecological connectivity along the river and into adjoining gullies. Indigenous vegetation now connects the river bank to the mouths of the Kirikiriroa and Mangonua gullies. Vegetation also provides bank stabilization and amenity value along the river.

Reduced Key sites

Nawton Wetland (Farnborough Drive Reserve)

As stated in the Downs et al. (2000) report, the Nawton wetland site went through drastic clearance for a residential development in 2000. This site and areas of surrounding properties are prone to winter flooding. Vegetation clearance has also meant some peat shrinkage, which is affecting buildings and other structures (e.g. cracks in driveways). This is the only key site on terrestrial peatland without an associated surface water body. Even though Horseshoe Lake has a larger area of peatland vegetated with natural vegetation, Nawton wetland has a variety of species not found at the younger, planted Horseshoe Lake site. The ecological ranking of this site had reduced due to the high degree of modification.

Whyte St kahikatea

This site was already one of the smallest sites in Hamilton City in 2000. Since then subdivision of land has further reduced it and some large kahikatea trees were removed because of a safety hazard posed to the new buildings. Garden exotics have been planted in the area as well.

Pukete Wetland

The loss of this area as a key site seems to be through a lack of management leading to exotic weeds outcompeting indigenous species in the area. Raupo and indigenous open wetland plants are now absent while the exotic *Glyceria maxima* is now the dominant. There were still some native fern species under a canopy of grey willow.

Results in a Regional Context

Some 268 ecological districts have been recognised in New Zealand, on the basis of their differing climate, landform, soil, geology and biological features (Myers et al. 1987). They are commonly used as a spatial framework on coarse filter for significance assessment (Walker, et al. 2008) Hamilton City, at 11080 ha, makes up 7.0% of the 159375 ha of Hamilton Ecological District (ED). Hamilton ED is confined to the Hamilton Basin with some of the surrounding hills and foothills included (McEwen, 1987). Leathwick et al. (1995) found less than 2% of natural vegetation that once existed in the ecological district pre 1840s still remains. Wetlands and conifer forests were the dominant ecosystems of Hamilton ED before human settlement (Harding, 1997). These two ecosystems also suffered the highest percentage reduction through anthropogenic activities. All past vegetation types are less than 2% cover within the district.

Large stands of kahikatea forest are important in a regional context due to the reduction in conifer forest of any substantial size across the ecological district (Downs et al. 2000). The largest area of kahikatea forest within Hamilton ED is Whewells Bush (11.5 ha). Within Hamilton City, the largest kahikatea stand is Claudelands Bush at approximately 6.5 ha with the inclusion of recent plantings on the western boundary. As recognised in the 2000 report, all kahikatea stands with an ecological score of 1 should be considered regionally significant due to stand size, age and management.

The other sites with the highest ecological score are also regionally significant. As a consequence of widespread drainage of wetlands across New Zealand, *Sporadanthus ferrugineus* is only found naturally in three sites, all within the Waikato Region. For that reason the *Sporadanthus-Empodisma* restiad bog reconstructed at Waiwhakareke Natural Heritage Park can be considered regionally significant, even though it is planted. The two other regionally ecologically significant key sites are Key Sites 16.4 and 16.7 along the Waikato River. Key site 16.7 (Hammond Bush) is dominated by pukatea/swamp maire forest, which has been almost completely removed from the Hamilton ED landscape. Both Waiwhakareke Natural Heritage Park and Hammond Bush are managed by planting of indigenous species and undertaking weed and pest control. The steep riverbank of the kamahi-mamaku forest of Key Site 16.4 (Riverbank Mamaku-kamahi forest, Hamilton Gardens) makes management difficult but this inaccessibility also helps with its preservation. This forest type is rare along the banks for the Waikato River and is the only example of this vegetation type within the city.

The severe loss of indigenous vegetation from both Hamilton City and Hamilton ED makes protection and enhancement of all indigenous vegetation essential within the city, especially if connectivity between indigenous remnants can be enhanced. As stated in Downs et al. (2000) and Harding (1997), very few opportunities are left in the district for indigenous ecosystem protection; therefore managing what still exists is extremely important.

Threats to the Key Sites

Threats to key sites are the same as set out by Downs et al. (2000). Updated information is provided below.

Invasive Weeds

Thirty four percent of dominant key site canopy species were exotic. Four of these are in the banned plants register (National Plant Pest Accord): grey willow, crack willow, tree privet and Japanese honeysuckle. Of the 162 exotic species recorded in key sites, 38 are classed as weeds. Under the Waikato Regional Pest Management Strategy 26 recorded species are classed as weeds. According to Howell (2008) 94 of the exotic species found are ecological weeds. One key site has already been lost to weed invasion and others are at risk if weeds remain uncontrolled. Totara Park is one site where weed control would be particularly valuable to improve the chances of kahikatea surviving competition from grey willow, as grey willow will out-compete the kahikatea and prevent regeneration (Coleman, 2010).

Vertebrate Pests

Morgan et al. (2009) surveyed 18 Hamilton gully, parkland and residential sites. Signs of rats, mice, hedgehogs, cats, possums and rabbits were found in the study area. No mustelids were detected and are therefore absent or in low numbers. Rats, mice and possums were found in the highest abundance in gully sites. Gully sites were the only sites where all animals were detected. These animals cause browse and predation damage to indigenous flora and fauna. High vegetation cover, inclusion of waterways and connectivity between rural and urban zones were reasons given as to why pest numbers were higher in gullies. Innes et al. (2010) studied ship rat densities in both managed and unmanaged forest fragments. It was found when forest fragments were managed the vegetation and leaf litter increased; unfortunately, so did the number of rats. To successfully protect indigenous flora and fauna, vegetation stands need both plant and animal pest management.

Surrounding Land Uses

Knowing what effect the surrounding land matrix is having on an area is important for the overall management of a site. Not only does the land immediately adjoining the site have an effect but also the land use in the local catchment. Studies have shown different land uses affect hydrological regimes, water quality, biodiversity and micro-climate of forest fragments (Mensing et al. 1998; Hicks et al. 2001; Denyer et al. 2006; Gobel, et al. 2007, Miller, 2011). Negative land use impacts include farming increasing nutrient runoff into the area, subdivisions increasing water and pollutant runoff and open spaces such as parklands increasing the edge effects in vegetated areas thus decreasing moisture and habitat sustainability. Positive land use impacts include vegetated corridors facilitating species movement and providing shelter for fauna and pest control in forestry blocks benefiting indigenous flora and fauna adjoining forests. The majority of key sites are in landscape matrixes dominated by residential subdivisions, parkland or open space, and/or naturalised exotic or indigenous vegetation. As the landuse has changed from farmland to urban, nutrient runoff is likely to have decreased, but the stormwater runoff would have increased. This

can lead to increased erosion and flooding in an area. Increasing scrub and forest improves river and gully bank stability, decreases surface water flows, improves water quality and reduces edge effects.

Habitat Sustainability

Studies into habitat decline and biodiversity loss recognise that at least 10% of remnant habitat cover is needed across a landscape to stem large scale biodiversity loss (McIntyre and Hobbs, 1999; Rutledge, 2003; Drinnan 2005). Currently Hamilton City is approximately 970 ha short of this 10% target. Not only would Hamilton City require more high quality natural areas to achieve this threshold but habitat would need to cover a variety of landforms, ideally reflecting the proportion of landforms and vegetation types within Hamilton City. With this in mind, the alluvial plain and peat bog landforms are the most under-protected landform types of Hamilton City. These landforms have had the most residential and industrial development inside the city because of their accessible terrain. Priority should be given where possible to increasing the indigenous cover and biodiversity on these landforms as they have the highest risk of associated vegetation types disappearing from the city. Riverbank and gully landforms are the most likely to reach the 10% indigenous cover threshold as they only need 2 ha and 35 ha increases respectively. A high proportion of the riverbank and gully systems consist of wasteland vegetation. Therefore there is the potential for council and private land owners to convert this land to indigenous habitat. When Waiwhakareke Natural Heritage Park revegetation has been completed, 37 ha will be added across peat bog, alluvial plain and hillslope landform types.

Threat Mitigation

Threat mitigation to key sites is the same as set out by Downs et al. (2000). Updated information is provided below.

Weed Control

A broad range of management happens within Hamilton's key sites from no management to intensive management. Downs et al. (2000) recommended focusing weed control at the highest ranked ecological sites. Of the eight highest ranked key sites six are in full or partial council ownership. Of these eight key sites Claudelands Bush, Southwell School, Horseshoe Lake, Forest Lake, Hammond Bush and Berkley kahikatea key sites all have weed control and planting of natives. Weeds such as wandering Jew, Mexican water lily and grey willow are either under continual control or have been eradicated from these sites. The two other highest ranked key sites, Burbush Road and the Riverbank Mamaku-kamahi forest at Hamilton Gardens are not actively managed at present. Burbush Road is fenced but had no signs of active management. Riverbank Mamaku-kamahi forest, Hamilton Gardens is on steep riverbank and it may be unrealistic to manage the whole site due to safety concerns and the risk of damaging the environment. Recommendations by Downs et al. (2000) are still relevant today.

Connectivity and Buffering

Due to the importance of the connectivity between key sites and buffering of these ecologically important zones many of the closer riverbank and gully sites are collated on to the same SNA

sheets. As stated above, surrounding land uses affect key sites with connected areas having the most influence. Therefore, buffering, closest seed sources and fauna movement need to be taken into consideration for management of key sites.

Interactions with Landowners

Since the Downs et al. (2000) report there has been increased co-operation between council, landowners and community groups in the restoration and management of natural areas within Hamilton City. Forty two of the 70 key sites recognised have had some management input from the community as well as the council.

In 2001 the Gully Restoration Programme was initiated. The aim of this programme is to raise awareness and appreciation of Hamilton gully systems and actively promote and enable the physical restoration of the gullies. Through this programme the council has provided practical workshops and seminars, regular newsletters and approximately 2000 eco-sourced native plants annually to residents keen on restoring the sections of gullies on their properties (funded by both Hamilton City Council and Waikato Regional Council). Currently 800 residents, including schools, are on the gully programme mailing list and approximately 200 people have received plants from the council over the years (pers comm. Tim Newton, Hamilton City Council March 2011; Clarkson et al. 2012). This has led to enhancement plantings and weed control taking place in all the largest gully systems and some minor gullies in Hamilton City. This has contributed to the increase in size, connectivity and diversity within the gully systems.

Private and community group restoration has occurred at non-gully sites as well. Restoration efforts at Waiwhakareke Natural Heritage Park, Claudelands Bush and Hammond Bush have had a significant positive effect on those key sites. Both Waiwhakareke Natural Heritage Park and Hammond Bush have increased in size and quality from the 2000 survey. There are other projects around the city also enhancing both key sites and other areas with native planting and management.

Following the success of the Hamilton Halo project in increasing tui numbers within Hamilton, in 2010 Project Echo was established to gather information about the resident long-tailed bat population within Hamilton City. This project aims to discover the distribution, roosting sites and population density of Hamilton's bat population. Although the programme is in its infancy, several new bat locations have already been discovered within the city (LeRoux 2010, LeRoux & LeRoux 2012). Having healthy old growth native forest within Hamilton City is essential to support tui and bat populations as well as many other fauna species.

Long Term Strategy

Some of the steps recommended by Downs et al. (2000) as part of the long term strategy of the key sites have been executed. Below are the recommendations from that report, and notes on implementation, and their relationship to the proposed Waikato Regional Policy Statement (RPS) Part B. All the recommendations are still relevant today and efforts to implement them should continue.

1. Increase the reserve network to include a range of representative examples of indigenous ecosystems for all the major land units. RPS section 11.1

Some gully key sites have been added to the council parks and reserves network. Indigenous vegetation types have been planted across a range of landform types at Waiwhakareke Natural Heritage Park.

2. Restoration of sites in council ownership. RPS section 11.1.1d

Since 2000 thirty-three of the key sites in full or partial council ownership have had some vegetation restoration management. This has varied in size from a small area of planting at the edge of a site to full site weed control and planting of large areas with new vegetation types.

3. Acquisition of reserve contributions from new subdivision developments. RPS section 11.1.1a

Parts of the Te Awa o Katapaki Reserve have come into council ownership in conjunction with the subdivision of the surrounding land, with more to come as development continues alongside the gully system. The Gordonton Road key site gullies within the Puketaha development are scheduled to come under council ownership in the future.

4. A broader strategy for the long term management of the key sites. RPS section 11.1.6

Management plans have been developed for Hamilton City parks and reserves which include key sites but there is still no overarching plan for all key sites in Hamilton City. This overarching plan is still necessary to properly protect and enhance the key sites. It would also help with providing information to landowners and the public about key sites.

5. Linkage of key sites through restoration of intervening areas. RPS section 11.1b and 11.1.1c

As recommended, areas between key gully sites and riverbank sites have received focused restoration efforts to increase linkages.

6. Graham Island also presents excellent possibilities for restoration as Hamilton's only permanent river island. RPS section 11.1c and 11.1d

No restoration effort has apparently taken place on the island.

7. Suggested management for Lake Rotoroa includes keeping the wooded area weed free and monitoring of marginal weeds. RPS section 11.2.2b

Weed removal of region plants identified in the Regional Pest Management Strategy has been undertaken at this site, with ongoing monitoring of these species numbers.

8. Lake Rotokaeo; reducing the effects of trampling and cycling. RPS section 11.2.2b.

A raised boardwalk has been installed in the wettest areas around the lake.

9. Horseshoe Lake/Waiwhakareke Natural Heritage Park; the creation of the proposed 'living museum' and development of a comprehensive restoration plan. RPS section 11.2.2b.

The restoration of Waiwhakareke Natural Heritage Park has been underway for seven years now. An Operative Management Plan (2011) has been adopted incorporating a restoration plan with the overall objective of creating a self-sustaining, pest-free habitat sanctuary that represents the original ecosystem diversity of the Hamilton Basin.

10. Active management of Hamilton's single peat bog (Nawton wetland), including maintenance of a high water table. RPS section 11.2.2b.

There has been no active management of the vegetation at the Nawton wetland site. Fortunately the site retains natural characteristics as the water table is still high. A boardwalk has been installed at the site.

11. Street-side plantings with a focus on indigenous species to create linkages through urban areas. RPS section 11.1.b and 11.1.1c.

All new major roads in Hamilton have had plantings, dominated by indigenous species, installed alongside them. This has greatly increased potential new natural corridors around Hamilton City. Unfortunately on some roads such as the Pukete section of Wairere Drive weed species such as ivy and agapanthus were used as well.

12. Further encouragement and support of restoration by school and community groups and individuals will also build connections between areas of ecological value. RPS section 11.1.5

As stated in the interactions with land owners section above, there has been an increased linkage and co-operation between the council and Hamilton City residents in the protection and promotion of indigenous areas of the city. This has led to community groups, schools and individual landowners helping in the management of many of the key sites within the city.

Further Recommendations

Many of the recommendations made in Downs et al. 2000 have been acted on by the council with positive results for the city and its vegetation. The following recommendations supplement these previous recommendations.

- Fauna survey required (RPS section 11.2): These key sites are limited to the ecological importance of vegetation within the city. No survey was undertaken in relation to habitat of any fauna species within the city. The RPS states significant habitat of indigenous fauna needs to be enhanced and maintained as well as indigenous vegetation. A survey needs to be completed and collated with existing data to understand the city's fauna populations and habitats in order to produce a comprehensive key sites network. The requirements for protecting fauna can differ from protecting vegetation (e.g. maintaining of hydrological regimes for fish species), and these need to be taken into account in the management of Hamilton City's natural areas.

- Enrichment plantings (RPS section 11.2.2a): There are many sites around Hamilton City that have been planted to develop areas of parkland into indigenous forest. These plantings consist of early succession species such as tarata, kanuka and karamu. In the future these sites

could become part of the network of ecologically significant sites within the city. To promote this progression MacKay et al. (2011) suggests enrichment planting of later succession species, be undertaken once the early succession species have developed; probably before 20 years has passed. This increases species richness and brings sites closer to the state of mature intact forests. The present survey also showed that sites with low human disturbance and quality maintenance (e.g. weed control) were in the best state.

- Increase native habitat (RPS section 11.1.1): To stem the loss of biodiversity within Hamilton City it will be necessary in the longer term to aim for the aspirational threshold of 10% minimum vegetation cover. To increase native vegetation cover the council, industry, iwi and community groups need to continue restoration efforts around the city and investigate how to most effectively reach the 10% threshold. While this needs to be done across all landform types realistically most progress can be made in the gully landform and 100% restoration of gullies would result in almost 10% native cover in Hamilton.

- Protection (RPS section 11.1.3 and 11.1.5): Loss of key sites has already occurred due to the lack of protection given to sites. Protection is needed for all sites, which could be by formal protection through the District Plan or other mechanisms, including incentive schemes.

Monitoring

Forty of the key sites identified by Downs et al. (2000) had permanent vegetation monitoring plots installed in 2010 using the iTree methodology (Nowak et al., 2003). These vegetation plots were located in sites that were accessible in terms of terrain or landowner permission. Monitoring plots also exist in Claudelands Bush and in the new plantings at Waiwhakareke Natural Heritage Park. Monitoring these sites in the future will give information about changes in vegetation structure, species richness and management effects. These should be re-measured at approximately five yearly intervals.

Eleven years have elapsed since the first key site survey. This is a longer time frame than the five years suggested by Downs et al. (2000). A rapid reconnaissance five yearly site check of the key sites to see if they are under threat may have prevented the loss of the Pukete Farm Park Gully site. It is therefore recommended that this style of monitoring survey of all key sites is undertaken in 2016.

Conclusion

A little over 1% of Hamilton City's area has been identified as key site habitat. This falls short of the 10% cover needed to reduce the most severe fragmentation threats. The lack of management or protection of some sites has led to the removal of two key sites from the network. A publicized overarching strategy for all key sites is needed to inform people of the existence and of these key sites to avoid further loss.

Overall there has been an increase in ecologically significant land within Hamilton City and restoration projects already occurring will continue to increase this area. However, the currently

maturing vegetation will still need to be supplemented by aiming for achievement of the 10% threshold in the longer term.

Increases need to take into account the preservation of different landforms and vegetation types representative of the city. Currently there is a distinct lack of key sites on alluvial terraces, Hamilton City's most dominant landform. Although gullies and riverbanks around the city are a significant source of biodiversity and connectivity, most of the other key sites are very isolated within the city landscape. Increasing the connectivity of sites around Hamilton City and with the surrounding peri-urban districts will increase the flow of native plant and animal species through the city.

The identification, protection and enhancement of key sites within Hamilton are important both to fulfil the City's obligations under the RMA and RPS and because these ecologically significant areas are important in their own right. They contribute to ecosystem functions, natural local heritage and the liveability of the city. They enhance indigenous biodiversity and provide services such as enhancement of amenity features, form part of the stormwater system. Full indigenous vegetation improves bank stability and increases water quality. The work done to increase the quality and quantity of key sites across the city has already had positive results. Future work will reinforce those gains and contribute a healthy, sustainable environment for generations to come.

Acknowledgements

Thank you to landowners for permission to view the native remnants on their properties. Thank you to Kemble Pudney, Daniel Laughlin, Emma Coleman and Catherine Bryan for comments on this document.

References

Atkinson, I. A. E. (1985), "Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand", *New Zealand Journal of Botany* **23**: 361-378.

Clarkson, B. D., Clarkson, B. R. & Downs, T. M. (2007), *Indigenous Vegetation types of Hamilton Ecological District*, CBER Contract Report 68. Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato)**.**

Clarkson, B. D. & McQueen, J. C. (2004), "Ecological Restoration in Hamilton City, North Island, New Zealand", *16th International Conference, Society for Ecological Restoration*, Victoria, Canada, Society for Ecological Restoration.

Clarkson, B. D., Merrett, M. & Downs, T. M. (2002), *Botany of the Waikato,* Hamilton, Waikato Botanical Society Inc. Physical Environment by McCraw, J. 13-22.

Collier, K. J., Aldridge, B. M. T. A., Hicks, B. J., Kelly, J., MacDonald, A., Smith, B. J. & Tonkin, J. (2009), "Ecological values of Hamilton urban streams (North Island, New Zealand): constraints and opportunities for restoration", *New Zealand Journal of Ecology* **33**(2): 177-189.

Coleman, E. J. (2010) "Mechanisms of interference between Kahikatea and Grey willow in the Waikato", unpublished MSc thesis, University of Waikato, New Zealand.

Cornes, T. S. & Clarkson, B. D. (2010), *Assessment of vegetation condition and health at Claudelands Bush (Jubilee Bush, Te Papanui)*, CBER Contract Report No. 113, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Cornes, T. S., Wehi, P. M. & Clarkson, B. D. (2008), *Waiwhakareke Restoration Plantings: Establishment of Experimental Monitoring Plots 2008*. CBER Contract Report No. 86, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Craig A. (2007), *Gully Reserves Management Plan,* December 2007 amendment of Turner, J. (2001), Hamilton City Council.

Denyer, K., Burns, B. & Ogden, J. (2006) "Buffering of native forest edge microclimate by adjoining tree plantations", *Austral Ecology*, **31**: 478-489.

Downs, T. M., Clarkson, B. D. & Beard, C. M. (2000), *Key Ecological Sites of Hamilton City*, CBER Contract Report No. 5., Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Drinnan, I. N. (2005), "The search for fragmentation thresholds in a southern Sydney suburb", *Biological Conservation,* **124**: 339–349.

Environment Waikato (2010), "Our Climate", Retrieved 6 January, 2010, from http://www.ew.govt.nz/environmental-information/About-the-Waikato-region/Our-natural-environment/Our-climate/.

Fitzgerald, N. & Innes, J. (2009), *Hamilton City Biennial Bird Counts, 2004-2008*, Landcare Research Contract Report LC0910/099, Landcare Research, Hamilton.

Gobel, P., Dierkes, C. & Coldewey, W. G. (2007), "Storm water runoff concentration matrix for urban areas", *Journal of Contaminant Hydrology*, **91** (1-2): 26-42.

Hamilton City Council (2011) *Hamilton City Council's 2010/11 annual report; a year in review,* Hamilton City Council.

Hamilton City Council & Waikato District Council (2005) *Strategic agreement on future urban boundaries between Hamilton City Council and Waikato District Council, March 2005,* Hamilton City Council and Waikato District Council.

Harding M. (1997), *Waikato protection strategy, a report to the forest heritage fund committee*, Forest Heritage Fund, Wellington.

Hicks, B. J. (2003), "Biology and potential impacts of rudd (Scardinius erythrophthalmus L.) in New Zealand", *Managing invasive freshwater fish in New Zealand.Proceedings of a workshop hosted by Department of Conservation,* R. Munro. Hamilton, New Zealand, Department of Conservation**:** 49-58.

Hicks, B. J., Brijs, J. & Bell, D. (2009), *Boat electrofishing survey of Lake Rotokaeo, Hamilton*, CBER Contract Report No. 93, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Hicks, B. J., Ling, N., Osbourne, M. W., Bell, D. G. & Ring, C. A. (2005), *Boat electrofishing survey of the lower Waikato River and its tributaries*, CBER Contract Report No. 39, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Hicks, B. J., Osborne, M. W. & Ling, N. (2006), "Quantitative estimates of fish abundance from boat electro-fishing". *Proceedings, Australian Society for Fish Biology annual conference, Darwin, NT*. 11-15 July 2005.

Hicks, B. J., Reynolds, G. B., Laboyrie, J. L. & Hill, C. D. H. (2001), *Ecological and physical characteristics of the Te Awa O Katapaki Stream, Flagstaff, Waikato*, CBER Contract Report No. 13, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Innes, J. , King, C. M., Bridgman, L., Fitzgerald N., Arnold G. & Cox N. (2010), "Effects of grazing on ship rat density in forest fragments of lowland Waikato, New Zealand", *New Zealand Journal of Ecology*, **34** (2): 227-232.

Le Roux, D. S. (2010), "Monitoring long-tailed bat (*Chalinolobus tuberculatus*) activity and investigating the effect of aircraft noise on bat behaviour in a modified ecosystem". unpublished MSc thesis, University of Waikato, New Zealand.

LeRoux, D. S. & LeRoux, N. N. (2012) *Hamilton city-wide Bat survey 2011/2012*, Project Echo and Kessels & Associates.

McIntyre, S. & Hobbs, R. (1999), "A framework for conceptualizing human effects in landscapes and its relevance to management and research models", *Conservation Biology* **13**: 1282–1292.

McEwen, M., (1987) *Ecological regions and districts of New Zealand,* New Zealand Biological Resource Centre publication 5. Department of Conservation, Wellington.

MacKay, D. B., Wehi, P. M & Clarkson, B. D. (2011), "Evaluating Restoration Success in Urban Forest Plantings in Hamilton, New Zealand", *Urban Habitats*.

McQueen, J. C. (2004), *Incorporation of Temple View into the Hamilton City Proposed District Plan - Field Investigation Results*, CBER Contract Report No., Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Mensing, D. M., Galatowitsch, S. M. & Tester, J. R. (1998), "Anthropogenic effects on the biodiversity of riparian wetlands of a northern temperate landscape", *Journal of Environmental Management*, **53**: 349-377.

Miller, K. T. (2011) "Understory restoration in Hamilton urban forests", Unpublished MSc thesis, University of Waikato, New Zealand.

National Institute of Water Atmospheric Research (2010), "New Zealand national climate summary", *NIWA Media Release, 13 January,* Auckland, NIWA**:** p. 1-38.

Nowak, D. J., Crane, D. E., Stevens J. C., Hoehn, R. E. (2003) "The urban forest effects (UFORE) model: Field data collection manual. USDA Forest Service, New York, U.S.A.

Ornithological Society of New Zealand (2010a), *Matuku: Waikato Region Newsletter* February, Hamilton, Ornithological Society of New Zealand.

Ornithological Society of New Zealand (2010b), *Matuku: Waikato Region Newsletter* June, Hamilton, Ornithological Society of New Zealand.

Ornithological Society of New Zealand (2010c), *Matuku: Waikato Region Newsletter* September, Hamilton, Ornithological Society of New Zealand.

Ornithological Society of New Zealand (2011), *Matuku: Waikato Region Newsletter* February, Hamilton, Ornithological Society of New Zealand.

Paris, B. (2010) *Hamilton Halo Project Post Operational Report*, EWDOCS n1796965, Environment Waikato.

Parks and Gardens Unit, Hamilton City Council (2004), *Donny Park Management Plan, 2004 first review*, Hamilton City Council.

Parks and Gardens Unit, Hamilton City Council (2009), *Minogue Park Operative Management Plan October 2009,* Hamilton City Council.

Parks and Gardens Unit, Hamilton City Council (2010), *Operative Hamilton Lake Domain Management Plan*, December 2010, Hamilton City Council.

Collier, K. J., Hamilton, D. P., Vant, W. N. & Howard-Williams, C. (2010) *The Waters of the Waikato*, Hamilton, Environment Waikato & Centre for Biodiversity and Ecology Research (The University of Waikato)**:** *Bats and the Waikato River* by Parsons, S. & Dekrout, A. p. 230.

Policy and Transport Group, Waikato Regional Council (2010), *Proposed Waikato Region policy statement, November 2010*, Waikato Regional Council.

Russell, P. (2010) *Waikato Regional Pest Management Strategy Operational Plan 2010-2011.* Environment Waikato.

Rutledge, D. (2003) "Landscape indices as measures of the effects of fragmentation: can pattern reflect process?", *Department of Conservation Science Internal Series No. 98*, Wellington, NZ

Smith, B. J. (2007) *Diversity of Adult Aquatic Insects in Hamilton Urban Streams and Seepages*, Waikato Regional Council.

Stevens, M. I., Clarkson, B. D., McLean, D. A. (2002) *Rototuna ecological survey*, CBER Contract Report No. 22, Hamilton, Centre for Biodiversity and Ecology Research (University of Waikato).

Waikato Regional Council (2010), *Project Echo Factsheet*, brochure, Waikato Regional Council, Hamilton.

Waikato Regional Council (2011, July), 'Bell' of the town. *Your Waikato: Your regional news update from Waikato Regional Council* **70**, 2

Walker, S.,Brower, A. L., Clarkson, B. D., Lee, W. G., Myers, S., Shaw, W. B., Stephens, R. T. T. (2008) "Halting indigenous biodiversity decline: ambiguity, equity and outcomes in RMA assessment of significance," *New Zealand Journal of Ecology* **32**(2)

Appendix one: SNA Review – Site Visit Assessment Form

Field sheets for inventory and quick assessment. Adapted from Ecobase and REA wetland field sheets, and Horizon Regional Council July 2007

Site number: **Site Name:**

Recorder: **Location Grid Ref/GPS:**

Date: **Start Time:** **Finish Time:**

General information for the site:

Tenure:	5 4 3 2 1	Mixed / Multiple Public property Maori land Private property Leased	
Protection status	9 8 7 6 5 4 3 2 1	No legal - no managed protection (pest control) Reserve (TLA) - no managed protection Covenant (QEII) - no managed protection Reserve (DoC) - no managed protection No legal protection, but fenced and/ or pest controlled Agreement, contract (RC) and managed protection* Reserve (TLA) managed protection* Covenant (QEII) and managed protection* Reserve (DoC) and managed protection* ***** managed protection is fenced and/or pest controlled	Estimated area (ha) legally protected (if not entire remnant): Protection measures (e.g. pest control, fencing):
Fencing	4 3 2 1	No fencing Some fencing (one side, large breaks) % Mostly fenced (areas where stock access is likely) % Secure, intact fencing around entire perimeter % **Draw existing fences on map.**	Year fenced (if known): Was the entire fence line seen? Yes / No
Matrix land-use	9 8 7 6 5 4 3 2 1 0	Dairying, cropping or horticulture Sheep, beef or other agriculture Lifestyle blocks Urban subdivisions Garden; parkland Open space; Bare land; Recreation land Plantation forestry Coastal dunes Permaculture tree lands; planted natives Indigenous forest or scrub	Production method: Organic / Conventional
Owner Details:		Name: Hamilton City Council Address: Phone Number(s): feedback requested Yes/No	

Significance Justification criteria to Identify SNA

(Source from http://www.ew.govt.nz/PageFiles/6777/rpsdecember07.pdf, pages 216-217)

The features that qualify the site for each criterion met (example):

Significance criteria (RPS)	For example…
Criteria_1 - Protected or Preserved	Hamilton City Council park
Criteria_2 - Recommended for Protection	Identified by DoC (1993) as being worthy of protection
Criteria_3 - Threatened or Endemic Species Habitat	Bat feeding site.
Criteria_4 - Under Represented	A patch of wetland which is under-represented (or rare) in the Hamilton Ecological District
Criteria_5 - Uncommon Before Settlement	River islands
Criteria_6 - Indigenous Wetland Habitat	Contains (or is likely to contain) a natural wetland.
Criteria_7 - Large Indigenous Habitat	c. 3 ha podocarp forest remnant in Hamilton City
Criteria_8 - Critical Aquatic Habitat	Wetland with potential mudfish habitat.
Criteria_9 - Healthy Indigenous Vegetation	Representative remnants of moderately dense podocarp forest,
Criteria_10 - Rare or Exceptional Representation	Nationally rare *Sporadanthus-Empodisma* bog habitat
Criteria_11 - Ecological Buffer Linkage or Corridor	Indigenous forest connected with a gully system

Significance Criteria met:

A. Site Description (see definition site in EWDOCS#1709807):

Is there a stream running through the site (circle) Yes? No?

B. Habitat and Vegetation Description

Unit Number	**Hydrological Regime**	**Category**	**Code**	**Character**	**Habitat area estimate**	**Vegetation description (Dominant species)**
1						
2						
3						

C. Flora and Fauna

C.1. Additional botanical information:

Include reference of rare, threatened or distinctive plant species seen or known to be, or have been present at the site (provide source and date of information e.g. SSBI, PNAP, botanical society. Also provide general comments on forest /vegetation composition e.g. dominant canopy species, understorey species etc.)

Rating information		(Tick appropriate level) for each unit.	Unit 1	Unit 2	Unit 3
Forest/scrub					
Canopy condition	1	Very sparse foliage, many large holes, dieback >20%.			
	2	Foliage sparse in some areas, canopy holes uncommon. Some dieback.			
	3	Foliage mostly dense, only occasional sparse areas, canopy holes rare, very occasional dieback.			
	4	Abundant dense foliage over whole canopy, no canopy holes or dieback.			
Mid Tier	1	No browse palatable species 45cm-1.35m. Understorey bare.			
	2	Very few browse palatable species 45cm-1.35m. Scattered seedlings of less palatable species.			
	3	Moderate browse palatable species 45cm-1.35m. Other species relatively abundant.			
	4	Abundant browse palatable species and other species present.			
Ground Cover	1	Bare soil, rock, >20% of forest floor. Ground vegetation (ferns, moss, seedlings etc <45cm tall) absent of uncommon. Leaf litter on remainder of forest floor.			
	2	Scattered bare soil & rock. Ground vegetation <20%. Leaf litter on remainder of forest floor.			
	3	Bare soil, rock absent or very uncommon. Ground vegetation 25%-50%. Leaf litter on remainder of forest floor.			
	4	No bare soil or rock, or eroding soil. Ground vegetation, abundant, 50%-100%. Leaf letter on remainder.			

Wetland Unit :

Description (please tick appropriate category)

Lake	Shallow water <2m	Swamp	Marsh	Fen	Bog	Shrub-carr
Grass/sedge meadow	Deciduous margin	Saline	Other (describe)			

Water in the system?	Yes	No	**Evidence of water level changes?**	Yes	No	Unsure
Degree of water turbidity	Clear		**Water Quality**	Algal blooms	Pollution	
	Translucent					
	opaque					

Plant Communities (enter % cover)

Wetland vegetation	Sedge/grass	100	Herbs		Shrubs		trees	
Vegetation bordering wetland (wetland margin)	Sedge/grass		Herbs		Shrubs		Trees	100
	Pasture?							

Plant vigour in wetland	**Wetland**	**Wetland margin**
	High√ Medium☐ Low ☐	High√ Medium☐ Low ☐

Invasive species in wetland: cover %	5	Distribution (circle)	single patch	>1 patch	continuous
Invasive species in margin: cover %	50	Distribution (circle)	single patch	>1 patch	continuous

☐ Source of water: spring ☐ surface flows ☐ stream/river ☐ precipitation only ☐

Erosion/Disturbance	**Wetland**	**Wetland margin**
Comments No disturbance		

C.2. Fauna

Record all fauna species (exotic and native) seen (including sign) or heard during the survey.

Indicate whether species were seen (s), heard (h) or whether sign (such as faeces, footprint) was observed.

D. Threats

D.1. Pest plants

Indicator	Rating	Estimate (Tick appropriate level)	Unit 1	Unit 2	Unit 3	Notes for dominant Species etc	Comments & suggested management
Ground cover weeds	1	Very common, cover >50% ground area.					
	2	Common, 10%-50% ground area.					
	3	Occasional, up to 10% ground area.					
	4	None present.					
Vine weeds	1	Very common, >50% canopy cover.					
	2	Common, 10%-50% canopy cover.					
	3	Occasional, up to 10% canopy cover.					
	4	None present.					
Shrub/Tree Weeds	1	Very common, <50% understorey or canopy cover.					
	2	Common, 10%-50% understorey or canopy cover.					
	3	Occasional, up to 10% understorey or canopy cover.					
	4	None present.					

D.2. Pest animals

If evidence of the same pest animal is present in different units, this needs to be indicated.

Indicator	Rating	Estimate (Tick appropriate level)	Unit 1	Unit 2	Unit 3	Notes for dominant species etc.	Comments & suggested management
e.g. Stock	1	Abundant fresh signs (droppings, major tracks and hoof prints) Stock heard or seen throughout area.					
	2	Common fresh sign but sometimes scattered. Occasional stock heard or seen. Confined to scattered areas on edge.					
	3	Sign uncommon. Sign is often old. Only near edges.					
	4	No damage.					

E. Human Associated Activities

(Rubbish (organic or inorganic) dumping, Stock grazing, Drainage, Earth works, Erosion, Top dressing, Fire, Vegetation clearing, Herbicide application, Harvest / vegetation clearing, Planting, Animal pest control, Domestic pets, Fencing)

Unit	Activity	Impact	Suggested Response
Notes			

F. Climatic Conditions

Humidity	Clouds	Winds	Temp (°C)
Dry	Clear	Calm	Hot > 25
Moist	-1/3 Cumulus	Light breeze (leaves)	Very warm 20-25
Mist	-2/3 Cumulus	Breeze (twigs)	Warm 15-20
Fog	Cirrus	Windy (branches)	Cool 10 - 15
Showers	Alto stratus	Storm (trees sway)	Cold 1 - 10
Rain	Stratus		Frost < 0
Hail	Nimbo stratus		
Sleet	Cumulonimbus		
Snow			

G. Context / Nearby Site Information (optional)

Record details of other areas of scrub, forest or wetland in the vicinity. Include SNA site number (if applicable and known), dominant vegetation, approximate size and likely condition (e.g. grazed) if known, etc. Provide as much information as possible.

H. Photo Record (optional)

Mark photo points on map with a cross. Indicate direction of photographs taken with arrow.

Photo No.	GPS Longitude / Easting	GPS Latitude / Northing	Description

I. Management Recommendations

What management activities would help to maintain or enhance this area? Specify and comment including activities such as pest control, fencing, weed control, time, planting buffers, threatened species protection and/or habitat restoration within a site.

Comments:

Appendix two: Key Ecological Sites in Hamilton City; ordered by dominant landform and location

Gullies and connected Riverbank sites

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
Te Awa O Katapaki Gully								
2.1	River Road North Gully	Gully	Grey willow forest Kanuka/mahoe forest	8.3	8.3	1, 4, 7, 11	2	2
Pukete Gullies								
2.3	Pukete Kanuka Gully I	Gully	Kanuka/kauri-rewarewa forest Kauri-kahikatea scrub^{n}	1.5	1.6	9	2	2
2.6	Pukete Kanuka Gully II	Gully	Kanuka-willow/mahoe forest	0.2	0.3	4, 9	3	3
6.3	Totara Park Wetland	Gully	(Kahikatea)/grey willow-(cabbage tree) forest Mixed native and exotic treeland	1.7	1.7	1, 4	1	2
Kirikiriroa Gully and riverside								
6.1	Riverbank North of Pukete Bridge	Riverbank	Mamaku-(alder)/mahoe forest (alder)-(wattle)/mixed native^{n} scrub	0.4	1.1	1, 4, 11	3	3
6.2	Kirikiriroa Gully, Harrowfield	Gully	Mahoe-pate forest Mixed native shrubland^{n} Cabbage tree/flax-pasture grassland	0.6	2.2	1, 4, 7, 11	2	2
3.1	Puketaha Astelia Gully	Gully	Grey willow-wheki forest	3.1	3.6	4, 7, 11	2	2
7.1	Kirikiriroa Gully Arm, adjacent to Gordonton Rd I	Gully	Cabbage tree/ grey willow-hawthorn forest Mixed native shrubland^{n}	0.6	0.6	4, 11	3	3
7.2	Kirikiriroa Gully Arm, adjacent to Gordonton Rd II	Gully	Cabbage tree/ grey willow-hawthorn forest	0.3	0.3	4, 11	2	3
7.3	Kirikiriroa Gully, Chartwell	Gully	Kahikatea/ mixed exotic and native forest Mixed native scrub^{n}	0.5	1.2	1, 4	2	2
7.9	Kirikiriroa Gully: Mangaiti	Gully	Carex-flax sedgeland^{n} Mixed native shrubland^{n}		3.8	4, 6, 7, 9, 11		2
Fairfield Gullies								
7.6	Donny Park Raupo	Gully	Raupo reedland Alder-willow treeland Mixed native shrubland^{n} Manuka shrubland^{n}	0.2	1.6	1, 4, 6, 7	3	2
7.8	Ranfurly Park Kanuka	Gully	Kanuka forest (Cabbage tree-kahikatea)^{n}/Carex-raupo sedge-reedland Mahoe-mamaku scrub^{n} mixed native shrubland^{n}	0.3	0.7	1, 6	3	2

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
Waitawhiriwhiri Gully								
11.1	Waitawhiriwhiri Gully, Edgecumbe Park	Gully	Tree fern scrub Cabbage tree-land	0.3	0.5	4, 11	3	3
11.2	Waitawhiriwhiri Gully, Whitiora	Gully	Mixed treefern/ mixed native tree^{n} forest	0.6	0.6	3, 11	3	3
Gibbon's Creek Gully								
11.6	Seeley's Gully	Gully	Mixed native forest^{n} Honeysuckle-bindweed vineland/Raupo - Carex sedge-reedland	2.2	2.2	1, 4, 6, 9	3	2
11.7	Peachgrove Kahikatea	Gully	Kahikatea/willow-mahoe forest (Kahikatea)/mahoe-cabbage tree forest Willow/Carex^{n} sedgeland	2.1	2.1	4, 6	2	2
Mangaonua Gully and Hammond Bush								
16.7	Hammond Bush	Riverbank	Pukatea/swamp maire forest Alder forest Tawa/titoki forest Mahoe/kanuka forest Machaerina/Phormium sedge/flaxland	1.8	3.3	3, 4, 7, 9, 11	1	1
16.8	Gully near Hammond Bush I	Gully	(Alder)/mahoe-lacebark forest	0.4	0.8	11	3	3
16.9	Gully near Hammond Bush II	Gully	Eucalypt-wattle/mixed native^{n} forest Alder-pine-eucalypt/mahoe-mamaku forest Lemonwood^{n}-eucalypt-kanuka^{n} forest Flax-cabbage tree/*Carex* flax/sedgeland^{n}	0.2	1.5	3, 6, 11	3	3
16.10	Riverside Kanuka, Hammond Park	Riverbank	Kanuka /mahoe forest Kanuka/toetoe scrub^{n}	0.3	0.8	3, 7, 9, 11	3	3
16.11	Mangaonua Streamside in Riverlea I	Gully	Kanuka/ mahoe forest	0.9	0.9	3, 7, 9, 11	2	2
16.12	Mangaonua Streamside in Riverlea II	Gully	Mahoe forest	0.1	0.1	3, 11	2	2
17.6	Mangaonua Streamside in Riverlea III	Gully	Mahoe forest	0.2	0.2	3, 11	2	2
17.7	Mangaonua Streamside in Riverlea IV	Gully	Mahoe forest	0.2	0.2	3, 11	2	2
17.8	Mangaonua Streamside in Riverlea V	Gully	Mahoe-kanuka forest	0.4	0.4	3, 11	2	2
17.5	Mangaonua Streamside in Berkley	Gully	Mahoe-pate-willow forest	0.6	0.7	3, 4, 7, 11	2	2

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
17.4	Mangaonua Gully Arm in Berkley III	Gully	Willow-mahoe-pate forest	0.4	0.7	3, 4, 7, 11	2	2
17.3	Berkley Kahikatea	Gully	Kahikatea forest	0.4	0.4	3, 4, 7, 9, 11	1	1
17.2	Mangaonua Gully Arm in Berkley II	Gully	Willow-mahoe-pate forest Lemonwood-totara-mahoe forest[n]	0.5	0.5	3, 4, 7, 11	2	2
17.1	Mangaonua Gully Arm in Berkley I	Gully	Willow-privet forest	0.2	0.3	3, 4, 7, 11	3	3
13.2	Mangaonua Gully, Silverdale	Gully	(Kahikatea)/treefern forest Grey willow/treefern forest	2.2	4.3	7, 11	3	3
13.1	Mangaonua Gully, Chelmsford	Gully	Willow-treefern forest	0.7	1.6	3, 11	2	2
Mangakotukutuku Gully								
16.14	Mangakotukutuku Gully, Te Anua Park	Gully	Eucalyptus-pine-(kahikatea)/ treefern- privet forest	0.3	0.6	10	3	3
16.15	Kanuka Patch, Mangakotukutuku Gully, Peacocke	Gully	Kanuka/privet forest	<0.1	<0.1	10	3	3
16.16	Mangakotukutuku Gully Arm, Peacocke	Gully	Grey willow forest	0.3	0.3	3, 10	3	3

Alluvial plain

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
1.2	Te Rapa North Kahikatea I	Alluvial Plain	Kahikatea forest		0.4	4		2
1.3	Te Rapa North Kahikatea II	Alluvial Plain	Kahikatea forest		0.6	3, 4		2
5.1	Burbush Rd Forest/ Perkins Bush	Alluvial Plain	Kahikatea forest	1.5	1.5	4, 9	1	1
6.4	Mooney St Kahikatea	Alluvial Plain	Kahikatea-mixed native forest	0.3	0.3	1, 4	2	2
10.2	Grove Park Kahikatea	Alluvial Plain	Kahikatea forest	0.1	0.1	1, 4	2	3
11.3	Claudelands Bush	Alluvial Plain	Kahikatea-(titoki)/mahoe forest (Kahikatea)/titoki-mahoe-pukatea forest Tawa forest Mixed native shrubland[n]	5.4	6.5	1, 4, 7, 9	1	1
12.1	Southwell Bush	Alluvial Plain	Kahikatea forest	0.9	1	4	1	1
12.2	Caldwell Native Bush	Alluvial Plain	Mixed native forest[n]	0.3	0.3	9	3	3
12.4	Hillcrest Kahikatea	Alluvial Plain	Kahikatea forest	1.3	1.3	1, 4, 9	2	2

Riverbank and islands

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
2.2	Riverside Alder forest with treeferns, Hamilton North	Riverbank	Alder-crack willow forest *Carex germinata* sedgeland Tree fuchsia-treefern -cabbage tree forest	1.6	1.9	3, 4, 11	3	2
2.4	Riverbank Mahoe scrub, Pukete	Riverbank	Mahoe-treefern forest	1.5	1.5	1, 9	3	3
2.5	Pukete Riverside Mamaku-mahoe forest	Riverbank	Mahoe-mamaku forest	1.2	1.2	4, 9	2	2
2.7	Pukete Riverside Kanuka	Riverbank	Kanuka/mahoe forest	0.5	0.5	4	2	2
7.4	Riverbank opposite St Andrews Golf Course	Riverbank	Alder/mahoe-black locust-treefern forest	1.5	1.5	11	2	2
7.5	St Andrews Kanuka	Riverbank	Kanuka/mahoe-silver fern forest	2.2	2.2	3, 4, 11	1	2
7.7	Riverbank opposite Ann St	Riverbank	Kanuka-treefern/mahoe-mapou forest	0.8	0.8	4, 9, 11	2	2
11.4	Riverbank south Miropiko	Riverbank	Kanuka/mahoe-karaka forest	0.1	0.1	3, 4	3	3
15.1	Graham Island (Te Motere o Kaipikau)	River Island	Pampas grassland Alder-wattle/ mahoe-privet forest Floodline vegetation	0.3	0.3	4, 5	3	3
16.1	Riverbank east of Cobham Bridge	Riverbank	Mahoe-tree fern-kamahi forest	0.2	0.2	1, 3, 11	2	2
16.2	River Island, with turf vegetation	River Island	(Alder)-(grey willow)/ *Paspalum-Glossostigma* herbfield	<0.1	<0.1	4, 5	3	3
16.3	Mamaku-mahoe forest, Hamilton Gardens	Riverbank	Mahoe-mamaku forest	1.6	1.8	4, 9, 10, 11	2	2
16.4	Riverbank Mamaku-kamahi forest, Hamilton Gardens	Riverbank	Kamahi-mamaku forest	1.5	1.7	4, 9, 10, 11	1	1
16.5	Hammond Park – Northern End	Riverbank	Eucalyptus-blackwood/mahoe-mamaku forest	0.3	0.5	11	3	3
16.6	Riverbank Kanka opposite Hammond Park	Riverbank	Kanuka- privet - mamaku forest	2.4	2.4	4, 7, 11	1	2
16.13	Riverside Kanuka, Peacocke	Riverbank	Kanuka/mahoe-privet forest	3.3	3.3	7, 11	3	3

Peat lakes, Peat bogs and hillslopes

Site No.	Name	Land Unit	Main Vegetation Type(s)	Area (ha)		Criteria	Ecol. Rank	
				old	new		old	new
5.2	Waiwhakareke Natural Heritage Park (Horseshoe Lake)	Peat Lake Peat Lake Alluvial plain & Peat bog Peat bog Hillslope Hillslope	Open water with water lily Baumea-raupo-kutakuta reedland Kahikatea-manuka-flax shrublandⁿ Cane rush-wire rush restiadlandⁿ Manuka-kanuka-kohuhu-ribbonwood shrublandⁿ Kohuhu-kauri shrublandⁿ	3.8	16.2	1, 3, 4, 6, 7, 8, 9, 10, 11	2	2
9.1	Nawton Wetland	Peat bog	Grey willow forest Manulka forest	2.2	0.9	1, 4	2	3
9.2	Brymer Park	Peat bog Hillslope	Paspalum-Carex-Baumea grass-sedgelandⁿ Mixed native scrublandⁿ		1	1, 4, 6		3
10.1	Lake Rotokaeo (Forest Lake)	Peat Lake Peat Lake Peat Lake & Hillslope Peat Lake Peat Lake	Manuka/Carex shrub-sedgelandⁿ Baumea reedland Manuka scrubⁿ Kahikatea forest ⁿ (Kanuka-karamu)ⁿ/exotic herbfield	4.8	5.5	1, 4, 6, 7, 9	1	1
11.8	Mixed planted forest near Golf Area, Hamilton Lake Domain	Hillslope	Mixed native-exotic forestⁿ	0.6	0.6	1, 4, 9	3	3
11.9	Planted Totara Forest, Hamilton Lake Domain	Hillslope	Totara forestⁿ	1.6	1.6	1, 4, 9	3	3
11.10	Lake Rotoroa (Hamilton Lake)	Peat Lake	Raupo-*Baumea* reed-sedgeland Acacia forest	51.0	56.1	1, 4, 6, 7	2	2
12.3	Waikato University Kahikatea	Hillslope	Kahikatea forest	<0.1	<0.1	4	3	3
14.1	Templeview Kahikatea	Hillslope	Kahikatea forest		1.2	4		2

ⁿ indicates planted

Ecological Rank: 1=very high, 2=high, 3= moderate

Appendix three: Ecological significance justification for key sites; ordered by ecological score

Ecological score 1

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
5.1	Burbush Rd Forest/ Perkins Bush	Best kahikatea forest in the west of the city	Species: tawa, titoki Feature: Understorey and shrub layers		
5.2	Waiwhakareke Natural Heritage Park (Horseshoe Lake)	Second largest site, second largest peat lake and contains nationally rare planted Sporadanthus restiadland	Species: swamp maire, pukatea, *Empodisma minus* Feature: Wetland fringe	+	Larger size, increased species and habitat diversity
10.1	Lake Rotokaeo (Forest Lake)	Diverse riparian vegetation and third largest peat lake	Regeneration: kahikatea, swamp coprosma, manuka, kanuka		
11.3	Claudelands Bush	Best and largest kahikatea forest	Species: kiekie, tawa, hangehange, titoki, *Collospermum haastatum*		
12.1	Southwell Bush	Fourth best kahikatea forest in the city and few weed species present	Species: tawa, titoki, hangehange		
16.4	Riverbank Mamaku-kamahi forest, Hamilton Gardens	Best mamaku-kamahi forest. Second best riverside forest	Species: rewarewa, large kowhai, *Metrosideros fulgens*		
16.7	Hammond Bush	Best riverside forest with rare vegetation type for the Waikato	Species: Swamp maire, tree fuchsia, pukatea and numerous others		
17.3	Berkley Kahikatea	Best and oldest kahikatea forest in a gully	Species: Tawa, titoki, largest kahikatea Corridor: Mangonua Gully		

Ecological score 2

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
2.1	River Road North Gully	Largest gully site. Third largest overall.	Feature: Kanuka forest and a wetland forest Species: Large fuchsia, Astelia		
2.2	Riverside Alder forest with treeferns, Hamilton North	Contains New Zealand passionfruit	Feature: Carex wetland and fuchsia treefern forest	+	Increased vegetation types
2.3	Pukete Kanuka Gully I	Largest kanuka dominant forest in a gully	Species: Large kanuka, fern diversity		
2.5	Pukete Riverside Mamaku-mahoe forest	Best example of mamaku-mahoe forest	Species: fern and epiphyte diversity		

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
2.7	Pukete Riverside Kanuka	Second largest riverside kanuka forest in the north	Species: Wheki-ponga		
3.1	Puketaha Astelia Gully	Largest Astelia population	Species: Sedge and fern diversity		
6.2	Kirikiriroa Gully, Harrowfield	Best mahoe-pate forest in the north. Regenerating	Species: Wheki-ponga, *Trichomanes venosum*, large mahoe and fuchsia		
6.3	Totara Park Wetland	Contains various aged kahikatea. Still have semi-swamp forest conditions.		-	Kahikatea known to not regenerate under willow canopy without management
6.4	Mooney St Kahikatea	Fifth largest kahikatea forest in the west. Closest natural vegetation to Horseshoe Lake	Species: Large titoki		
7.3	Kirikiriroa Gully, Chartwell	Large kahikatea present. Old plantings present. Established planted wetland			
7.4	Riverbank opposite St Andrews Golf Course	Second best mahoe-mamaku forest in the north			
7.5	St Andrews Kanuka	Best riverside kanuka forest in the north	Species: New Zealand Passionfruit, *Metrosideros fulgens*, fern diversity	-	Large path installed reducing size
7.6	Donny Park Raupo	Best raupo wetland in a gully		+	Willow control. Natives planted
7.7	Riverbank opposite Ann St	Only kanuka/mahoe-mapou forest	Species: kiekie, *Metrosideros fulgens*		
7.8	Ranfurly Park Kanuka	Kanuka forest in a gully in central city	Species: large kanuka	+	Well established wetland
7.9	Kirikiriroa Gully: Mangaiti	Developed planted Carex dominant wetland and native scrubland Largest wetland site.			
11.6	Seeley's Gully	Diverse native planted gully	Species: *Clematis paniculata* (planted) Feature: Carex and raupo wetland. Native tree, grass and fern regeneration Connectivity: Gibbon's Creek	+	Large well developed forest. Regenerating
11.7	Peachgrove Kahikatea	Regenerating kahikatea and native dominant wetland	Connectivity: Gibbon's Creek		
11.10	Lake Rotoroa (Hamilton Lake)	Largest site and largest peat lake	Species: *Dianella nigra*		
12.4	Hillcrest Kahikatea	Third largest kahikatea forest. Developed understorey			
13.1	Mangaonua Gully, Chelmsford	Second largest Astelia population. Corridor along Mangaonua Gully.	Species: Wheki-ponga, swamp coprosma (planted)		

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
16.1	Riverbank east of Cobham Bridge	Forest with kamahi in canopy, native dominant canopy	Species: Koromiko, supplejack, *Cordyline banksii*		
16.3	Mamaku-mahoe forest, Hamilton Gardens	Best mamaku-mahoe forest in south	Species: *Rhabdothamnus solandri*, large Fuchsia Diversity: Ferns, shrubs, sedges		
16.6	Riverbank Kanuka opposite Hammond Park	Largest kanuka forest in the south	Species: Tawa	-	Privet now dominant in the sub-canopy
16.8	Gully near Hammond Bush I	Native dominant gully connected to Hammond Bush	Diversity: Ferns	+	Now part of Hammond Bush. Plantings. Regenerating
16.11	Mangaonua Streamside in Riverlea I	Corridor. Kanuka/mahoe dominant forest in Mangaonua Gully	Size: Largest site on Riverlea section of the gully		
16.12	Mangaonua Streamside in Riverlea II	Corridor along Mangaonua Gully	Species: Fuchsia Diversity: Ferns		
17.2	Mangaonua Gully Arm in Berkley II	Corridor along Mangaonua Gully	Species: Fuchsia Diversity: Ferns		
17.4	Mangaonua Gully Arm in Berkley III	Corridor along Mangaonua Gully	Species: Fuchsia		
17.5	Mangaonua Streamside in Berkley	Corridor along Mangaonua Gully	Species: Fuchsia Feature: Carex sedgeland		
17.6	Mangaonua Streamside in Riverlea III	Corridor along Mangaonua Gully	Species: Fuchsia		
17.7	Mangaonua Streamside in Riverlea IV	Corridor along Mangaonua Gully	Diversity: ferns sedges		
17.8	Mangaonua Streamside in Riverlea V	Corridor. Kanuka/mahoe dominant forest in Mangaonua Gully	Species: Large kanuka		
1.1	Te Rapa North Kahikatea II	Fourth largest kahikatea forest in the west			
1.2	Te Rapa North Kahikatea III	Third largest kahikatea forest in the west			
14.1	Templeview Kahikatea	Western most kahikatea stand. Largest on a hillslope			

Ecological score 3

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
2.4	Riverbank Mahoe scrub, Pukete	Best example of riverside mahoe dominant scrub			
2.6	Pukete Kanuka Gully II	Second largest gully site in the west			
6.1	Riverbank North of Pukete Bridge	Native dominant steep riverbank. Connectivity with Kirikiriroa Gully			
7.1	Kirikiriroa Gully Arm, adjacent to Gordonton Rd I	Native dominant understorey in the north east	Diversity: ferns		
7.2	Kirikiriroa Gully Arm, adjacent to Gordonton Rd II	Natives in understorey in the north east	Species: Astelia grandis, wheki-ponga Diversity: ferns	-	Not much in the understorey
9.1	Nawton Wetland	Terrestrial peatland swamp forest	Species: Swamp coprosma, Lobelia anceps	-	Majority cleared. Exotic dominant canopy.
9.2	Brymer Park	Wetland on terrestrial peat			
10.2	Grove Park Kahikatea	Smallest kahikatea forest	Species: miro	-	-No regeneration or understorey
11.1	Waitawhiriwhiri Gully, Edgecumbe Park	Cabbage tree –land with restoration plantings, Waitawhiriwhiri Gully			
11.2	Waitawhiriwhiri Gully, Whitiora	native-dominated vegetation, Waitawhiriwhiri Gully	Species: Adiantum fulvum, wheki-ponga, kiekie		
11.4	Riverbank south Miropiko	Native dominant riverbank forest	Species: Adiantum aethiopicum, Large kanuka + kamahi.		
11.8	Mixed planted forest near Golf Area, Hamilton Lake Domain	Old native plantings, regenerating understorey			
11.9	Planted Totara Forest, Hamilton Lake Domain	Planted totara forest			
12.2	Caldwell Native Bush	Planted native species with regeneration			
12.3	Waikato University Kahikatea	Small stand of secondary kahikatea forest			
13.2	Mangaonua Gully, Silverdale	Largest site on Mangaonua Gully, diverse regenerating understorey	Species: Tmesipteris elongata, Chiloglottis cornuta, wheki-ponga, large kahikatea		
15.1	Graham Island (Te Motere o Kaipikau)	Largest of two river islands			
16.2	River Island, with turf vegetation	Smallest of two river islands.	Native dominant herbfield		

Site No.	Name	Justification		Change in Ecological Score	
		Main	Other	+ or -	Reason
16.5	Hammond Park – Northern End	Buffer to highly ecologically significant site	Species: Rhabdothamnus solandri, Hebe stricta, Cordyline banksii and hangehange		
16.9	Gully near Hammond Bush II	Connectivity between Hammond Park and Riverlea			
16.10	Riverside Kanuka, Hammond Park	Connectivity between Hammond Bush and Riverlea			
16.13	Riverside Kanuka, Peacocke	Second largest kanuka forest. Privet in canopy	Species: kiekie, Adiantum cunninghamii		
16.14	Mangakotukutuku Gully, Te Anua Park	Native vegetation Mangakotukutuku Gully	Species: Large kahikatea		
16.15	Kanuka Patch, Mangakotukutuku Gully, Peacocke	Kanuka forest Mangakotukutuku Gully			
16.16	Mangakotukutuku Gully Arm, Peacocke	Native dominant understorey Mangakotukutuku Gully	Species: Wheki-ponga and swamp coprosma		
17.1	Mangaonua Gully Arm in Berkley I	Connectivity along Manganoa Gully	Species: kahikatea, Earina mucronata, Rhabdothamnus solandri (planted)		

Appendix four: Species Lists

Plants

Common Name	**Species Name**
Acer sp.	*Acer* sp.*
African clubmoss	*Selaginella kraussiana**
agapanthus	*Agapanthus praecox* subsp. *orientalis**
akeake	*Dodonaea viscosa*
alder	*Alnus glutinosa**
allseed	*Polycarpon tetraphyllum**
aluminium plant/weed	*Lamium galeobdolon**
apple tree	*Malus x domestica**
arum lily	*Zantedeschia aethiopica**
asparagus fern	*Asparagus setaceus**
Asplenium bulbiferum x flaccidum	*Asplenium bulbiferum x flaccidum*
Asplenium gracillimum	*Asplenium gracillimum*
Australian fireweed	*Senecio bipinnatisectus**
bamboo	*Bambusa / Phyllostachys* sp.*
bamboo grass	*Oplismenus hirtellus var. imbecillis*
bamboo orchid	*Earina mucronata*
banana passionfruit vine	*Passiflora mixta**
barberry	*Berberis darwinii**
barnyard grass	*Echinochloa crus-galli**
Baumea articulata	*Baumea articulata*
Baumea rubiginosa	*Baumea rubiginosa*
Baumea teretifolia	*Baumea teretifolia*
bear's breeches	*Acanthus mollis**
beggars' tick	*Bidens frondosa**
Begonia sp.	*Begonia* sp.*
bindweed	*Convolvulus* sp.*
black locust	*Robinia pseudacacia**
black maire	*Nestegis cunninghamii*
black nightshade	*Solanum nigrum**
blackberry	*Rubus fruticosus**
blackwood	*Acacia melanoxylon**
blue lily pilly	*Syzygium oleosum**
blue morning glory	*Ipomoea indica**
bog nertera	*Nertera* sp.
bracken fern	*Pteridium esculentum*
broadleaf	*Griselinia littoralis*
broad-leaved dock	*Rumex obtusifolius**
broad-leaved fleabane	*Conyza sumatrensis**
broad-leaved plantain	*Plantago major**
buddleia	*Buddleja davidii**
bush flax	*Astelia fragrans*
bush rice grass	*Microlaena avenacea*
buttercup	*Ranunculus repens**
button fern	*Pellaea rotundifolia*
cabbage tree	*Cordyline australis*
cabbage tree	*Cordyline banksii*
camellia	*Camellia japonica**
cane rush	*Sporadanthus ferrugineus*
canna lily	*Canna indica**
Carex dissita	*Carex dissita*

Carex germinata	*Carex germinata*
Carex maorica	*Carex maorica*
Carex solandri	*Carex solandri*
Carex virgata	*Carex virgata*
cherry laurel	*Prunus laurocerasus**
chestnut	*Castanea sativa**
Chinese lantern	*Abutilon darwinii**
Chinese privet	*Ligustrum sinense**
Chinese windmill palm	*Trachycarpus fortune**
cleavers	*Galium aparine**
clematis	*Clematis paniculata*
climbing dock	*Rumex sagittatus**
Collospermum hastatum	*Collospermum hastatum*
common lawn daisy	*Bellis perennis**
common maidenhair	*Adiantum cunninghamii*
common tree daisy	*Olearia arborescens*
Coprosma propinqua	*Coprosma propinqua*
Coprosma propinqua × robusta	*Coprosma propinqua × robusta*
Coprosma rhamnoides	*Coprosma rhamnoides*
Coprosma sp.	*Coprosma* sp.
Coprosma spathulata	*Coprosma spathulata*
Coprosma tenuifolia	*Coprosma tenuifolia*
coral tree	*Erythrina crista-galli**
Corokia sp.	*Corokia* sp.
crack willow	*Salix fragilis**
cretan brake	*Pteris cretica*
cudweed	*Gamochaeta coarctata*
dandelion	*Taraxacum officinale**
deadly nightshade	*Atropa bella-donna**
Deparia petersenii	*Deparia petersenii*
Diplazium australe	*Diplazium australe*
dock	*Rumex* sp.*
egeria	*Egeria densa**
elaeagnus	*Elaeagnus x reflexa**
elephant ear	*Alocasia brisbanensis**
Epacris sp.	*Epacris* sp.
Epilobium parviflorum	*Epilobium parviflorum**
exotic broom	*Cytisus scoparius**
exotic umbrella sedge	*Cyperus eragrostis**
fatsia	*Fatsia japonica**
fig	*Ficus carica**
five finger	*Pseudopanax arboreus*
flax	*Phormium tenax*
fleabane	*Conyza canadensis**
forget-me-not	*Myosotis arvensis**
foxglove	*Digitalis purpurea**
fragrant fern	*Microsorum scandens*
Gahnia sp.	*Gahnia* sp.
Gahnia xanthocarpa	*Gahnia xanthocarpa*
garden forget-me-not	*Myosotis sylvatica**
garlic weed	*Allium triquetrum**
gingko	*Gingko biloba**
Glossostigma sp.	*Glossostigma elatinoides*
gooseberry	*Ribes uva-crispa**

gorse	*Ulex europaeus**
grape	*Vitis vinifera**
grey willow	*Salix cinerea**
gully fern	*Pneumatopteris pennigera*
gum	*Eucalyptus sp.**
gunnera	*Gunnera tinctoria**
gypsywort	*Lycopus europaeus**
hangehange	*Geniostoma ligustrifolium var. ligustrifolium*
hanging spleenwort	*Asplenium flaccidum*
hawkbit	*Leontodon taraxacoides**
hawksbeard	*Crepis capillaries**
hawthorn	*Crataegus monogyna**
hebe cultivar	*Hebe* sp.
heketara	*Olearia rani*
hen and chicken fern	*Asplenium bulbiferum*
Himalayan cedar	*Cedrus deodara**
Himalayan honeysuckle	*Leycesteria formosa**
hinau	*Elaeocarpus dentatus*
holly	*Ilex aquifolium**
honesty	*Lunaria annua subsp. annua**
hook sedge	*Uncinia uncinata*
horse chestnut	*Aesculus hippocastanum**
hounds tongue	*Microsorum pustulatum*
houpara	*Pseudopanax lessonii*
hydrangea	*Hydrangea macrophylla**
Hypolepis distans	*Hypolepis distans*
ink weed	*Phytolacca octandra**
Isolepis sepulcralis	*Isolepis sepulcralis**
Isolepis sp.	*Isolepis* sp.
ivy	*Hedera helix**
Japanese cedar	*Cryptomeria japonica**
Japanese flowering cherry	*Prunus serrulata**
Japanese honeysuckle	*Lonicera japonica**
Japanese maple	*Acer palmatum**
jasmine	*Jasminum polyanthum**
Jerusalem cherry	*Solanum pseudocapsicum**
jointed fern	*Arthropteris tenella*
jointed rush	*Juncus articulatus*
Juncus acuminatus	*Juncus acuminatus**
Juncus effusus	*Juncus effusus**
Juncus planifolius	*Juncus planifolius*
Juncus sp.	*Juncus* sp.*
kahikatea	*Dacrycarpus dacrydioides*
Kahili ginger	*Hedychium gardnerianum**
kaikaiatua	*Rhabdothamnus solandri*
kaikomako	*Pennantia corymbosa*
kamahi	*Weinmannia racemosa*
kanono	*Coprosma grandifolia*
kanuka	*Kunzea ericoides*
karaka	*Corynocarpus laevigatus*
karamu	*Coprosma robusta*
karo	*Pittosporum crassifolium*
kauri	*Agathis australis*
kawaka	*Libocedrus plumosa*

kawakawa	*Macropiper excelsum*
kiekie	*Freycinetia banksii*
king fern	*Ptisana salicina*
kiokio	*Blechnum novae zealandiae*
kiwakiwa	*Blechnum fluviatile*
kohuhu	*Pittosporum tenuifolium*
korokio	*Corokia cotoneaster*
koromiko	*Hebe stricta*
kowhai	*Sophora microphylla*
kowharawhara	*Astelia solandri*
kuta	*Eleocharis sphacelata*
lacebark	*Hoheria sexstylosa*
lacebark	*Hoheria populnea*
ladder fern	*Nephrolepis cordifolia**
lance fern	*Blechnum chambersii*
lancewood	*Psuedopanax crassifolius*
large-leaved kowhai	*Sophora tetraptera*
Lastreopsis microsora	*Lastreopsis microsora*
Lastreopsis microsora subsp. *pentangularis*	*Lastreopsis microsora subsp. pentangularis*
Lastreopsis sp.	*Lastreopsis* sp.
leaf-less rush	*Juncus filicaulis**
leather-leaf fern	*Pyrrosia eleagnifolia*
lemon	*Citrus limon**
lemonwood	*Pittosporum eugenoides*
lesser joyweed	*Alternanthera denticulata**
Lilaeopsis novae-zelandiae	*Lilaeopsis novae-zelandiae*
liquidambar	*Liquidambar styraciflua**
loquat	*Eriobotrya japonica**
lotus	*Lotus pedunculatus**
macadamia	*Macadamia tetraphylla**
tuhara	*Machaerina sinclairii*
macrocarpa	*Cupressus macrocarpa**
magnolia	*Magnolia grandiflora**
mahoe	*Melicytus ramiflorus*
maire-taiki	*Mida salicifolia*
mamaku	*Cyathea medullaris*
mangeao	*Litsea calicaris*
manuka	*Leptospermum scoparium*
mapou	*Myrsine australis*
marbleleaf	*Carpodetus serratus*
Metrosideros diffusa	*Metrosideros diffusa*
Metrosideros fulgens	*Metrosideros fulgens*
Metrosideros perforata	*Metrosideros perforata*
Mexican daisy	*Erigeron karvinskianus**
milk tree	*Streblus heterophyllus*
milkweed	*Euphorbia peplus**
mingimingi	*Leucopogon fasciculatus*
miro	*Prumnopitys ferruginea*
monkey musk	*Mimulus guttatus**
montbretia	*Crocosmia x crocosmiiflora**
moth plant	*Araujia sericifera**
mountain flax	*Phormium cookianum*
naked ladies	*Amaryllis belladonna**
Nandina domestica	*Nandina domestica**

nasturtium	*Tropaeolum majus**
native umbrella sedge	*Cyperus ustulatus*
New South Wales warratah	*Telopea speciosissima**
New Zealand passionfruit	*Passiflora tetrandra*
ngaio	*Myoporum laetum*
nikau	*Rhopalostylis sapida*
Norfolk Island pine	*Araucaria heterophylla**
Nymphaea sp.	*Nymphaea* sp.*
NZ jasmine	*Parsonsia heterophylla*
NZ shore lobelia	*Lobelia anceps*
oak	*Quercus* sp.*
olearia	*Olearia* sp.
orange alstroemeria	*Alstroemeria aurea**
oxalis	*Oxalis* sp.*
oxeye daisy	*Leucanthemum vulgare**
Paesia scaberula	*Paesia scaberula*
pampas	*Cortaderia selloana**
parataniwha	*Elatostema rugosum*
Parsonsia sp.	*Parsonsia* sp.
paspalum	*Paspalum* sp.*
pate	*Schefflera digitata*
patience	*Rumex patientia**
pearlwort	*Sagina procumbens**
pennyroyal	*Mentha pulegium**
Petries starwort	*Callitriche petriei subsp. petriei*
Phoenix palm	*Phoenix canariensis**
pigeonwood	*Hedycarya arborea*
pine	*Pinus* sp.*
pink bindweed	*Calystegia sepium subsp. roseata*
plantain	*Plantago lanceolata**
poataniwha	*Melicope simplex*
pohuehue	*Muehlenbeckia australis*
pokaka	*Elaeocarpus hookerianus*
poplar	*Populus* sp.*
poroporo	*Solanum aviculare*
Prunus sp.	*Prunus* sp.*
psuedopanax	*Pseudopanax* sp.
Pteris sp.	*Pteris* sp.*
puka	*Griselinia lucida*
pukatea	*Laurelia novae zelandiae*
puriri	*Vitex lucens*
purple wind grass	*Lachnagrostis striata*
ramarama	*Lophomyrtus bullata*
rangiora	*Brachyglottis repanda*
Ranunculus sp.	*Ranunculus* sp.*
radiata pine	*Pinus radiata*
rasp fern	*Doodia australis*
raupeka	*Earina autumnalis*
raupo	*Typha orientalis*
red azolla	*Azolla filiculoides*
red dead nettle	*Lamium purpureum**
redwood	*Sequoia sempervirens**
reed sweet grass	*Glyceria maxima**
rewarewa	*Knightia excelsa*

rhododendron	*Rhododendron ponticum* subsp*. ponticum**
ribbonwood	*Plagianthus regius*
rimu	*Dacrydium cupressinum*
round-leaved coprosma	*Coprosma rotundifolia*
royal fern	*Osmunda regalis**
rye	*Secale cereal**
sand coprosma	*Coprosma acerosa*
scarlet pimpernel	*Anagallis arvensis**
scrambling fumitory	*Fumaria muralis**
sheeps sorrel	*Rumex acetosella**
shining spleenwort	*Asplenium oblongifolium*
sickle spleenwort	*Asplenium polyodon*
silk tree	*Albizia julibrissin**
silver beech	*Nothofagus menziesii*
silver birch	*Betula pendula**
silver fern	*Cyathea dealbata*
small flowered nightshade	*Solanum nodiflorum*
smooth shield fern	*Lastreopsis glabella*
Sonchus sp.	*Sonchus* sp.*
spindle tree	*Euonymus europaeus**
stinking iris	*Iris foetidissima**
stinking mayweed	*Anthemis cotula**
strap fern	*Grammitis billardierei*
supplejack	*Ripogonum scandens*
swamp astelia	*Astelia grandis*
swamp blueberry	*Dianella haematica*
swamp coprosma	*Coprosma tenuicaulis*
swamp cypress	*Taxodium distichum**
swamp kiokio	*Blechnum minus*
swamp mahoe	*Melicytus micranthus*
swamp maire	*Syzygium maire*
swamp millet	*Isachne globosa*
swamp sedge	*Carex secta*
sweet fern	*Pteris macilenta*
sweet vernal	*Anthoxanthum odoratum**
tanekaha	*Phyllocladus trichomanoides*
tangle fern	*Gleichenia dicarpa*
taupata hybrid	*Coprosma repens* hybrid
tawa	*Beilschmiedia tawa*
tender brake	*Pteris tremula*
thin-leaved coprosma	*Coprosma areolata*
thistle	*Cirsium arvense**
thornapple	*Datura stramonium**
thread fern	*Blechnum filiforme*
titoki	*Alectryon excelsus*
Tmesipteris sp.	*Tmesipteris* sp.
toad rush	*Juncus bufonius var. bufonius**
toetoe	*Austroderia fulvida*
toropapa	*Alseuosmia quercifolia*
totara	*Podocarpus totara*
tree fuchsia	*Fuchsia excorticata*
tree lucerne	*Chamaecytisus palmensis**
tree privet	*Ligustrum lucida**
true maidenhair	*Adiantum aethiopicum*

turutu	*Dianella nigra*
umbrella palm	*Hedyscepe canterburyana**
Uncinia banksii	*Uncinia banksii*
walnut	*Juglans ailantifolia**
wandering Jew	*Tradescantia fluminensis**
waratah	*Telopea* sp.*
water fern	*Histiopteris incisa*
water pepper	*Persicaria hydropiper**
wattle	*Acacia* spp.*
wheki	*Dicksonia squarrosa*
wheki-ponga	*Dicksonia fibrosa*
white clover	*Trifolium repens**
white maire	*Nestegis lanceolata*
wild radish	*Raphanus raphanistrum**
wild strawberry	*Duchesnea indica**
willow weed	*Persicaria maculosa**
wineberry	*Aristotelia serrata*
wire rush	*Empodisma minus*
wiwi	*Juncus edgariae*
wonder tree	*Idesia polycarpa**
woolly nightshade	*Solanum mauritianum**
yew	*Taxus baccata**
Yorkshire fog	*Holcus lanatus**

* Exotic species

Animals

Common Name	**Class**	**Species Name**
Australasian harrier	Bird	*Circus approximans*
Australasian shoveller	Bird	*Anas rhynchotis*
Australian coot	Bird	*Fulica atra australis*
banded kokopu	Fish	*Galaxias fasciatus*
bellbird	Bird	*Anthornis melanura*
blackbird	Bird	*Terdus merula**
black shag	Bird	*Phalacrocorax melanoleucos*
black swan	Bird	*Cygnus atratus**
black teal	Bird	*Anthya novaeseelandiae*
brown trout	Fish	*Salmo trutta**
Canada goose	Bird	*Branta canadensis**
carp	Fish	*Cyprinius carpio**
Caspian tern	Bird	*Sterna caspia*
catfish	Fish	*Amieurus nebulosus**
chaffinch	Bird	*Fringilla coelebs**
common bully	Fish	*Gobiomorphus cotidianus*
common smelt	Fish	*Retropinna retropinna*
domestic duck	Bird	*Anas platyrhynchos domesticus**
domestic goose	Bird	*Branta* sp.*
fantail	Bird	*Rhipidura fuliginosa*
feral rock pigeon	Bird	*Columba livia**
frog	Amphibian	*Littoria aurea**
gambusia	Fish	*Gambusia affinis**
giant kokopu	Fish	*Galaxias argenteus*
goldfinch	Bird	*Cardulelis carduelis**

goldfish	Fish	*Carassius auratus**
grey duck	Bird	*Anas superciliosa*
grey mullet	Fish	*Mugil cephalus*
grey teal	Bird	*Anas gracilis*
grey warbler	Bird	*Gerygone igata*
inanga	Fish	*Galaxias maculatus*
kingfisher	Bird	*Halcyon sancta*
little black shag	Bird	*Phalacrocorax sulcirostris*
little pied cormorant	Bird	*Phalarocorax sulcirostris*
little shag	Bird	*Phalacrocorax melanoleucos*
long finned eel	Fish	*Anguilla dieffenbachii*
long-tailed bat	Mammal	*Chalinolobus tuberculatus*
magpie	Bird	*Gymnorhina tibicen**
mallard duck	Bird	*Anas platyrhynchos**
Muscovy duck	Bird	*Cairina moschata**
mynah	Bird	*Acridotheres tristis**
New Zealand dabchick	Bird	*Poliocephalus rufopectus*
paradise shelduck	Bird	*Tadorna variegate*
perch	Fish	*Perca fluviatilis**
pied shag	Bird	*Phalacrocrax varius*
pied stilt	Bird	*Himantopus himantopus*
pukeko	Bird	*Porphyrio porphyrio*
rudd*	Fish	*Scardinius erythrophthalmus*
shining cuckoo	Bird	*Chrysococcyx lucidus*
short finned eel	Fish	*Anguilla australis*
silvereye	Bird	*Zosterops lateralis*
skylark	Bird	*Alauda arvenis**
song thrush	Bird	*Turdus philomelos**
sparrow	Bird	*Passer domesticus*
spur-winged plover	Bird	*Vanellus miles*
starling	Bird	*Sturnis vulgaris**
tench	Fish	*Tinca tinca**
torrentfish	Fish	*Cheimarrichthys fosteri*
tui	Bird	*Prosthemadera novaeseelandiae*
welcome swallow	Bird	*Hirundo tahitica*
white doves	Bird	*Streptopelia risoria**
white faced heron	Bird	*Ardea novaehollandiae*
white headed stilt	Bird	*Himantopus himantopus leucocephalus*
yellow hammer	Bird	*Emberiza citronella**

* Exotic species