
WAIWHAKAREKE
NATURAL HERITAGE PARK

2022

GROUND

TRUTHING

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Waiwhakareke Natural Heritage Park 2022 Ground Truthing

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by

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Cover picture: Vegetation at Waiwhakareke. Captured at Waiwhakareke Natural Heritage Park, September 2022. Photo: Rachel Nepia.

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Executive Summary

This report presents the findings of routine monitoring of Waiwhakareke Natural Heritage Park (WNHP) in preparation for enrichment and infill planting in 2023 to 2024. The monitoring was carried out during September 2022 and included 44 plots across 10 polygons in landforms designated as kauri forest, rimu/tawa forest, swamp shrubland, pukatea-kahikatea forest and kahikatea-pukatea-swamp maire forest. Plot size and number in each polygon were selected to represent a sample area of 5 % of the total polygon area. In each plot the plants were counted by height class, and a percentage of canopy cover was estimated. Vegetation composition, canopy openness, regeneration and plant mortality are discussed in the report. These observations were considered with recommended planting plans generated by the WNHP planting tool, and changes were recommended to provide finalised planting plans. We recommend that this data is regularly fed back into the tool to refine recommended planting plans based on observed patterns of survival.

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Introduction

Located in Hamilton, New Zealand, Waiwhakareke Natural Heritage Park (WNHP) is an award-winning urban restoration project occupying 65.6 hectares of land that was once wholly a working farm. Through the combined efforts of community volunteers, Hamilton City Council, tertiary education institutions and community groups, Waiwhakareke is being transformed from pastureland into an urban biodiversity hot spot. In addition to its biodiversity value, Waiwhakareke has been open to the public since 2019, with functioning paths, lakeside boardwalks, carparking, and toilet facilities that make the park a valuable community resource for recreation and teaching. Further development is underway to create a new carpark and walkway linking the Hamilton Zoo with WNHP.

Waiwhakareke Natural Heritage Park is sectioned into land units based on landform, and each land unit is assigned a goal vegetation type according to what vegetation was historically characteristic of that landform in the Waikato Region (Figure 1). Each vegetation type has a typical species complement, which was generated by a planting design software tool based on land area and successional stage. Conversion from pasture to native vegetation occurs in sections. Annual plantings are carried out by community volunteers each Arbor Day, and by smaller groups of community volunteers regularly during the year. Primary successional plants are planted first into open pasture, with species that are generally short-lived (decades), hardy and fast-growing, to form a canopy. Species such as *Leptospermum scoparium*, *Kunzea ericoides* s.l. and *Phormium tenax* are part of this primary successional complement that transform the harsh, open pasture environment, creating conditions that are more stable in temperature and humidity, and less prone to high winds and frosts. When these stable and sheltered conditions are reached, enrichment planting occurs where mid-successional species are added into the plantings, approximately 10 years after primary successional plantings. Mid-successional species are more tolerant of shade, and more dependent on the shelter of a developed canopy. These include species such as *Beilschmiedia tawa* and *Dacrydium cupressinum*. Mid-successional species are long-lived (centuries) and an important part of the canopy and emergent layer of the vegetation. With further development of the vegetation late successional species will be planted or expected to return on their own, such as epiphytes and ferns. Late successional species in forests require moist and shaded conditions, and, in the case of epiphytes, establish on existing host trees.

In 2018 a review of the planting methodology identified a need for an intermediate planting stage between primary succession planting and enrichment planting due to survival rate of some light-loving but frost sensitive species. This intermediate planting was designated 'infill' and is a fundamental intermediate stage that assists with canopy development. During infill light-loving species are planted which are tolerant of the exposed conditions present in the early stages of forest development but would benefit from some wind and frost protection. These species are often later successional canopy species such as *Agathis australis* and *Phyllocladus trichomanoides* for a ridge, and *Knightia excelsa* and *Dacrydium cupressinum* for a hill slope. Planting earlier in the successional sequence gives these canopy species an opportunity to utilise the high light levels and get a head start ahead of canopy closure. Since 2018 infill has been used based on the percentage of gaps and occurs within the first ten years of pioneer planting.

Ground truthing occurs as required, prior to enrichment and infill planting, to ensure the vegetation is on a trajectory toward the target vegetation type, and to provide guidelines for the volunteers performing the plantings. Early ground-truthing monitoring identified poor survival of many species that was not accounted for in the initial version of the planting tool, resulting in less than optimal enrichment planting lists. In 2018 the tool was adapted to allow for a mixed planting list approach, suggesting a range of primary and mid-successional species for enrichment based on the percentage of canopy closure in the area to be planted (Corney and Wallace, 2018). This ensures that suggested planting lists are suited to the degree of canopy closure in each polygon. The tool user can input the area of the polygon, and the degree of canopy closure (>40 %, 20-40 %, or <20 %). For example, when canopy closure is <20 % a species list will be suggested that includes a mixture of both primary and mid-successional plants. Enrichment planting lists in the current report were generated using the updated tool. This report summarises the findings for the ground truthing carried out in 2022 for the enrichment plantings scheduled for 2024.

Methods

Planting plans were generated using the Waiwhakareke planting tool based on three key parameters: polygon area, vegetation type, and degree of canopy closure. The canopy openness estimate allows the tool to present a planting plan with a mixture of primary successional and mid-successional species that would be appropriate for the polygon. The

only species excluded include ferns, which will return autonomously, and poisonous plants which pose a health and safety risk, such as *Urtica ferox*. Ground-truthing was carried out to assess the recommended planting plan against the on-the-ground conditions of each polygon.

Ground truthing occurred for each polygon scheduled for enrichment or infill. Vegetation plots were measured to give an account of current species diversity, density, regeneration, and canopy openness. Plot size was calculated to represent approximately 1 % of actual polygon area, and plot number generated a sample area of approximately 5 % of total polygon area (see Table 1). In each plot plants were counted, and recorded in height classes of <15 cm, 16-45 cm, 46-75 cm, 76-105 cm, 106-135 cm and >135 cm. For species appearing in the >135 cm height class percentage of canopy cover was estimated. At each polygon comparison was also made between the current species complement, and recommended species complement generated by the planting tool.

Detailed planting plans are presented showing the species recommended by the tool, and recommended numbers based on the degree of canopy openness. Any changes that have been made are indicated on the table. Planting numbers are generally kept at approximately 1,000 plants per hectare for enrichment. Current species numbers are also given as an extrapolation based on calculated density of each species in the measured plots for each polygon.

Table 1: Sampling intensity

Vegetation Type	Polygon	Polygon Size (ha)	Plot Size (m)	No. of Plots
Kahikatea-pukatea-swamp maire forest	54	0.04	2x2	5
	57	0.4	5x5	8
Kauri forest	61	0.02	2x2	3
	63	0.3	5x5	6
Pukatea-Kahikatea forest	56	0.27	5x5	5
	59	0.12	5x5	2
Swamp Shrubland	55	0.16	5x5	3
	58	0.18	5x5	4
Rimu-tawa	60	0.14	5x5	3
	62	0.99	10x10	5
Total		2.62		44

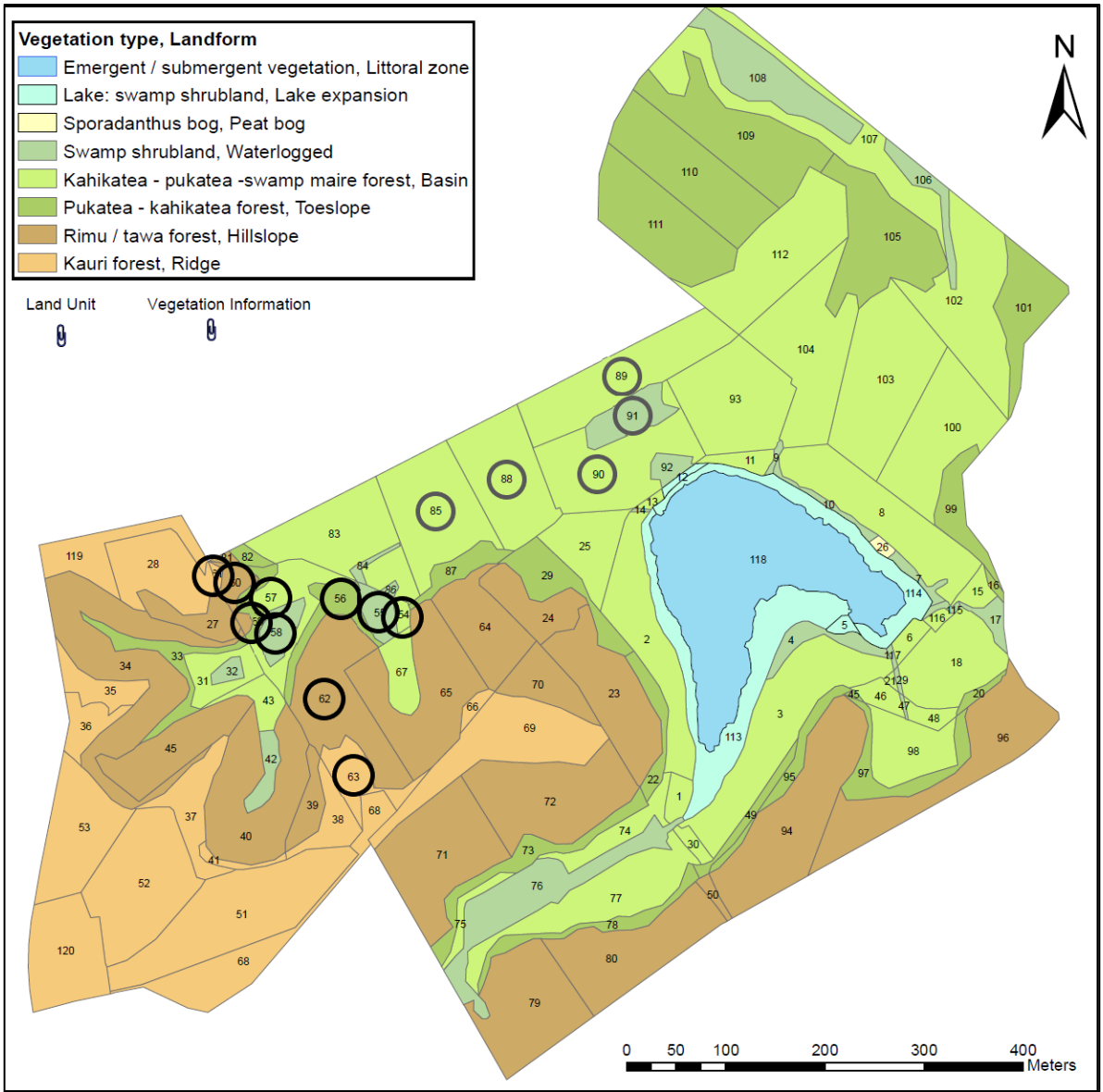


Figure 1: A map of Waiwhakareke Natural Heritage Park, showing polygon numbers and outlines, with their corresponding landform and vegetation type. Polygons for enrichment (black circles) and infill (grey circles) are shown.

Polygons for enrichment

Kauri Forest



Figure 2: Samples of vegetation in the kauri forest type: vegetation in polygon 61 adjacent to the walking track (Top); edge vegetation in polygon 63 (Bottom).

Table 2: Summary of polygons for enrichment within the kauri vegetation type

Polygon No.	Landform	Area (Ha)
61	Ridge	0.02
63	Ridge	0.30
Total		0.32

Target Vegetation Description

Ridge top vegetation at Waiwhakareke Natural Heritage Park is planned to reflect the historical vegetation of Hamilton and its environs. This vegetation type is described in the Waiwhakareke Natural Heritage Park Operative Management Plan (Hamilton City Council, 2011). It is dominated by *Agathis australis* (kauri) and *Phyllocladus trichomanoides* (tanekaha)

in the canopy, with other broadleaved canopy species including *Beilschmiedia tawa* (tawa) and *Knightia excelsa* (rewarewa). Understory shrubs characterising this vegetation type include *Leptecophylla juniperina subsp. juniperina* (prickly mingimingi), *Leucopogon fasciculatus* (mingimingi), and *Cyathea dealbata* (silver fern) and *Dicksonia squarrosa* (wheki) tree ferns. The ground tier is composed of sedges, grasses, ferns, and occasional kauri grass.

At the primary stage of planting, the original tool recommended densely planted species include *Coprosma robusta*, *Veronica stricta*, *Hoheria sexstylosa*, *Kunzea robusta*, *Leptospermum scoparium* and *Myrsine australis*. Moderate density of *Agathis australis*, *Leucopogon fasciculatus*, *Knightia excelsa*, and *Pittosporum tenuifolium* was also prescribed, with sparse occurrences of *Carmichaelia australis*, *Coprosma rhamnoides*, *Coriaria arborea*, *Lygodium articulatum*, and *Olearia rani*. The revised version of the planting tool assumes that sufficient numbers of these species are surviving so the enrichment phase does not include these species. However, many of the dominant target species in this vegetation type, either died or were not planted and are currently not sufficiently represented. For this reason, we recommend the inclusion of species from the 20-40 % canopy openness list for infill to ensure we include species that should be within the land use type that were not planted or did not survive in earlier plantings.

During the enrichment phase of planting, the planting tool recommends addition of species such as *Alectryon excelsus*, *Beilschmiedia tawa*, *Coprosma arborea*, *Coprosma grandifolia*, *Dacrydium cupressinum*, *Geniostoma ligustrifolium subsp. ligustrifolium*, *Olearia rani*, *Pittosporum eugenioides*, *Rhabdothamnus solandri*, *Alseuosmia quercifolia*, *Melicope ternata* and *Myrsine salicina*.

Polygon 61

Polygon 61 consists of two small bands of vegetation either side of the main walking track at the northern edge of the park. Part of the polygon area is unplanted as the buffer area of the park. The dominant species recorded include *Kunzea robusta* and *Leptospermum scoparium*.

Polygon 63

Polygon 63 is an area of vegetation accessible from a clearing on the main walking track. There are grass tracks bounding each side of the vegetation which also assist with accessibility. The dominant species observed here included *Kunzea robusta*, *Leptospermum scoparium*, *Myrsine australis* and *Coprosma robusta*.

Canopy Openness

Canopy openness on average of 24 % open (see Table 3) in Kauri Forest polygons. Canopy species representing a large percentage of cover include *Kunzea robusta*, *Veronica stricta*, *Leptospermum scoparium*, and *Myrsine australis* (see Table 4). Polygon 61 had the highest degree of canopy closure.

Table 3: Summary of canopy openness in polygons with kauri vegetation type

Polygon	Min Cover %	Max Cover %	Average Cover %	Average Open %
Kauri forest	70	95	86	24
63	70	95	83	17
61	95	95	95	37

Table 4: Average percentage cover for species over 135 cm tall in kauri ridge forest in polygons 63 and 61.

Species/Polygon	63	61
<i>Kunzea robusta</i>	41	85
<i>Veronica stricta</i>	10	80
<i>Leptospermum scoparium</i>	35	8
<i>Myrsine australis</i>	14	
<i>Coprosma robusta</i>	9	
<i>Phormium tenax</i>	5	
<i>Melicytus ramiflorus</i>		5
<i>Pittosporum tenuifolium</i>	5	
<i>Veronica stricta (dead)</i>	4	
<i>Hoheria sexstylosa</i>	2	5
<i>Hedycarya arborea</i>	3	
<i>Cordyline australis</i>	3	
<i>Nestegis lanceolata</i>	3	
<i>Melicytus ramiflorus (dead)</i>	2	
<i>Phyllocladus trichomanoides</i>	1	
<i>Alectryon excelsa</i>	1	

Regeneration

Regeneration was minimal in Polygons 61 and 63 (see Table 6). *Solanum mauritianum* (woolly nightshade) and *Myrsine australis* were the only species detected as seedlings. The understory in many areas of polygon 61 and polygon 63 was predominantly exotic grass species, preventing regeneration. Polygon 63 also had some dense areas of *Kunzea robusta* that left the understory dark and dry, minimising regeneration.

Table 5: Density and diversity of seedlings (less than 45 cm in height) in kauri vegetation polygons

Polygon	63	61
Sample area (m ²)	150	10

Total Seedlings	4	0
Density (seedlings/ m ²)	0.027	0
Species	2	0
Diversity (species/ m ²)	0.02	0

Table 6: Counts of naturally regenerating seedlings located in Kauri forest. * denotes non-native species.

Species	Polygon	<15 cm	16-45 cm	16-75 cm	Total
<i>Solanum mauritianum</i> *	63	3			3
<i>Myrsine australis</i>	63		1		1
Total		3	1	0	4

Tree Mortality

Kauri ridge vegetation demonstrated mortality of *Melicytus ramiflorus* and *Veronica stricta*, as shown in Table 7. *Veronica stricta* has a relatively shorter expected life spans than other species, and this mortality is to be expected where planting occurred over 10 years previous.

Table 7: Percentage of dead versus living plants for species with incidence of mortality in kauri ridge vegetation

Species/Polygon	61	63
<i>Melicytus ramiflorus</i>	0 %	100 %
<i>Veronica stricta</i>	0%	67 %

Recommendations for planting activities

Polygon 61 is accessible from the main track. It is an extremely small area so care should be taken to make volunteers aware of the planting limits. The planting tool recommends planting one or two of a wide range of species. However, we recommend focusing on planting larger numbers of a few key species. Over time, regeneration of a wider range of species will naturally occur from adjacent seed sources.

Polygon 63 is accessible by the main track. Two grassed tracks run either side of the main area of vegetation, and a large, grassed area is adjacent, making access for plant delivery and volunteer coordination easy. Polygon 63 is a larger area of vegetation than Polygon 61, and as such, can handle a wider range of species. There are some large open patches where volunteers should be directed to plant light-loving species. Some areas of the polygon have dense stands of *Phormium tenax* that may be difficult for some volunteers to navigate.

Dense canopy of *Kunzea robusta* in some areas of Polygon 63 may need to be thinned, or canopy gaps engineered to allow for effective growth of light-loving enrichment species.

Dense canopy cover creates favourable microclimate conditions (stable temperatures and humidity) for the youngest stage of mid/late successional enrichment seedling germination and growth (<45 cm tall). However, older juveniles (>45 cm tall), are less sensitive to the microclimate and require more light for growth. Engineering of canopy gaps (light-wells) can facilitate growth of any enrichment species approximately 45cm or taller. This is an acceleration of the natural successional processes that occur when the short-lived early-successional tree species reach their life spans and senesce. Care should be exercised to keep canopy gaps small to prevent resurgence of herbaceous groundcover weeds. Light-well creation should not occur until after enrichment species are planted (but within several months of the planting occurring). Prior ecological research in urban forest restoration suggests creation of sparse light wells approximately 2-4 m in diameter to allow 20-40% canopy openness as isolated light-wells where sun-loving late-successional species need to be established (e.g. *Agathis australis*, kauri). This can sometimes be achieved by thinning the canopy cover layers by removing a few branches, rather than completely opening the canopy. Entire trees can be, but should rarely be, removed. Pruned material (i.e. branches) should always remain on the forest floor nearby as it provides important nutrient cycling and habitat.

Changes to the recommended planting list in Polygon 61 were mainly based on the small size of the area to be planted. The tool recommended one of a wide range of species to be planted. We suggest selecting a few key species to add and planting higher numbers of those. The species selected include *Agathis australis* – a key canopy species for ridge forest type – as well as *Alectryon excelsus*, *Coprosma arborea*, *Dacrydium cupressinum*, *Hoheria sexstylosa* and *Knightia excelsa*.

Similarly, several changes have been recommended to the planting list for Polygon 63 suggested by the planting tool. We recommend reducing or removing a few species which are already well established and abundant, including *Coprosma robusta*, *Kunzea robusta*, *Leptospermum scoparium*, and *Veronica stricta*. Conversely, some species have not had evidence of survival in this area, and we recommend waiting for another 5-10 years before planting for better planting conditions, including greater humidity and shelter. These species include *Phyllocladus trichomanoides*, and *Beilschmiedia tawa*. Some other species that have not had good survival in the past but are still recommended if planting sites can be carefully selected, include *Dacrydium cupressinum*, *Knightia excelsa*, and *Agathis*

australis. These species should have plenty of light - either by planting on the margins of the polygon, or in generous light wells. *Alseuosmia macrophylla* and *Alseuosmia quercifolia* are unlikely to survive at this stage, and difficult to propagate, so sourcing would be an issue. These should be reassessed in 10 years. *Podocarpus totara*, *Coprosma rhamnoides* and *Coprosma rigida* have been increased due to observations of good growth and survival in other areas of ridge-type forest. *Podocarpus totara* could also be increased further if *P. laetus* is unable to be sourced.

In general, we recommend a minimum number of 5 individuals per species for logistical reasons, and some species have been increased in number to reach this threshold.

Table 8: Recommended enrichment planting list for Polygon 61 based on a combination of the tool-produced 20-40% gaps list and <20% gaps list. Suggested changes are given based on on-the-ground observations of the polygons and per polygon planting numbers are given.

Scientific name	50% <20	20% >40	30% 20-40	Total 1 ha	P61 0.02 Ha	Changes	P61 Adjusted	Comments
<i>Agathis australis</i>	-	0	10	11	0	5	5	Long lived species key for this forest type
<i>Alectryon excelsus</i>	54	-	38	92	2	4	6	
<i>Alseuosmia macrophylla</i>	-	-	26	26	1	-1	-	
<i>Alseuosmia quercifolia</i>	36	-	26	61	1	-1	-	
<i>Beilschmiedia tawa</i>	27	-	-	27	1	-1	-	
<i>Carmichaelia australis</i>	-	23	-	23	0	-0	-	
<i>Coprosma arborea</i>	36	23	26	84	2	4	6	
<i>Coprosma grandifolia</i>	71	-	51	122	2	-2	-	
<i>Coprosma lucida</i>	-	46	51	98	2	-2	-	
<i>Coprosma rhamnoides</i>	-	23	-	23	0	-0	-	
<i>Coprosma rigida</i>	-	23	26	49	1	-1	-	
<i>Coprosma robusta</i>	-	92	103	195	4	-4	-	Abundant
<i>Coprosma spathulata</i>	-	-	26	26	1	-1	-	
<i>Cordyline banksii</i>	-	23	26	49	1	-1	-	
<i>Dacrydium cupressinum</i>	18	-	13	30	1	4	5	Long lived species
<i>Gahnia pauciflora</i>	-	-	26	26	1	-1	5	
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>	36	-	26	61	1	-1	-	
<i>Hoheria sexstylosa</i>	-	92	-	92	2	3	-	
<i>Knightia excelsa</i>	-	35	38	73	1	4	5	Long lived species
<i>Kunzea robusta</i>	-	46	-	46	1	-1	5	Abundant
<i>Leptecophylla juniperina subsp. juniperina</i>	-	23	26	49	1	-1	-	
<i>Leptospermum scoparium (dry variety)</i>	-	46	-	46	1	-1	-	Abundant
<i>Leucopogon fasciculatus</i>	-	46	-	46	1	-1	-	
<i>Libocedrus plumosa</i>	-	17	-	17	0	-0	-	
<i>Melicope ternata</i>	36	-	26	61	1	-1	-	
<i>Myrsine australis</i>	-	92	-	92	2	-2	-	
<i>Myrsine salicina</i>	36	-	26	61	1	-1	-	
<i>Nestegis lanceolata</i>	-	-	19	19	0	-	-	
<i>Olearia rani</i>	36	-	26	61	1	-1	-	
<i>Phyllocladus trichomanoides</i>	-	1	10	11	0	-	-	
<i>Pittosporum eugenioides</i>	36	23	26	84	2	-2	-	
<i>Pittosporum tenuifolium</i>	-	46	-	46	1	-1	-	
<i>Podocarpus laetus</i>	-	17	19	36	1	-1	-	
<i>Pseudopanax arboreus</i>	-	-	26	26	1	-	-	
<i>Pseudopanax crassifolius</i>	-	23	26	49	1	-1	-	
<i>Raukaua anomalus</i>	-	-	26	26	1	-1	-	
<i>Rhabdothamnus solandri</i>	36	-	-	36	1	-1	-	
<i>Veronica stricta</i>	-	11	-	11	0	0	-	Abundant

<i>Scientific name</i>	50% <20	20% >40	30% 20-40	Total 1 ha	P61 0.02 Ha	Changes	P61 Adjusted	Comments
	453	774	761	1,988	40	-7	32	

Table 9: Recommended enrichment planting list for Polygon 63 based on a combination of the tool-produced 20-40% gaps list and <20% gaps list. Suggested changes are given based on on-the-ground observations of the polygons and per polygon planting numbers are given.

<i>Scientific name</i>	70% <20	20% >40	10% 20-40	Total 1 ha	P63 0.3 Ha	Changes	P61 Adjusted	Comments
<i>Agathis australis</i>	-	0	3	4	1	19	20	None found in polygon.
<i>Alectryon excelsus</i>	75	-	13	88	26	-	26	
<i>Alseuosmia macrophylla</i>	-	-	9	9	3	-3	-	Unlikely to survive
<i>Alseuosmia quercifolia</i>	50	-	9	58	17	-17	-	Unlikely to survive
<i>Beilschmiedia tawa</i>	37	-	-	37	11	-11	-	Wait for better conditions
<i>Carmichaelia australis</i>	-	23	-	23	7	2	9	Currently space for more in open areas
<i>Coprosma arborea</i>	50	23	9	81	24	-	24	
<i>Coprosma grandifolia</i>	99	-	17	117	35	-	35	
<i>Coprosma lucida</i>	-	46	17	63	19	-	19	
<i>Coprosma rhamnoides</i>	-	23	-	23	7	4	11	Species currently doing well in Ridge forest
<i>Coprosma rigida</i>	-	23	9	32	9	3	12	Species currently doing well in Ridge forest
<i>Coprosma robusta</i>	-	92	34	127	38	-38	-	Abundant
<i>Coprosma spathulata</i>	-	-	9	9	3	2	5	Minimum of 5 of a species per polygon
<i>Cordyline banksii</i>	-	23	9	32	9	-	9	
<i>Coriaria arborea</i>	-	-	-	-	-	-	-	
<i>Dacrydium cupressinum</i>	25	-	4	29	9	-	9	2 dead plants found
<i>Gahnia pauciflora</i>	-	-	9	9	3	2	5	Minimum of 5 of a species per polygon
<i>Geniostoma ligustrifolium subsp.</i>	50	-	9	58	17	-	17	
<i>Hoheria sexstylosa</i>	-	92	-	92	28	-	28	
<i>Knightia excelsa</i>	-	35	13	47	14	-	14	
<i>Kunzea robusta</i>	-	46	-	46	14	-14	-	Abundant
<i>Leptecophylla juniperina subsp. juniperina</i>	-	23	9	32	9	-	9	
<i>Leptospermum scoparium (dry variety)</i>	-	46	-	46	14	-14	-	Abundant
<i>Leucopogon fasciculatus</i>	-	46	-	46	14	-	14	
<i>Libocedrus plumosa</i>	-	17	-	17	5	5	10	Quite hardy
<i>Melicope ternata</i>	50	-	9	58	17	-	17	
<i>Myrsine australis</i>	-	92	-	92	28	-28	-	Well established
<i>Myrsine salicina</i>	50	-	9	58	17	-	17	
<i>Nestegis lanceolata</i>	-	-	6	6	2	8	10	Doing well, good location to plant more
<i>Olearia rani</i>	50	-	9	58	17	-	17	
<i>Phyllocladus trichomanoides</i>	-	1	3	4	1	-1	-	High mortality. Wait for better conditions.
<i>Pittosporum eugenioides</i>	50	23	9	81	24	-	24	
<i>Pittosporum tenuifolium</i>	-	46	-	46	14	-	14	
<i>Podocarpus laetus</i>	-	17	6	24	7	-	7	
<i>Podocarpus totara</i>	-	-	-	-	-	10	10	Species currently doing well in Ridge forest
<i>Pseudopanax arboreus</i>	-	-	9	9	3	2	5	Minimum of 5 of a species per polygon
<i>Pseudopanax crassifolius</i>	-	23	9	32	9	-	9	

Scientific name	70% <20	20% >40	10% 20-40	Total 1 ha	P63 0.3 Ha	Changes	P61 Adjusted	Comments
<i>Raukaua anomalus</i>	-	-	9	9	3	2	5	Minimum of 5 of a species per polygon
<i>Rhabdothamnus solandri</i>	50	-	-	50	15	-	15	
<i>Veronica stricta</i>	-	11	-	11	3	-3	-	Well established
	634	774	254	1,661	498	-68	430	

Rimu/tawa forest



Figure 3: Samples of vegetation in the rimu/tawa forest type: vegetation from polygon 62 (Top); area of dense kanuka Polygon 62 (bottom right); vegetation in Polygon 62 (bottom left)

Table 10: Summary of polygons for enrichment within the rimu/tawa vegetation type

Polygon No.	Landform	Area (Ha)
60	Hillslope	0.14
62	Hillslope	0.99
Total		1.47

Target Vegetation Description

The target vegetation type for hillslope landform polygons is rimu/tawa forest. The vision for rimu/tawa forest includes a canopy dominated by *Beilschmiedia tawa* with emergent

interspersed *Dacrydium cupressinum*, *Prumnopitys ferruginea*, *Dacrycarpus dacrydioides*, *Podocarpus totara*, and *Metrosideros robusta*. Other widespread broadleaved species in the canopy will include *Alectryon excelsus*, *Elaeocarpus dentatus*, *Knightia excelsa*, and *Laurelia novae-zelandiae*. In the understorey small trees, shrubs, and tree ferns including *Melicytus ramiflorus*, *Hedycarya arborea*, and *Cyathea dealbata* stand over a ground layer of ferns and grasses such as *Asplenium bulbiferum*, *Blechnum discolor*, *Hymenophyllum demissum*, and *Microlaena avenacea*. During initial planting, the tool recommended densely planting *Hoheria sexstylosa*, *Kunzea robusta*, *Leptospermum scoparium*, and *Myrsine australis*, with moderate densities of *Coprosma robusta*, *Pittosporum tenuifolium*, and *Weinmannia racemosa*.

Polygon 62

Polygon 62 is the largest polygon scheduled for enrichment. It is accessible from the main track and is bisected by a grass track. The dominant species recorded include *Leptospermum scoparium*, *Phormium tenax*, *Kunzea robusta*, and *Coprosma robusta*.

Polygon 60

Polygon 60 is an area of rimu-tawa forest accessible by the main track, and adjacent to Polygons 61 and 59. It includes a narrow strip of vegetation on one side of the track, and a larger tract of vegetation on the other side of the track. The south-eastern edge of the polygon is bordered by a grass track that is partially over-grown. These tracks make for easy access to the polygon. The dominant species recorded in Polygon 60 include *Leptospermum scoparium*, *Pittosporum tenuifolium* and *Cordyline australis*.

Canopy Openness

Canopy openness was generally high across the polygons, with an average of 16 % open (see Table 12). Canopy species representing a large percentage of cover include *Leptospermum scoparium*, *Pittosporum tenuifolium*, *Phormium tenax* and *Kunzea robusta* (see Table 13). Polygon 62 had the highest degree of canopy closure, with large areas of dense *L. scoparium* and *K. robusta* that may require thinning to ensure successful enrichment.

Table 11: Summary of canopy openness in polygons with rimu/tawa vegetation type

Polygon	Min Cover %	Max Cover %	Average Cover %	Average Open %
Rimu / tawa forest	50	95	84	16
62	75	95	88	12
60	50	95	77	23

Table 12: Average percentage cover for species over 135 cm tall in rimu/tawa forest in polygons 62 and 60.

Species	Polygon 62	Polygon 60
<i>Leptospermum scoparium</i>	40	35
<i>Phormium tenax</i>	35	
<i>Kunzea robusta</i>	31	7
<i>Pittosporum tenuifolium</i>	4	28
<i>Cordyline australis</i>	5	25
<i>Coprosma robusta</i>	23	5
<i>Veronica stricta (dead)</i>	8	7
<i>Coprosma robusta (dead)</i>	4	9
<i>Solanum mauritianum</i>	5	
<i>Hedycarya arborea</i>	1	8
<i>Veronica stricta</i>	4	
<i>Melicytus ramiflorus</i>	3	5
<i>Plagianthus regius</i>	2	5
<i>Sophora microphylla</i>	3	3
<i>Podocarpus totara</i>	1	5
<i>Myrsine australis</i>	2	4
<i>Alectryon excelsa</i>	2	
<i>Plagianthus regius (dead)</i>	2	
<i>Alectryon excelsa (dead)</i>	2	
<i>Lophomyrtus bullata</i>	1	

Regeneration

Rimu/tawa forest polygons had among the highest seedling density and diversity, compared with other forest types. *Hoheria sexstylosa* was the most commonly regenerating species, followed by *Melicytus ramiflorus* and then *Solanum mauritianum* (see Table 14). Polygon 60 had the most speciose seedling regeneration, and greatest density of seedlings per unit of area (see Table 15). Regeneration was low in some areas of Polygon 62 where dense canopy growth inhibited light and encouraged dry ground tier conditions.

Table 13: Counts of naturally regenerating seedlings located in Rimu/tawa forest. Asterisk indicates non-native species.

Species	Polygon	<15 cm	16-45 cm	46-75 cm	Total
<i>Hoheria sexstylosa</i>	60	80	2		82
<i>Melicytus ramiflorus</i>	62	19	3	7	29
	60	15	6	3	24
<i>Solanum mauritianum*</i>	62	2	15	2	19
	60		2		2
<i>Berberis glaucocarpa*</i>	62	2	2	1	5
	60	7	1		8
<i>Ligustrum sinense*</i>	62	6	1	1	8
	60	2			2
<i>Myrsine australis</i>	62	4	1		5

Species	Polygon	<15 cm	16-45 cm	46-75 cm	Total
<i>Diplazium australe</i>	62	1	1	2	4
<i>Cordyline australis</i>	62			1	1
	60		1		1
<i>Kunzea robusta</i>	62	2			2
<i>Plagianthus regius</i>	60	1			1
<i>Rubus sp.*</i>	60	1			1
<i>Pittosporum crassifolium</i>	60	1			1
Grand Total		143	36	17	196

Table 14: Density and diversity of seedlings (less than 75 cm in height) in rimu/tawa vegetation

Polygon	60	62
Sample area (m ²)	75	500
Total Seedlings	122	74
Density (seedlings/ m ²)	1.6	0.148
Species	10	9
Diversity (species/ m ²)	0.1	0.018

Tree Mortality

Hillslope rimu/tawa vegetation exhibited mortality of *Alectryon excelsus*, *Coprosma robusta*, *Cordyline australis*, *Dacrydium cupressinum*, *Plagianthus regius* and *Veronica stricta*, as shown in Table 16. Percentage of dead plants was greatest for *D. cupressinum*, *V. stricta* and *C. robusta*. Both *C. robusta* and *V. stricta* have relatively shorter expected life spans than other species, and this mortality is to be expected where planting occurred over 10 years previous. Mortality of *D. cupressinum* is more concerning as this species is intended to be a major canopy species of this forest type.

Table 15: Percentage of dead plants for species with incidence of mortality in hill slope vegetation

Species/Polygon	60	62	Total
<i>Alectryon excelsus</i>		17%	17%
<i>Coprosma robusta</i>	60%	38%	46%
<i>Cordyline australis</i>		20%	20%
<i>Dacrydium cupressinum</i>		100%	100%
<i>Plagianthus regius</i>	0%	25%	20%
<i>Veronica stricta</i>	100%	50%	57%

Recommendations for planting activities

Polygons 60 and 62 are easily accessible for volunteers. Polygon 60 is bisected by the main track. It is also accessible from an overgrown grass track down the southeast side of the

polygon. Polygon 62 is also accessible via grassed tracks that run through the centre of the polygon and on the southeast side. Polygon borders are not clearly visible, and care should be taken to communicate these to volunteers.

The planting plans outlined in Tables 16 and 17 show several species which we have recommended not be included in the plantings at this stage for various reasons. These should all be tracked in the database (once developed) to ensure that they are planted once the vegetation is more suitable. Due to current low humidity conditions, we recommend precluding *Beilschmiedia tawa*, *Alseuosmia macrophylla*, *Alseuosmia quercifolia*, *Coprosma spathulata*, *Geniostoma ligustrifolium subsp. ligustrifolium* and *Coprosma grandifolia*. Other species have been reduced or removed due to current high abundance, such as *Coprosma robusta*, or dense natural regeneration, such as *Melicytus ramiflorus*. We recommend a cautious approach with *Lophomyrtus bullata* as it is one of the most susceptible species to Myrtle rust, a destructive plant disease in the Myrtaceae family (Smith et al., 2019). Though this species has already been planted in some areas of the park, limiting density of *Lophomyrtus bullata* could help to prevent spread of the disease through the park in the future. *Mida salicifolia* has been removed as it is more suited to ridge type vegetation, and the tool should be reviewed to ensure correct classification of species such as this.

We have also recommended an increase in some species numbers for various reasons. For example, *Dacrydium cupressinum* was not planted in the previous infill for Polygon 60 and we recommend planting more. Care should be taken with where to plant these – ensure that there is a sufficiently large light well. *Coprosma rigida* has also been recommended for increased density as it has demonstrated good survival and growth in other similar areas of WNHP.

In general, we recommend a minimum number of 5 individuals per species for logistical reasons. Some species have been increased in number to reach this threshold, e.g., *Fuchsia excorticata* and others have been removed, particularly if there is some doubt as to sourcing and survival, e.g., *Raukaua anomalus* and *Rhabdothamnus solandri*.

Table 16: Recommended enrichment planting list for Polygon 60 using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	60% of <20	20% of >40%	20% of 20-40	Total 1 ha	Tool 60	Changes	60	Comments
<i>Alectryon excelsus</i>	22	0	16	38	5	0	5	
<i>Alseuosmia macrophylla</i>	14	0	11	25	4	-4	0	Unlikely to survive
<i>Alseuosmia quercifolia</i>	14	0	11	25	4	-4	0	Unlikely to survive
<i>Aristotelia serrata</i>	0	34	16	50	7	0	7	
<i>Beilschmiedia tawa</i>	44	0	0	44	6	-6	0	Wait for better conditions.
<i>Brachyglottis repanda</i>	0	0	11	11	1	-1	0	Minimum of 5
<i>Coprosma arborea</i>	14	22	11	47	7	0	7	
<i>Coprosma grandifolia</i>	14	0	11	25	4	-4	0	Too early
<i>Coprosma lucida</i>	0	22	11	33	5	0	5	
<i>Coprosma rigida</i>	0	22	11	33	5	0	5	Will thrive both under canopy and in open spaces
<i>Coprosma robusta</i>	0	45	21	66	9	-9	0	Abundant
<i>Coprosma spathulata</i>	14	0	11	25	4	-4	0	Too early
<i>Cordyline australis</i>	0	45	21	66	9	-9	0	Abundant
<i>Dacrydium cupressinum</i>	0	22	16	38	5	5	10	None planted in infill
<i>Dianella nigra</i>	29	0	0	29	4	-4	0	Minimum of 5
<i>Elaeocarpus dentatus</i>	29	0	21	50	7	0	7	
<i>Fuchsia excorticata</i>	14	0	11	25	4	2	5	Minimum of 5
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>	29	0	0	29	4	-4	0	Too early
<i>Hedycarya arborea</i>	29	0	21	50	7	0	7	
<i>Hoheria sexstylosa</i>	0	90	0	90	13	-3	10	Regenerating naturally
<i>Knightia excelsa</i>	0	17	8	25	3	-3	0	High mortality
<i>Kunzea robusta</i>	0	45	0	45	6	-6	0	Abundant
<i>Leptospermum scoparium (dry variety)</i>	0	45	21	66	9	-9	0	Abundant
<i>Leucopogon fasciculatus</i>	14	0	11	25	4	2	5	
<i>Litsea calicaris</i>	11	0	8	19	3	2	5	
<i>Lophomyrtus bullata</i>	0	22	11	33	5	-5	0	Myrtle rust risk
<i>Melicytus ramiflorus subsp. ramiflorus</i>	29	45	21	95	13	-8	5	Abundant
<i>Metrosideros robusta</i>	11	17	8	36	5	0	5	
<i>Mida salicifolia</i>	14	0	0	14	2	-2	0	More suited to ridge areas
<i>Myrsine australis</i>	0	90	43	133	19	0	19	
<i>Myrsine salicina</i>	14	0	11	25	4	0	4	
<i>Neomyrtus pedunculata</i>	14	0	0	14	2	-2	0	Not right areas for planting within this polygon
<i>Nestegis lanceolata</i>	11	0	8	19	3	-3	0	Not right areas for planting within this polygon
<i>Olearia rani</i>	14	0	11	25	4	2	5	
<i>Phyllocladus trichomanoides</i>	0	0	0	0	0	0	0	
<i>Piper excelsum</i>	29	0	21	50	7	0	7	
<i>Pittosporum eugenoides</i>	14	22	11	47	7	0	7	
<i>Pittosporum tenuifolium</i>	0	45	0	45	6	-6	0	Abundant
<i>Plagianthus regius</i>	0	45	21	66	9	0	9	
<i>Podocarpus totara</i>	0	17	8	25	3	3	6	
<i>Prumnopitys ferruginea</i>	22	0	16	38	5	0	5	

Scientific name	60% of <20	20% of >40%	20% of 20-40	Total 1 ha	Tool 60	Changes	60	Comments
<i>Pseudopanax arboreus</i>	29	0	21	50	7	0	7	
<i>Pseudopanax crassifolius</i>	0	22	11	33	5	0	5	
<i>Raukaua anomalus</i>	0	0	11	11	1	-1	0	Minimum of 5
<i>Rhabdothamnus solandri</i>	14	0	0	14	2	-2	0	Minimum of 5
<i>Rhopalostylis sapida</i>	14	0	11	25	4	-4	0	Not right areas for planting within this polygon
<i>Schefflera digitata</i>	14	0	11	25	4	-4	0	Not right areas for planting within this polygon
<i>Streblus heterophyllus</i>	0	0	11	11	1	-1	0	Minimum of 5
<i>Veronica stricta</i>	0	11	0	11	2	-2	0	Minimum of 5
<i>Weinmannia racemosa</i>	22	0	16	38	5	0	5	
	559	747	557	1,862	261	-95	165	

Table 17: Recommended enrichment planting list for Polygon 62 using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	60% of <20	20% of >40%	20% of 20-40	Total 1 ha	Tool 62	Changes	62	Comments
<i>Agathis australis</i>				0	0	20	20	As per 2020 ground-truthing.
<i>Alectryon excelsus</i>		80	36	39	39	-39	0	Good survival of infill sufficient.
<i>Alseuosmia macrophylla</i>		53	24	26	26	-26	0	Unlikely to survive.
<i>Alseuosmia quercifolia</i>		53	24	26	26	-26	0	Unlikely to survive.
<i>Aristotelia serrata</i>	168	80		16	16	0	16	
<i>Beilschmiedia tawa</i>			73	62	61	-61	0	Wait until conditions improve.
<i>Brachyglottis repanda</i>		53		5	5	25	30	None planted yet. Focus on edges and large gaps.
<i>Coprosma arborea</i>	112	53	24	31	31	20	51	None planted in early planting phases.
<i>Coprosma grandifolia</i>		53	24	26	26	-26	0	Too dry.
<i>Coprosma lucida</i>	112	53		11	11	0	11	
<i>Coprosma rigida</i>	112	53		11	11	29	40	None planted yet. Focus on edges and large gaps.
<i>Coprosma robusta</i>	225	107		22	22	-22	0	Abundant
<i>Coprosma spathulata</i>		53	24	26	26	-26	0	Too dry.
<i>Cordyline australis</i>	225	107		22	22	0	22	
<i>Dacrydium cupressinum</i>	112	80		14	14	-14	0	Wait until conditions improve.
<i>Dianella nigra</i>			48	41	41	0	41	
<i>Elaeocarpus dentatus</i>		107	48	52	51	0	51	
<i>Fuchsia excorticata</i>		53	24	26	26	0	26	
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>			48	41	41	-41	0	Too early.
<i>Hedycarya arborea</i>		107	48	52	51	0	51	
<i>Hoheria sexstylosa</i>	450			23	23	0	23	
<i>Knightia excelsa</i>	84	40		8	8	12	20	Low survival. Focus on edges and large gaps.
<i>Kunzea robusta</i>	225			11	11	-11	0	Abundant
<i>Leptospermum scoparium (dry variety)</i>	225	107		22	22	-22	0	Abundant
<i>Leucopogon fasciculatus</i>		53	24	26	26	0	26	
<i>Litsea calicaris</i>		40	18	19	19	0	19	
<i>Lophomyrtus bullata</i>	112	53		11	11	-11	0	Avoid myrtle rust.
<i>Melicytus ramiflorus subsp. ramiflorus</i>	225	107	48	63	62	-32	30	Regenerating naturally.
<i>Metrosideros robusta</i>	84	40	18	24	24	0	24	
<i>Mida salicifolia</i>			24	20	20	-20	0	More suited to ridge-type vegetation.
<i>Myrsine australis</i>	450	214		44	44	0	44	
<i>Myrsine salicina</i>		53	24	26	26	0	26	
<i>Neomyrtus pedunculata</i>			24	20	20	0	20	
<i>Nestegis lanceolata</i>		40	18	19	19	0	19	Focus on light wells.
<i>Olearia rani</i>		53	24	26	26	0	26	
<i>Phyllocladus trichomanoides</i>					0	0	0	As per 2020 ground-truthing.
<i>Piper excelsum</i>		107	48	52	51	0	51	
<i>Pittosporum eugenioides</i>	112	53	24	31	31	0	31	Only plant if eco sourced

Scientific name	60% of <20	20% of >40%	20% of 20-40	Total 1 ha	Tool 62	Changes	62	Comments
<i>Pittosporum tenuifolium</i>	225			11	11	-11	0	Abundant
<i>Plagianthus regius</i>	225	107		22	22	0	22	
<i>Podocarpus totara</i>	84	40		8	8	22	30	Low survival.
<i>Prumnopitys ferruginea</i>		80	36	39	39	0	39	
<i>Pseudopanax arboreus</i>		107	48	52	51	0	51	
<i>Pseudopanax crassifolius</i>	112	53		11	11	19	30	Plant in light wells and edges.
<i>Raukaua anomalus</i>		53		5	5	0	5	
<i>Rhabdothamnus solandri</i>			24	20	20	0	20	
<i>Rhopalostylis sapida</i>		53	24	26	26	0	26	
<i>Schefflera digitata</i>		53	24	26	26	0	26	
<i>Streblus heterophyllus</i>		53		5	5	25	30	None planted in 20-40
<i>Veronica stricta</i>	56			3	3	-3	0	Abundant
<i>Weinmannia racemosa</i> var. <i>racemosa</i>		80	36	39	39	0	39	
	3,735	2,784	931	1,261	1,248	-216	1,033	

Kahikatea-pukatea-swamp maire forest



Figure 4: Samples of vegetation in the kahikatea-pukatea-swamp maire forest type: vegetation from polygon 54 (Top); vegetation in Polygon 57 (bottom)

Table 18: Summary of polygons for enrichment within the kahikatea-pukatea-swamp maire vegetation type

Polygon No.	Landform	Area (Ha)
54	Basin	0.04
57	Basin	0.4
Total		0.44

Target Vegetation Description

Kahikatea-pukatea-swamp maire forest is a type of semi-swamp forest that was once common in the Hamilton Basin. This vegetation type is also well represented in the long-term vision for WNHP. The canopy is dominated by species that can outcompete others in water-logged and swampy soils: *Dacrycarpus dacrydioides*, *Laurelia novae-zelandiae*, and *Syzygium*

maire. In the understory broadleaved trees are more diverse including species such as *Cordyline australis*, *Leptospermum scoparium*, *Coprosma tenuicaulis*, *Pennantia corymbosa*, *Fuchsia excorticata* and *Schefflera digitata*. The ground tier is dominated by *Carex* sedges and *Phormium tenax*, with ferns such as *Blechnum novae-zelandiae* and *Pneumatopteris pennigera* also common.

Polygon 54

Polygon 54 is a strip of vegetation partially bisected by the main path. The dominant species recorded include *Plagianthus regius*, *Carex secta* and *Coprosma propinqua*. This polygon appears to be only recently planted and is not in need of enrichment.

Polygon 57

Polygon 57 is an unusually shaped area of vegetation surrounding polygon 58. The boundaries of the polygon can be very difficult to delineate as the vegetation is similar to adjacent polygon 58, 59 and 56. The dominant species recorded here include *Carex secta*, *Phormium tenax*, *Coprosma propinqua* and *Leptospermum scoparium*.

Canopy Openness

Canopy openness was very high in Polygon 54 with an average of 99 % open (see Table 12). In Polygon 54 few species reached over 135 cm tall as most were young plants. In Polygon 57 canopy openness was 14 % on average and species representing a large percentage of cover included *Carex secta*, *Phormium tenax*, *Coprosma propinqua* and *Leptospermum scoparium* (see Table 13).

Table 19: Summary of canopy openness in polygons with kahikatea-pukatea-swamp maire vegetation type

Polygon	Min Cover %	Max Cover %	Average Cover %	Average Open %
<i>Kahikatea-pukatea-swamp maire forest</i>	1	100	63	42
54	1	2	2	99
57	60	100	86	14

Table 20: Average percentage cover for species over 135 cm tall in kahikatea-pukatea-swamp maire forest in polygons 54 and 57

Species	Average % Cover Polygon 54	Polygon 57
<i>Carex secta</i>	1	48
<i>Phormium tenax</i>		26
<i>Leptospermum scoparium</i>		9
<i>Meliccytus ramiflorus</i>		7

Species	Average % Cover Polygon 54	Polygon 57
<i>Coprosma propinqua</i>	1	10
<i>Solanum aviculare</i>		5
<i>Dacrycarpus dacrydioides</i>		4
<i>Coprosma tenuifolium</i>		4
<i>Plagianthus regius</i>	2	

Regeneration

Kahikatea-pukatea-swamp maire forest polygons had lower than average seedling density and diversity, compared with other forest polygons. *Melicytus ramiflorus* was the most commonly regenerating species (see Table 18). Regeneration data for Polygon 54 is misleading, as all the species in this polygon are planted but occupy smaller height classes. Data for polygon 57 illustrates true regeneration. It is encouraging to see regeneration of ferns such as *Cyathea dealbata* and *Dicksonia squarrosa* in Polygon 57.

Table 21: Counts of naturally regenerating seedlings located in Kahikatea-pukatea-swamp maire forest. Asterisks indicate non-native species.

Species	Polygon	<15 cm	16-45 cm	46-75 cm	Total
<i>Melicytus ramiflorus</i>	54	11	12	5	28
	57	6	22	9	37
<i>Diplazium australe</i>	57			3	3
<i>Prunus serrulata*</i>	57		2		2
<i>Coprosma tenuicaulis</i>	54		2		2
<i>Phormium tenax</i>	54	1			1
<i>Cyathea dealbata</i>	57			1	1
<i>Dicksonia squarrosa</i>	54			1	1
<i>Cordyline australis</i>	54			1	1
<i>Coprosma robusta</i>	57		1		1
Grand Total		18	40	20	78

Table 22: Density and diversity of seedlings (less than 75 cm in height) in kahikatea-pukatea-swamp maire vegetation

Polygon	54	57
Sample area (m ²)	20	200
Total Seedlings	34	44
Density (seedlings/ m ²)	1.7	0.22
Species	6	6
Diversity (species/ m ²)	0.3	0.03

Tree Mortality

Basin kahikatea-pukatea-swamp maire vegetation demonstrated mortality of *Coprosma propinqua* and *Cordyline australis*, as shown in Table 21.

Table 23: Percentage of dead plants for species with incidence of mortality in hill slope vegetation

Species/Polygon	54	57	Total
<i>Coprosma propinqua</i>	25%	0%	20%
<i>Cordyline australis</i>	0%	25%	20%

Recommendations for planting activities

Polygon 54 is not recommended for enrichment. The planting appears to be very young and has not developed to a stage that will allow for the planting of enrichment species.

Polygon 57 is an unusual shape, and both accessibility and navigation of this polygon may be difficult for volunteers in some places. The main section of polygon 57 may be planted by volunteers, as this is easily accessible from the track. However, the narrow arm of this polygon might be better suited to planting by WNHP staff who are familiar with the park and can use GPS to navigate the polygon. Volunteers should take care as the drain can be obscured by vegetation in places, and difficult to see.

We have recommended to increase numbers of *Carex* varieties to be planted in drain areas that are currently dominated by exotic grasses. We have also recommended an increase in numbers for *Coprosma tenuicaulis*, *Hoheria sexstylosa*, *Myrsine australis* and *Plagianthus regius* as species that will thrive here and contribute to canopy closure.

We have recommended reduction or removal of some species based on conditions. *Coprosma grandifolia*, *Coprosma spathulate*, *Schefflera digitata* and *Geniostoma ligustrifolium* are examples of this. *Mida salicifolia* is more suited to ridge-type vegetation and has been recommended for removal from the planting list. *Melicytus ramiflorus* is showing signs of healthy regeneration and has been removed for this reason.

Table 24: Recommended enrichment planting list for polygon 57 using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	70% of <20	10% of >40%	20% of 20-40	Total 1 ha	Tool 57	Changes	57	Comments
<i>Brachyglottis repanda</i>	0	14	13	27	11	0	11	
<i>Carex geminata</i>	0	0	0	0	0	64	64	To out compete grasses in the drain
<i>Carex secta</i>	0	28	27	54	22	28	50	To out compete grasses in the drain
<i>Carex virgata</i>	0	28	0	28	11	39	50	To out compete grasses in the drain
<i>Carpodetus serratus</i>	0	14	13	27	11	0	11	
<i>Coprosma areolata</i>	0	14	13	27	11	0	11	
<i>Coprosma grandifolia</i>	25	0	13	38	15	-15	0	Too early
<i>Coprosma propinqua</i>	0	28	27	54	22	0	22	
<i>Coprosma rigida</i>	0	28	0	28	11	0	11	
<i>Coprosma robusta</i>	0	28	27	54	22	0	22	
<i>Coprosma rotundifolia</i>	25	14	13	52	21	0	21	
<i>Coprosma spathulata</i>	49	0	27	76	30	-30	0	Too early
<i>Coprosma tenuicaulis</i>	0	28	54	81	33	32	65	Will survive well here
<i>Cordyline australis</i>	0	28	0	28	11	0	11	
<i>Dacrycarpus dacrydioides</i>	0	21	0	21	8.2	-8	0	Very well established within the polygon
<i>Dianella haemata</i>	25	0	13	38	15	0	15	
<i>Elaeocarpus hookerianus</i>	25	0	13	38	15	0	15	
<i>Fuchsia excorticata</i>	49	0	27	76	30	0	30	
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>	49	0	0	49	20	-20	0	Too early
<i>Hedycarya arborea</i>	25	0	13	38	15	0	15	
<i>Hoheria sexstylosa</i>	0	14	0	14	5.5	30	35	Good species to use to shade out flax
<i>Knightia excelsa</i>	0	10	10	20	8.1	0	8	
<i>Laurelia novae-zelandiae</i>	74	0	40	114	46	0	46	
<i>Leptospermum scoparium (wet variety)</i>	0	28	27	54	22	-22	0	Abundant
<i>Leucopogon fasciculatus</i>	25	0	13	38	15	0	15	
<i>Melicope simplex</i>	25	0	13	38	15	0	15	
<i>Melicytus ramiflorus subsp. ramiflorus</i>	25	14	13	52	21	-21	0	Regenerating on its own
<i>Mida salicifolia</i>	25	0	0	25	9.8	-10	0	More suited to ridge-type vegetation
<i>Myrsine australis</i>	0	14	13	27	11	9	20	Will thrive here.
<i>Neomyrtus pedunculata</i>	25	14	13	52	21	0	21	
<i>Nestegis cunninghamii</i>	18	10	10	39	15	0	15	
<i>Pennantia corymbosa</i>	49	0	27	76	30	0	30	
<i>Plagianthus regius</i>	0	28	27	54	22	28	50	Good species to use to shade out flax
<i>Prumnopitys taxifolia</i>	0	10	10	20	8.1	7	15	Will do well here.
<i>Schefflera digitata</i>	49	0	27	76	30	-30	0	Too early
<i>Syzygium maire</i>	74	0	40	114	46	-16	30	Consider myrtle rust and only plant along the drain.
	655	409	580	1644	658	66	724	

Swamp shrubland



Figure 5: Samples of vegetation in the swamp shrubland forest type: vegetation from polygon 55 (Top); vegetation in Polygon 58 (bottom)

Table 25: Summary of polygons for enrichment within the swamp shrubland vegetation type

Polygon No.	Landform	Area (Ha)
55	Waterlogged	0.16
58	Waterlogged	0.18
Total		0.34

Target Vegetation Description

The target vegetation type for waterlogged landform polygons is swamp shrubland forest. This vegetation type generally occurs on the margins of streams and drainage channels, and near the lake edge where the ground can get water-logged and often flooded. In these wetland areas the emergent species include *Syzygium maire*, *Leptospermum scoparium*, and *Cordyline australis* with the occasional tree fern. These are scattered over a shrubby understory comprised of species such as *Coprosma propinqua*, *Coprosma rigida*, *Coprosma tenuicaulis*, and *Coprosma rotundifolia*. The ground tier is dominated by sedges, herbs, and rushes and grasses such as *Carex*, *Baumea*, *Astelia*, and *Gahnia*. During initial planting, the tool recommended densely planting *Hoheria sexstylosa*, *Kunzea robusta*, *Leptospermum scoparium*, and *Myrsine australis*, with moderate densities of *Coprosma robusta*, *Pittosporum tenuifolium*, and *Weinmannia racemosa*.

Polygon 55

Polygon 55 is an area of vegetation accessible from the main track and bordering polygons 54 and 56. There is a drainage channel going through the polygon and can be damp in places. The dominant species recorded include *Phormium tenax*, *Leptospermum scoparium*, *Coprosma robusta* and *Dacrycarpus dacrydioides*.

Polygon 58

Polygon 58 is an area of vegetation that has no track access points. As such, it could be difficult for volunteers to locate and access without support. It is bisected by a stream that is obscured by vegetation in places. Vegetation is dominated by *Phormium tenax*, *Leptospermum scoparium*, *Coprosma robusta* and *Dacrycarpus dacrydioides*.

Canopy Openness

Canopy openness was generally low across the polygons, with an average of 20 % open (see Table 12). Canopy species representing a large percentage of cover include *Leptospermum scoparium*, *Carex secta*, *Phormium tenax* and *Coprosma robusta* (see Table 13). Polygon 58 had the highest degree of canopy closure, including dense areas of *P. tenax* that can be difficult to navigate through. Polygon 55 also had some dense areas of *P. tenax*.

Table 26: Summary of canopy openness in polygons with swamp shrubland vegetation type

Polygon	Min Cover %	Max Cover %	Average Cover %	Average Open %
Swamp shrubland	60	95	80	20
55	65	90	78	22
58	60	95	81	19

Table 27: Average percentage cover for species over 135 cm tall in swamp shrubland forest in polygons 55 and 58

Species	Polygon 55	Polygon 58
<i>Leptospermum scoparium</i>	48	30
<i>Carex secta</i>		39
<i>Phormium tenax</i>	48	23
<i>Coprosma robusta</i>	30	
<i>Melicytus ramiflorus</i>		15
<i>Coprosma tenuicaulis</i>	5	20
<i>Dacrycarpus dacrydioides</i>	5	5
<i>Coprosma propinqua</i>		3

Regeneration

Swamp shrubland forest polygons had among the lowest seedling density and diversity, compared with other vegetation types. *Melicytus ramiflorus* was, again, the most commonly regenerating species, followed by *Diplazium australe* (see Table 25). Polygon 58 had the most speciose seedling regeneration, and greatest density of seedlings per unit of area (see Table 26). Areas of dense flax coverage in Polygon 55 may have attributed to this.

Table 28: Counts of naturally regenerating seedlings located in Swamp shrubland forest

Species	Polygon	<15 cm	16-45 cm	46-75 cm	Total
<i>Melicytus ramiflorus</i>	58	3	1	4	8
<i>Diplazium australe</i>	58			2	2
<i>Cyathea dealbata</i>	58			1	1
<i>Coprosma tenuicaulis</i>	55	1			1
<i>Coprosma areolata</i>	55			1	1
<i>Solanum aviculare</i>	58		1		1
Grand Total		4	2	8	14

Table 29: Density and diversity of seedlings (less than 75 cm in height) in swamp shrubland vegetation

Polygon	55	58
Sample area (m ²)	75	100
Total Seedlings	3	12
Density (seedlings/ m ²)	0.04	0.12
Species	3	5
Diversity (species/ m ²)	0.04	0.05

Tree Mortality

Waterlogged swamp shrubland vegetation demonstrated mortality of *Carpodetus serratus* and *Dacrycarpus dacrydioides* (Table 28). Percentage of dead plants was greatest for *Carpodetus serratus*, at 50 %.

Table 30: Percentage of dead plants for species with incidence of mortality in waterlogged vegetation

Species/Polygon	55	58	Total
<i>Carpodetus serratus</i>	50%		50%
<i>Dacrycarpus dacrydioides</i>	25%	0%	14%

Recommendations for planting activities

The planting tool recommends a selection of swamp shrubland species for Polygons 55 and 58 that reflect the wet conditions in these polygons. We recommend a few departures from the recommended list based on on-the ground observations. *Leptospermum scoparium var scoparium* should be removed as it is already very abundant in both Polygon 55 and Polygon 58. Care should be taken when planting *Syzygium maire* to ensure it is planted in areas that are damp but also sheltered as this species can be prone to frost.

It was suggested that large numbers (density of 2 m²) of mound-forming species such as *Carex* species be planted out in areas where exotic weeds are currently dominating. We recommend staying close to the recommended enrichment density of 4 m² to avoid turning the swamp shrubland into a grassland.

Table 31: Recommended enrichment planting list for Polygon 55 (0.16 ha) using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	55% of <20	20% of >40%	25% of 20-40	Total 1 ha	Tool 55	Changes	55	Comments
<i>Carex geminata</i>	-	48	-	48	8	0	8	
<i>Carex lessoniana</i>	-	24	-	24	4	0	4	
<i>Carex maorica</i>	-	48	-	48	8	0	8	
<i>Carex secta</i>	-	267	293	559	89	0	89	
<i>Carex virgata</i>	-	267	-	267	43	0	43	
<i>Coprosma propinqua</i>	-	48	73	121	19	0	19	
<i>Coprosma rigida</i>	-	48	73	121	19	0	19	
<i>Coprosma rotundifolia</i>	220	48	73	341	55	0	55	
<i>Coprosma tenuicaulis</i>	-	97	146	243	39	0	39	
<i>Cordyline australis</i>	-	97	-	97	15	0	15	
<i>Cyperus ustulatus</i>	-	48	-	48	8	0	8	
<i>Dianella haemata</i>	-	-	37	37	6	0	6	
<i>Gahnia xanthocarpa</i>	-	24	73	97	16	0	16	
<i>Juncus edgariae</i>	-	48	-	48	8	0	8	
<i>Laurelia novae-zelandiae</i>	83	-	-	83	13	0	13	
<i>Leptospermum scoparium (wet variety)</i>	-	48	73	121	19	-19	0	Abundant
<i>Pennantia corymbosa</i>	110	-	37	147	23	0	23	
<i>Syzygium maire</i>	83	-	27	110	18	0	18	Plant in protected wet areas
	495	1,162	904	2,561	410	-9	401	

Table 32: Recommended enrichment planting list for Polygon 58 (0.18 ha) using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	15% of <20	60% of >40%	25% of 20-40	Total 1 ha	Tool 58	Changes	58	Comments
<i>Carex geminata</i>	-	145	-	145	26	0	26	
<i>Carex lessoniana</i>	-	73	-	73	13	0	13	
<i>Carex maorica</i>	-	145	-	145	26	0	26	
<i>Carex secta</i>	-	800	293	1092	197	0	197	
<i>Carex virgata</i>	-	800	-	800	144	0	144	
<i>Coprosma propinqua</i>	-	145	73	218	39	0	39	
<i>Coprosma rigida</i>	-	145	73	218	39	0	39	
<i>Coprosma rotundifolia</i>	60	145	73	278	50	0	50	
<i>Coprosma tenuicaulis</i>	-	290	146	437	79	0	79	
<i>Cordyline australis</i>	-	290	-	290	52	0	52	
<i>Cyperus ustulatus</i>	-	145	-	145	26	0	26	
<i>Dianella haemata</i>	-	-	37	37	7	0	7	
<i>Gahnia xanthocarpa</i>	-	73	73	146	26	0	26	
<i>Juncus edgariae</i>	-	145	-	145	26	0	26	Needs to be planted in the drain.
<i>Laurelia novae-zelandiae</i>	23	-	-	23	4	0	4	
<i>Leptospermum scoparium (wet variety)</i>	-	145	73	218	39	-39	0	Abundant
<i>Pennantia corymbosa</i>	30	-	37	67	12	0	12	
<i>Syzygium maire</i>	23	-	27	50	9	0	9	Must be planted in wet protected areas.
	135	3,487	904	4526	815	- 39	775	

Pukatea-kahikatea Forest



Figure 6: Samples of vegetation in the pukatea-kahikatea forest type: vegetation from polygon 62 (Top); area of dense kanuka Polygon 62 (bottom right); vegetation in Polygon 62 (bottom left)

Table 33: Summary of polygons for enrichment within the pukatea-kahikatea vegetation type

Polygon No.	Landform	Area (Ha)
56	Toeslope	0.27
59	Toeslope	0.12
Total		0.39

Target Vegetation Description

The target vegetation type for toeslope landform polygons is pukatea-kahikatea forest. Semi-swamp forest was once one of the most widespread vegetation types in the Hamilton Basin. This

vegetation type is well represented in the long-term vision for WNHP. Kahikatea-pukatea Forest is dominated by *Dacrycarpus dacrydioides* and *Laurelia novae-zelandiae*. Other species interspersed in the canopy include *Dacrydium cupressinum*, *Prumnopitys taxifolia*, *Elaeocarpus hookerianus*, and the occasional *Cordyline australis*. The understory is comprised of *Cyathea dealbata*, *Myrsine australis*, *Geniostoma ligustrifolium* var. *ligustrifolium*, *Coprosma areolata*, and *Streblus heterophyllus*. In the ground tier species such as *Hymenophyllum demissum*, *Asplenium bulbiferum*, *Astelia fragrans*, *Astelia grandis*, and *Microlaena avenacea* will be found. During initial planting, the tool recommended densely planting *Hoheria sexstylosa*, *Kunzea robusta*, *Leptospermum scoparium*, and *Myrsine australis*, with moderate densities of *Coprosma robusta*, *Pittosporum tenuifolium*, and *Weinmannia racemosa*.

Polygon 56

Polygon 56 is a central area of vegetation which is bisected by a path, with two prongs of vegetation that stretch around the edge of Polygon 62. The dominant species include *Leptospermum Scoparium*, *Carex secta*, and *Phormium tenax*. The average canopy openness is 59%.

Polygon 59

Polygon 40 is a narrow, zig-zagging area of pukatea-kahikatea toeslope forest. It is accessible via the main track. Vegetation is dominated by *Leptospermum scoparium*, *Melicytus ramiflorus*, and *Phormium tenax*. The canopy has open areas and has an average of 75 % of open canopy in the sampled areas.

Canopy Openness

Canopy openness was generally high across the polygons, with an average of 36 % open (see Table 12). Canopy species representing a large percentage of cover include *Carex secta*, *Leptospermum scoparium*, *Melicytus ramiflorus*, *Phormium tenax* and *Coprosma tenuicaulis* (see Table 13). Polygon 59 had the highest degree of canopy closure.

Table 34: Summary of canopy openness in polygons with pukatea-kahikatea vegetation type

Polygon	Min Cover %	Max Cover %	Average Cover %	Average Open %
Pukatea-Kahikatea Forest	40	90	64	36
59	60	90	75	25
56	40	70	59	41

Table 35: Average percentage cover for species over 135 cm tall in pukatea-kahikatea forest in polygons 39, 40 and 45

Species	Polygon 59	Polygon 56
<i>Carex secta</i>		40
<i>Leptospermum scoparium</i>	25	22
<i>Melicytus ramiflorus</i>	28	3
<i>Phormium tenax</i>	10	22
<i>Coprosma tenuicaulis</i>		13
<i>Kunzea robusta</i>	5	10
<i>Cordyline australis</i>	5	
<i>Coprosma robusta</i>	5	4
<i>Dacrycarpus dacrydioides</i>	5	3
<i>Sophora microphylla</i>		2
<i>Coprosma rigida</i>		2
<i>Plagianthus regius</i>		2

Regeneration

Melicytus ramiflorus was, again, the most commonly regenerating species in pukatea-kahikatea forest type (see Table 32). Polygon 59 had the most speciose seedling regeneration, and greatest density of seedlings per unit of area for this vegetation type (see Table 33).

Table 36: Counts of naturally regenerating seedlings located in Pukatea-kahikatea forest.

Species	Polygon	<15 cm	16-45 cm	Total
<i>Melicytus ramiflorus</i>	59		8	3
	56		3	1
<i>Diplazium australe</i>	59	1		1
<i>Myrsine australis</i>	56			1
<i>Coprosma robusta</i>	56			1
<i>Carex secta</i>	56			1
<i>Cyathea dealbata</i>	59		1	1
Grand Total		1	12	7

Table 37: Density and diversity of seedlings (less than 75 cm in height) in pukatea-kahikatea vegetation

Polygon	56	59
Sample area (m ²)	125	50
Total Seedlings	8	13
Density (seedlings/ m ²)	0.064	0.26
Species	5	4
Diversity (species/ m ²)	0.04	0.08

Tree Mortality

Toeslope pukatea-kahikatea vegetation demonstrated mortality of *Cordyline australis* and *Dacrycarpus dacrydioides*, as shown in Table 35. Percentage of dead plants was greatest for *Cordyline australis*, at 33 %.

Table 38: Percentage of dead plants for species with incidence of mortality in toeslope vegetation

Species/Polygon	56	59	Total
<i>Cordyline australis</i>		33%	33%
<i>Dacrycarpus dacrydioides</i>	17%	0%	14%

Recommendations for planting activities

Polygons 56 and 59 are easily accessible for volunteers from the main track. However, their unusual shape means that polygon borders are not easily discerned. Care should be taken to instruct and guide volunteers to plant recommended species in appropriate locations within the polygon borders.

We have recommended that several species be removed from the planting list due to lack of canopy development and humidity, including *Beilschmiedia tawa*, *Coprosma grandifolia*, *Geniostoma ligustrifolium* var *ligustrifolium*, and *Schefflera digitata*. Other species have been reduced or removed based on current abundance, such as *Leptospermum scoparium*, or abundant natural regeneration, such as *Melicytus ramiflorus*. We have recommended increasing numbers of *Dacrycarpus dacrydioides* due to good conditions for growth and evidence of successful establishment of existing individuals. *Mida salicifolia* is more suited to ridge-type vegetation and has been recommended for removal from the planting list. Though this species has already been planted in some areas of the park, limiting density of *Lophomyrtus bullata* could help to prevent spread of the disease through the park in the future.

Table 39: Recommended enrichment planting list for Polygon 56 using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	60% of	15%	25% of 20-	Total 1	Tool	Changes	56	Comments
<i>Aristotelia serrata</i>	-	34	38	72	20	0	20	
<i>Beilschmiedia tawa</i>	20	-	-	20	6	-6	0	Not enough humidity.
<i>Carpodetus serratus</i>	-	34	38	72	20	0	20	
<i>Coprosma areolata</i>	27	17	19	63	17	0	17	
<i>Coprosma grandifolia</i>	27	-	19	46	12	-12	0	Not enough humidity.
<i>Coprosma robusta</i>	-	68	77	145	39	-39	0	Abundant within polygon not necessary to plant
<i>Coprosma tenuicaulis</i>	-	17	19	36	10	0	10	
<i>Cordyline australis</i>	-	34	-	34	9	0	9	
<i>Dacrycarpus dacrydioides</i>	-	51	-	51	14	0	14	
<i>Dacrydium cupressinum</i>	-	26	29	54	15	0	15	
<i>Fuchsia excorticata</i>	27	-	19	46	12	0	12	
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>	41	-	-	41	11	0	11	
<i>Hedycarya arborea</i>	27	-	19	46	12	0	12	
<i>Hoheria sexstylosa</i>	-	34	-	34	9	0	9	
<i>Laurelia novae-zelandiae</i>	82	-	58	139	38	0	38	
<i>Leptospermum scoparium (wet variety)</i>	-	34	-	34	9	-9	0	Abundant within polygon not necessary to plant
<i>Leucopogon fasciculatus</i>	27	-	19	46	12	0	12	
<i>Lophomyrtus bullata</i>	-	17	19	36	10	-10	0	Myrtle rust risk.
<i>Melicope simplex</i>	27	-	19	46	12	0	12	
<i>Melicytus micranthus</i>	27	-	19	46	12	0	12	
<i>Melicytus ramiflorus subsp. ramiflorus</i>	54	34	38	126	34	-34	0	Abundant and naturally regenerating.
<i>Mida salicifolia</i>	27	-	-	27	7	-7	0	
<i>Myrsine australis</i>	-	34	38	72	20	0	20	
<i>Nestegis cunninghamii</i>	20	13	14	47	13	0	13	
<i>Plagianthus regius</i>	-	34	38	72	20	0	20	
<i>Prumnopitys taxifolia</i>	-	26	29	54	15	0	15	
<i>Pseudopanax crassifolius</i>	-	17	19	36	10	0	10	
<i>Rhopalostylis sapida</i>	54	-	38	92	25	0	25	
<i>Schefflera digitata</i>	27	-	19	46	12	0	12	
<i>Sophora microphylla</i>	-	34	-	34	9	0	9	
<i>Streblus heterophyllus</i>	-	-	38	38	10	0	10	
<i>Weinmannia racemosa var. racemosa</i>	20	-	14	35	9	0	9	
	535	560	697	1,792	484	-118	366	

Table 40: Recommended enrichment planting list for Polygon 59 (0.12 ha) using a combination of <20% gaps, 20-40% gaps and >40% gaps. Changes to the tool-based recommendations are given based on on-the-ground observations of the polygons and per polygon planting numbers are outlined.

Scientific name	30% of <20	20% of >40%	50% of 20-40	Total 1 ha	Tool 59	Changes	59	Comments
<i>Aristotelia serrata</i>	-	46	77	122	15	-	15	
<i>Beilschmiedia tawa</i>	10	-	-	10	1	-1	-	Wait until canopy is established.
<i>Carpodetus serratus</i>	-	46	77	122	15	-	15	
<i>Coprosma areolata</i>	14	23	38	74	9	-	9	
<i>Coprosma grandifolia</i>	14	-	38	52	6	-6	-	Wait until canopy is established.
<i>Coprosma robusta</i>	-	91	154	245	29	-29	-	Abundant, no need for more to be planted.
<i>Coprosma tenuicaulis</i>	-	23	38	61	7	-	7	
<i>Cordyline australis</i>	-	46	-	46	5	-	5	
<i>Dacrycarpus dacrydioides</i>	-	68	-	68	8	4	12	Lots of open areas with wind protection.
<i>Dacrydium cupressinum</i>	-	34	58	92	11	-	11	
<i>Fuchsia excorticata</i>	14	-	38	52	6	-	6	
<i>Geniostoma ligustrifolium subsp. ligustrifolium</i>	20	-	-	20	2	-2	-	Wait until canopy is established.
<i>Hedycarya arborea</i>	14	-	38	52	6	-	6	
<i>Hoheria sexstylosa</i>	-	46	-	46	5	-	5	
<i>Laurelia novae-zelandiae</i>	41	-	115	156	19	-	19	
<i>Leptospermum scoparium (wet variety)</i>	-	46	-	46	5	-5	-	Abundant, no need for more to be planted.
<i>Leucopogon fasciculatus</i>	14	-	38	52	6	-	6	
<i>Lophomyrtus bullata</i>	-	23	38	61	7	-7	-	
<i>Melicope simplex</i>	14	-	38	52	6	-	6	
<i>Melicytus micranthus</i>	14	-	38	52	6	-	6	
<i>Melicytus ramiflorus subsp. ramiflorus</i>	27	46	77	149	18	-18	-	Naturally regenerating.
<i>Mida salicifolia</i>	14	-	-	14	2	-2	-	More suited to ridge-type vegetation.
<i>Myrsine australis</i>	-	46	77	122	15	-	15	
<i>Nestegis cunninghamii</i>	10	17	29	56	7	-	7	
<i>Plagianthus regius</i>	-	46	77	122	15	-	15	
<i>Prumnopitys taxifolia</i>	-	34	58	92	11	-	11	
<i>Pseudopanax crassifolius</i>	-	23	38	61	7	-	7	
<i>Rhopalostylis sapida</i>	27	-	77	104	12	-	12	
<i>Schefflera digitata</i>	14	-	38	52	6	-6	-	Wait until canopy is established.
<i>Sophora microphylla</i>	-	46	-	46	5	-	5	
<i>Streblus heterophyllus</i>	-	-	77	77	9	-	9	
<i>Weinmannia racemosa var. racemosa</i>	10	-	29	39	5	-	5	
	267	747	1,394	2,408	289	-74	215	

Infill Plantings



Figure 7: Sample of vegetation at infill polygons

Polygons 85, 88, 89, 90 and 91 have been recommended for infill planting to fill gaps caused by mortality of primary successional species and to supplement species that were left out of primary plantings due to plant availability. The goal vegetation type for polygons 85,88,89, and 90 is Kahikatea-pukatea-swamp maire forest, and for polygon 91 is swamp shrubland type. Infill planting is designed to replace species with poor survival, and supplement the species complement with primary successional species that may have been missed at the original planting.

Table 41: Summary of polygons for infill

Polygon No.	Landform	Goal Vegetation Type	Area (Ha)
85	Basin	Kahikatea-pukatea-swamp maire forest	0.99
88	Basin	Kahikatea-pukatea-swamp maire forest	0.91
89	Basin	Kahikatea-pukatea-swamp maire forest	1.05
90	Basin	Kahikatea-pukatea-swamp maire forest	1
91	Waterlogged	Swamp shrubland	0.3
Total			4.25

By polygons 85, 88, 89, 90 and 91 a path bisects the area, making access very easy. The vegetation looks in generally good condition, and some infill appears to have happened in places where there are new plants on the borders. There are some areas where planting is sparse and infill of primary species is required, unless the area is being reserved for infrastructure or art. Some areas of the infill section are boggy and wet and volunteer planters should wear appropriate footwear. The boundaries between the polygons are indistinguishable, however as the vegetation types are largely the same, this shouldn't be an issue. Care should be taken to point out boundaries for Polygon 91 where the vegetation type is different.

Species identified in the infill planting sections include *Coprosma robusta*, *Cordyline australis*, *Plagianthus regius*, *Dacrycarpus dacrydioides*, *Coprosma tenuicaulis*, *Coprosma rigida*, *Coprosma propinqua*, *Leptospermum scoparium*, *Kunzea robusta*, *Phormium tenax*, *Myrsine australis*, *Aristotelia serrata* and *Carex secta*. Several of these species were flowering which is a positive indicator of health and development. *Dacrycarpus dacrydioides* has some mortality, but also some individuals looking very healthy. *Myrsine australis* and *Aristotelia serrata* were all in poor health and do not appear to be thriving in this area.

Conclusions and Recommendations

Waiwhakareke Natural Heritage Park has benefited from addition of two permanent staff at the park and their contribution is evident in the increased weed management that is occurring, and the general improved condition of the park. In addition, the WNHP staff made a significant contribution to the ground truthing this year, including identifying key species and suggesting amendments to the planting list generated by the tool. Because of their contribution minimal changes were needed to the supplied plant lists.

The work detailed in this report highlighted some areas for future discussion. When undertaking enrichment planting a long-term vision is required. Waiwhakareke Natural Heritage Park is a multi-generational project, and the vegetation trajectories are dynamic. Hence, when the vegetation conditions are not conducive for the enrichment species which will form the key components of the canopy to thrive, we have time to wait for the vegetation to develop further. To assist this, findings on the survival of plantings should be fed back into the tool to improve the success of future enrichment plantings, especially for long-lived canopy species.

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Appendix One: Species List (*indicates exotic species)

Scientific Name	Common name	Life form
<i>Alectryon excelsus</i>	titoki	tree
<i>Aristotelia serrata</i>	wineberry/makomako	tree
<i>Berberis glaucocarpa</i> *	barberry	tree
<i>Carex secta</i>	pukio	sedge
<i>Carpodetus serratus</i>	putaputaweta	tree
<i>Coprosma areolata</i>	thin leaved coprosma	shrub
<i>Coprosma propinqua</i>	mingimingi	shrub
<i>Coprosma rigida</i>		shrub
<i>Coprosma robusta</i>	karamu	tree
<i>Coprosma rotundifolia</i>	round-leaved coprosma	shrub
<i>Coprosma tenuicaulis</i>	swamp coprosma	shrub
<i>Cordyline australis</i>	cabbage tree	monocot tree
<i>Cyathea dealbata</i>	silver fern	fern
<i>Dacrycarpus dacrydioides</i>	kahikatea	tree
<i>Dicksonia squarrosa</i>	wheki	fern
<i>Diplasium australe</i>		fern
<i>Veronica stricta</i>	Koromiko	shrub
<i>Hedycarya arborea</i>	pigeonwood	tree
<i>Hoheria sexstylosa</i>	long leaved lacebark	tree
<i>Knightia excelsa</i>	rewarewa	tree
<i>Kunzea robusta</i>	kanuka	tree
<i>Laurelia novae-zelandiae</i>	pukatea	tree
<i>Leptospermum scoparium</i>	manuka	tree
<i>Ligustrum sinense</i> *	chinese privet	tree
<i>Lophomyrtus bullata</i>	ramarama	shrub
<i>Melicytus ramiflorus</i>	mahoe	tree
<i>Muehlenbeckia australis</i>	pōhuehue	climber
<i>Myrsine australis</i>	mapou	tree
<i>Nestegis lanceolata</i>	white maire	tree
<i>Phormium tenax</i>	flax	monocot
<i>Phyllocladus trichomanoides</i>	tanekaha	tree
<i>Pittosporum crassifolium</i>	karo	tree
<i>Pittosporum tenuifolium</i>	kohuhu	tree
<i>Plagianthus regius</i>	ribbonwood, manatu	tree
<i>Podocarpus totara</i>	totara	tree
<i>Prumnopitys taxifolia</i>	matai	tree
<i>Prunus serrulate</i> *	Japanese hill cherry	tree
<i>Rubus sp.*</i>	blackberry	climber
<i>Solanum aviculare</i>	poroporo	tree
<i>Solanum mauritianum</i> *	woolly nightshade	tree
<i>Sophora microphylla</i>	kowhai	tree

Appendix Two: Polygon Aerials





**Waiwhakareke Natural
Heritage Park**

 **Hamilton City Council**
10 Southdown Drive

AREA 55
Swamp Shrubland
WATERLOGGED



2015 Aerial



**Waiwhakareke Natural
Heritage Park**



AREA 56
Puketea - Kahikatea Forest
TOESLOPE



2015 Aerial



Waiwhakareke Natural Heritage Park



AREA 57

Kahikatea - Pukatea - Swamp Maire Forest BASIN



2015 Aerial



**Waiwhakareke Natural
Heritage Park**



AREA 58
Swamp Shrubland
WATERLOGGED



2015 Aerial



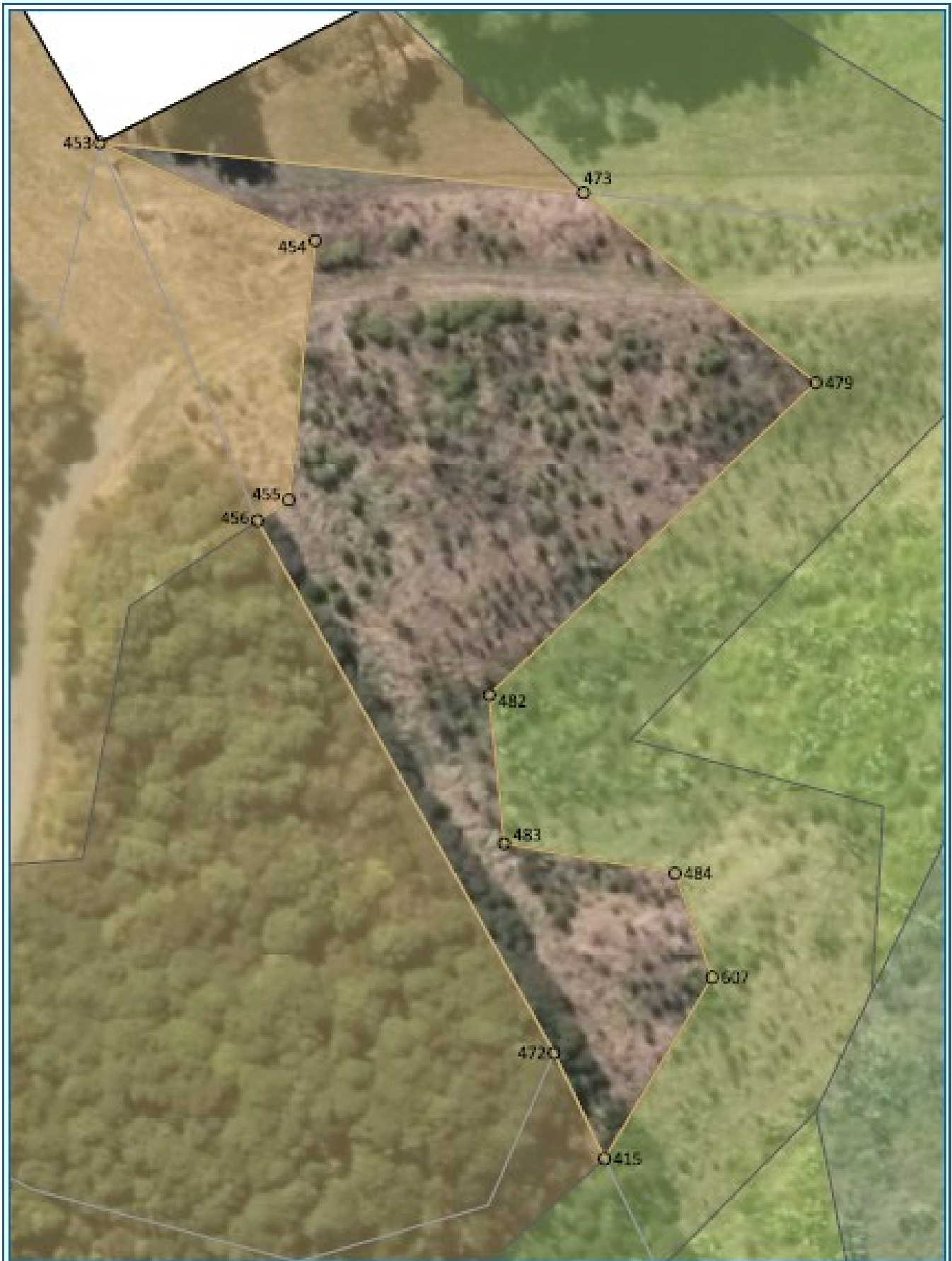
Waiwhakareke Natural Heritage Park

Hamilton City Council
He Kaitiaki Take Kōwhiri

AREA 59
 Puketea - Kahikatea Forest
 TOESLOPE



2015 Aerial



**Waiwhakareke Natural
Heritage Park**



AREA 60
Rimu - Tawa Forest
HILLSLOPE



2015 Aerial



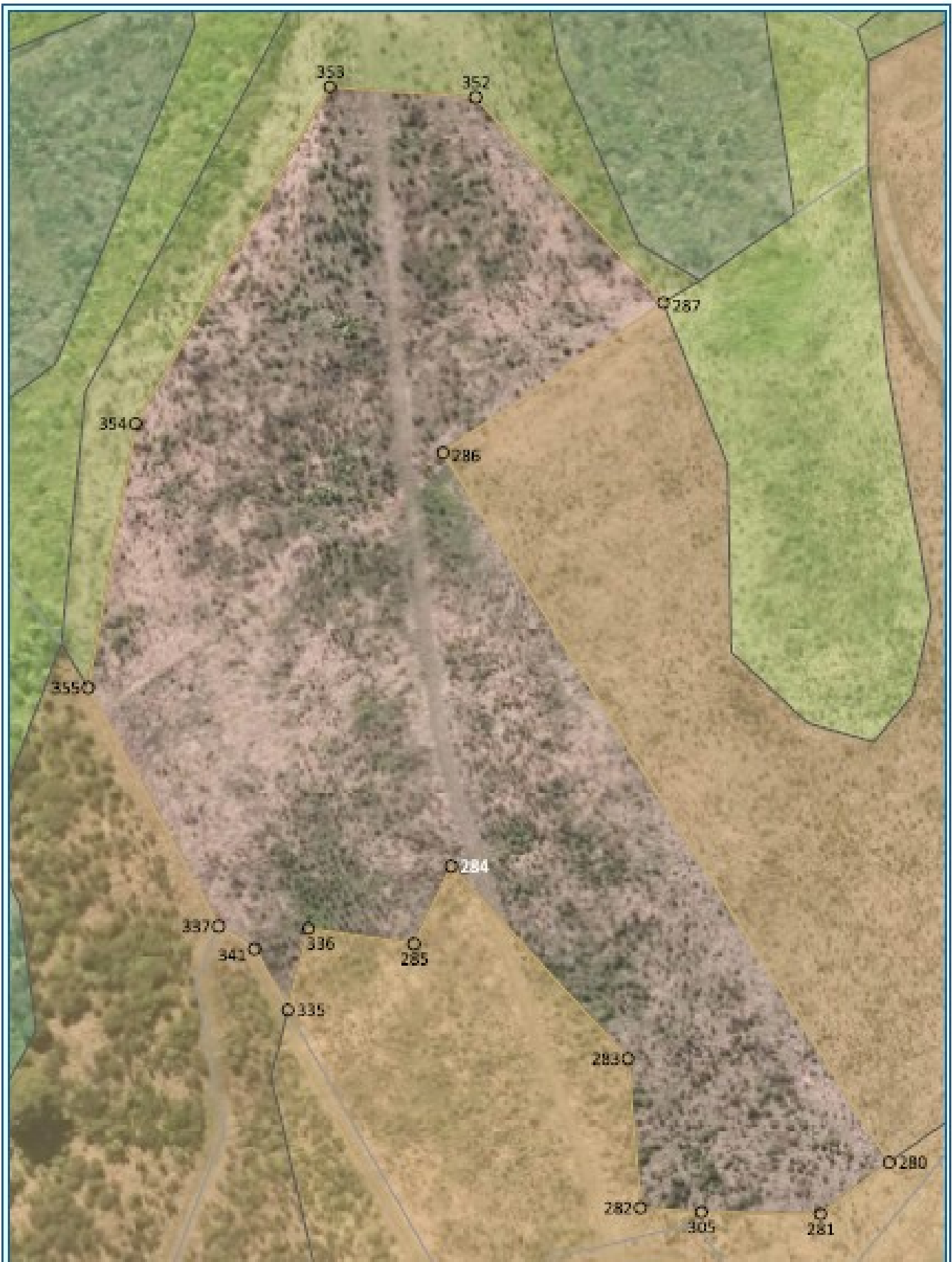
**Waiwhakareke Natural
Heritage Park**



AREA 61
Kauri Forest
RIDGE



2015 Aerial



Waiwhakareke Natural Heritage Park



AREA 62
 Rimu - Tawa Forest
 HILLSLOPE



2015 Aerial



Waiwhakareke Natural Heritage Park



AREA 63
Kauri Forest
RIDGE



2015 Aerial



Waiwhakareke Natural Heritage Park

Hamilton City Council
Te Kaitiaki Take Kōwhiri

AREA 85
Kahikatea - Pukatea - Swamp Maire Forest
BASIN



2015 Aerial



**Waiwhakareke Natural
Heritage Park**



AREA 88

**Kahikatea - Pukatea - Swamp Maire Forest
BASIN**



2015 Aerial



**Waiwhakareke Natural
Heritage Park**

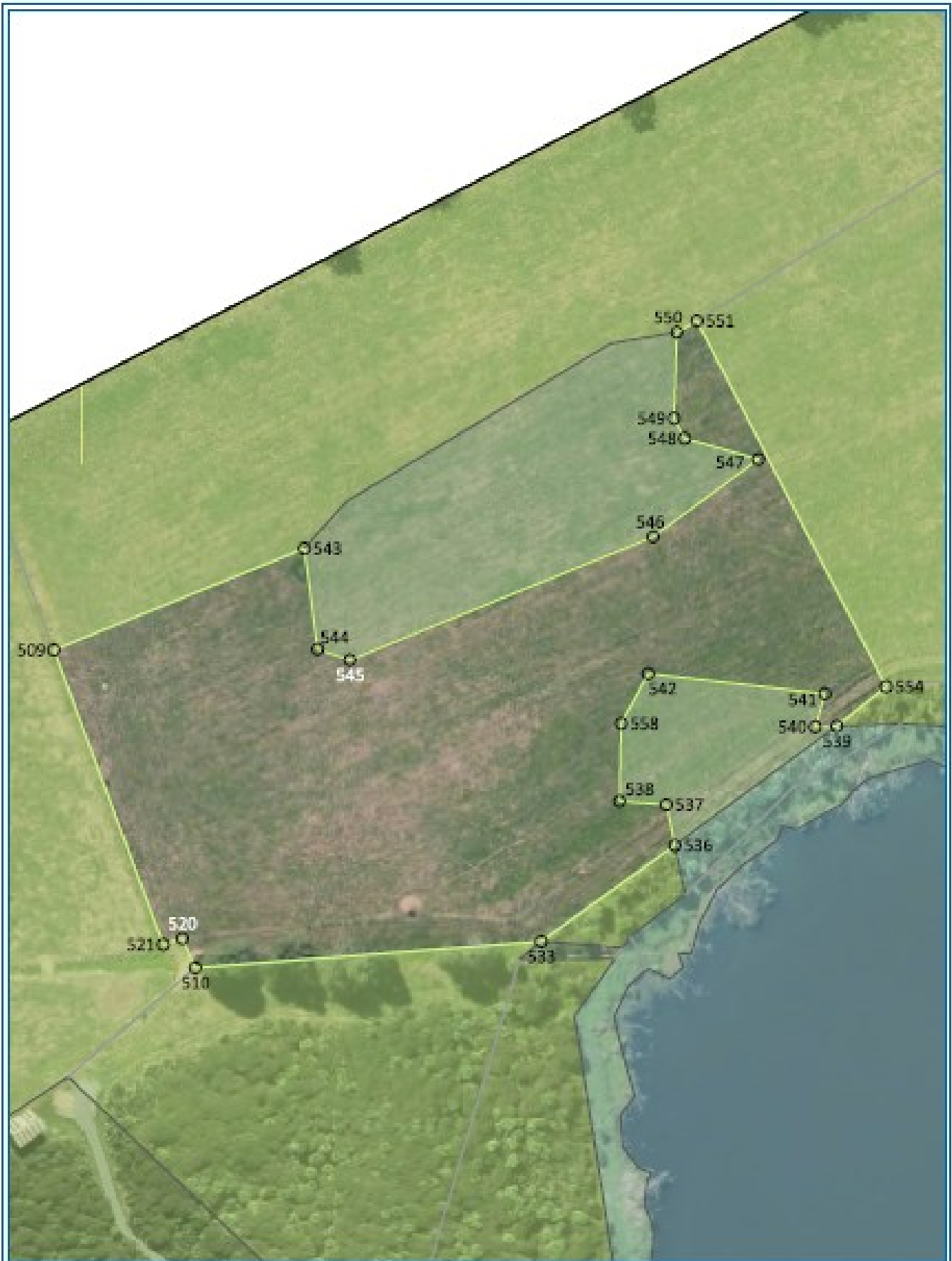


AREA 89

Kahikatea - Pukatea - Swamp Maire Forest
BASIN



2015 Aerial



Waiwhakareke Natural Heritage Park

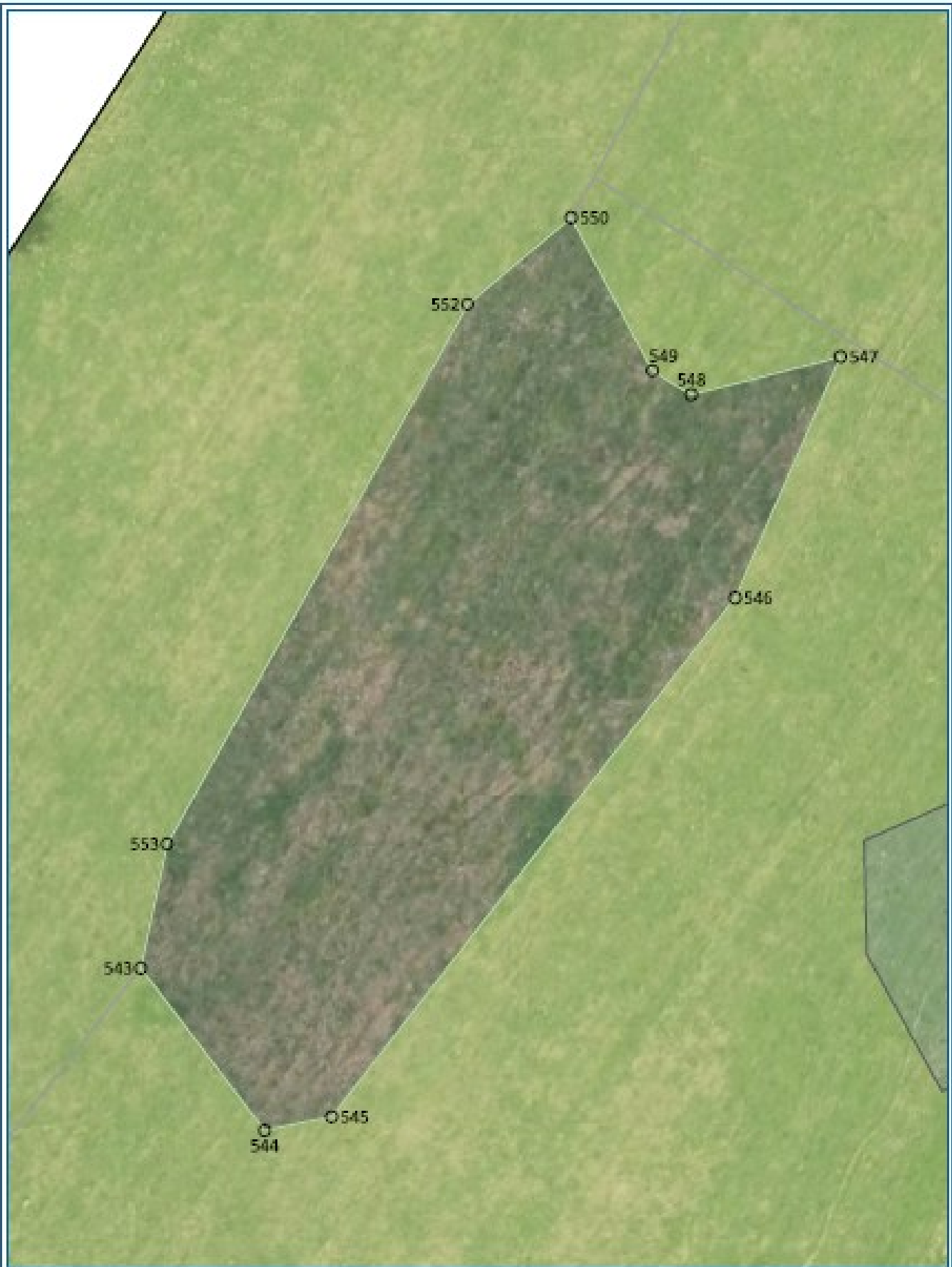


AREA 90

Kahikatea - Pukatea - Swamp Maire Forest BASIN



2015 Aerial



Waiwhakareke Natural Heritage Park



AREA 91
Swamp Shrubland
WATERLOGGED



2015 Aerial