State and Potential for Indigenous Forest Patches and their Connectivity within the Whau Local Board district and to the NW Wild Link

A report for Auckland Council

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Abstract

A preliminary forest patch-corridor-matrix model has been described for the Whau Board area of Tamaki Makaurau - Auckland City that is expected to contribute to ecological integrity, natural character and legibility of the landscape, and ultimately ecological literacy of an engaged community and culture.

A natural infrastructure and functionality is already largely present and intact within the Board area. Existing initiatives in western Auckland such as the North West Wildlink and many community-based conservation and pest management projects will be the catalyst for realising the goals of this landscape framework.

Implementation will involve enriching existing **Patches** and corridors through standard weed and pest management practices; under- or inter-planting of native noble trees, ground covers and vines; or full restoration where required, and ongoing vigilance and maintenance.

Principal **Corridors** will include stream edges, roads, motorways, railways, coastal edges and hedges which together provide connectivity for both flighted wildlife and smaller creatures.

Strategic gap filling in a few areas will enhance connectivity to a very high standard.

Residents shall be encouraged and incentivised to raise the ecological quality of the **Matrix** – in their own gardens and properties. This will be achieved through neighbourhood groups taking informed ownership of their patch.

The optimised patch configuration for the Whau Board area may be implemented by using a 200 m grid overlay across the District that prescribes at least one grove of noble trees per grid square, ca. 1 ha forest patch per square km and a ca. 5 ha sanctuary per 25km^2.

In general, such a pattern and the **involvement of community** in getting there will raise awareness and **shift the culture** of local government, boards, businesses and the wider community towards a stronger identity and sensitivity and protectiveness towards their natural heritage - their taonga. This will in due course contribute to **legibility of landscape and sense of place** among citizens – that relates specifically to Whau - Tamaki-Makaurau – Te Ika a Maui – Aotearoa – and an ecological literacy that will engender raised awareness and understanding of the critical role that ecology has in our future sustainability and well-being.

It is timely (given the recent formulation of Auckland City's aspirational policies to be biodiverse and ecologically functional) to review progress and develop a strategic approach to the ongoing fulfilment of the vision of achieving an urban and peri-urban environment for the communities of the Whau that has ecological integrity and natural character, supports a rich array of indigenous wildlife and which contributes to the well-being of the whenua or land, the water and of its people.

There will need to be widespread consultation and engagement and explanation of these principles in order to achieve buy-in and then active support and incentives from Council since its success will depend on all these partners working together.

Contract

Auckland Council (Whau Local Board) has requested Colin Meurk Consultancy (CMC) to analyse available desk-top information on patch clustering and spacings across the Whau Board District, Auckland City in order to define gaps between native forest patches that reduce connectivity across the district and opportunities for closing the gaps. For the Whau Local Board this will enable strategic decisions and actions in terms of planning, protection, habitat restoration on public land (parks and river or rail corridors), land purchase, and incentives for land owners to improve the habitat value within the matrix. For whau communities this will enable engagement and an understanding of the choices that will most effectively help build a thriving landscape in which to live.

Purpose of Report

To provide information to the Board and communities that enable strategic decisions and actions for (each class of) particular places to achieve ecological integrity, connectivity, and natural character at a landscape/catchment scale.

This will be based on an analysis of the existing state and configuration of patches, linkages, and matrix at a landscape level within a landscape ecology framework.

This then provides evidential support for prioritising land protection, pest management, acquisition and connectivity within the Board area and to the wider NW Wildlink.

Technical guidance is provided on managing and restoring each class of land/ecosystem within the Board area, that achieves ecological function and connectivity and supports goals of healthy land/whenua and community.

The particular tasks may be summarised as: desktop **Landscape Evaluation**, in the Whau Board area of Auckland, of natural and semi-natural Remnants, Restoration projects, Parks and Treelands of potential future indigenous habitat and linkages (streams, road and rail corridors, shelter belts and coastal cliffs, mangroves and salt marshes).

And

Identification of Gaps to fulfilling Landscape Integrity, Connectivity and Natural Character from the present configuration (that is to achieve overall ecological function of the Whau land and waterscape)

And

Recommending Strategies and Methods for Weed and Pest control, Regeneration and Restoration options to fill the gaps and prioritise actions.

Background

There is a rich history of initiatives for habitat conservation and landscape connectivity in western Auckland culminating in the visionary concept of the North-West Wildlink (Boffa Miskell 2017). This sets the scene or endeavours to join up island sanctuaries, mainland islands, and urban habitat patches enabling endangered wildlife to re-establish around and through the city by the 'halo effect'[1], flight paths along corridors and stepping stones. This is also a temporal stepping stone to 'Predator Free NZ' (PFNZ).

Mackay et al. (2001) presented an illustrated history and interpretation of the Whau Catchment nearly two decades ago which laid out the key ecological, recreational and other social values and factors influencing the function of the Catchment and what actions could be taken to mitigate effects. A Whau community workshop (Trotman 2016) spelled out a

[1] "Halo Effect" is the descriptive term given to dispersal of plant propagules or wildlife in concentric patterns around habitat patches that provide sanctuary for source populations. The pattern is generally described as an exponential decay curve radiating out from the source, which means that the density of dispersing elements diminishes slowly then rapidly at some threshold distance. For NZ plant seedlings this inflexion point is at about 100 m from the source, beyond which there is a long 'tail' of infrequent effective dispersal. Halo effect is one of the descriptors or mechanisms for landscape connectivity and integrity.

whole range of aspirations for the district and catchment. Green connectivity, environmental mitigation and recreational opportunities came out as top concerns. Most people are not aware of the nature and role of biodiversity; and think it is the domain of councils who have it under control. Clearly however, there is a need for collective responsibility in achieving broad landscape aspirations in and around cities.

Community groups are already working on pest eradication from these existing remnants, nurturing regeneration, planting up new habitat, and creating walk/cycleways. It is timely to review progress and develop a strategic approach to the ongoing fulfilment of the vision of achieving an urban and peri-urban environment for the communities of the Whau that has ecological integrity and natural character, supports a rich array of indigenous wildlife and which contributes to the well-being of the whenua or land, the water and of its people.

There are many sources of information available from Auckland council to assist this exercise – the (historic/potential) ecosystem typology for the Auckland region, the analysis of generally constrained waterways, their characteristics, and remedial actions required to restore them to health (Reid et al. 2009; Reid et al. 2010). And there is a comprehensive set of GIS maps (https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html; see Fig. 1) that include potential (pre-existing) vegetation based on broad soil types, remnant and significant habitats, some patches of exotic-dominated canopies, LIDAR map of all vegetation taller than 1.5 m that picks out clusters or denser areas of trees regardless of

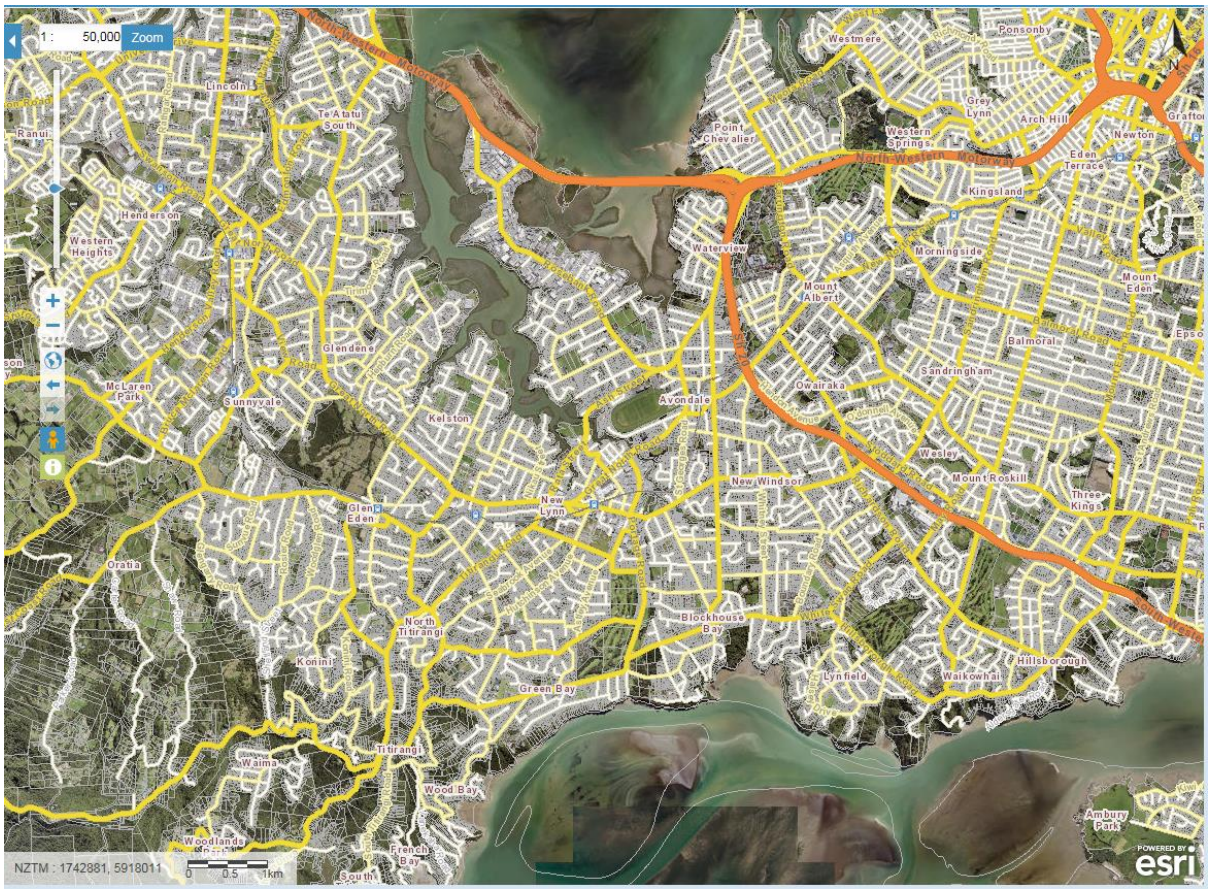

Figure 1: Publicly accessible Geospatial map facility; image including the Whau catchment and Board area with streets/roads and areal imagery.

origin, satellite imagery showing existing configuration of buildings, streets, rail corridors, drainage patterns, salt marsh and mangrove, the drainage system, and a gap analysis showing 100 m and 500 m buffers around native forest patches greater than 1 ha.

There are two aspects to connectivity – firstly is the facilitation of wildlife movement through the landscape – together with associated plant propagule dispersal, germination and establishment. Precise requirements are species-dependent, but habitat type, structure and spatial configuration all play a role along with availability of large healthy 'source' habitat areas, stepping stones and corridors within the flight or dispersal capabilities of the organism in question. It also depends on there being a sympathetic and receptive urban matrix of large trees, smaller shrubs, ground covers, leaf mulch and healthy soil. Finally, the most critical barrier for much of New Zealand's wildlife is presence of introduced, mammalian predators. Many of our species have zero-tolerance of these invaders. A comparable obstacle applies to native plants due to vigorous competition from continentally-honed trees, shrubs and dense grasses.

The second aspect of connectivity is that between people and nature through recreation, gardening, forest bathing (shinrin-yoku - https://www.mamanatural.com/forest-bathing/), etc. This depends on universally accessible green, open, forested and/or watery space that becomes part of the daily experience of all in the community, and especially young people growing up with a curiosity to explore the workings of the world. For health benefits to accrue from forest-bathing it is suggested that 'walking in the woods' once a week is a reasonable target with the measured physiological and mental benefits lasting for at least that length of time.

An understanding of the natural world and its function is vital to being able to live in it, within its limits and to respect it. The absence of these encounters in life results in 'extinction of experience' (Miller 2005); and the absence of indigenous nature in the landscape leads, not only to extinction of identity with something you never see, but ultimately to extinction of (indigenous) species.

For micro-managing habitat establishment and management, there is also a need to understand the positioning of plants (and their dependent animals) along environmental (stress) and dynamic successional (disturbance) gradients (Grime 1979, 2001).

From landscape connectivity and natural character also comes **legibility** – which is about revealing the history of the place and leading to place-making. Everyone should know their history, see it in front of their eyes and feel comfortable in their place which continually

reinforces that history. History includes overlapping geo-tectonic, geomorphologic, biogeographic, and cultural – tangata whenua, mana whenua, colonial, and fusion layers.

Interpretation of land, soil, and vegetation (e.g. the *Epilobium hirtigerum* story in the Waitakere Council grounds – Fig. 2), along with the built or material culture, all helps to inform and educate citizens and school children about their place, their natural and cultural heritage, and sense of belonging.

Figure 2: Explanatory board for an enhanced population of the locally rare *Epilobium hirtigerum* next to a Henderson car park.

Theoretical Framework

Empirical support for the form and configuration of functional habitat is provided by Meurk & Hall (2006). This is based on island biogeographic theory (MacArthur & Wilson 1967) in which the diversity of habitat and species richness is a function of patch size, topographic diversity, and edge effects, and the proximity to other **source** or **sink** patches, the modes of dispersal of species and the vectors of the propagules – usually wind, water or animals.

The 'rule of thumb' application of this theory is that, for a cultural landscape, large compact shaped forest patches of > 5 ha should exist at no more than 5 km distance from other similar patches. This means firstly that there are buffered sanctuaries for sensitive (core) species spaced regularly across the landscape – within easy flying distance of bush birds. The need for large compact patches arises from the 'edge effects' associated with bush margins (Dasmann 1988, Davies-Colley et al. 2000, Young & Mitchell 1993). These edges are

less sheltered from wind, are drier, sunnier, and more prone to invasion by weeds and predators. Linear patches are dominated by edge effects (Fig. 3).

Smaller (1 ha) patches are spaced at about 1 km intervals and there are groves of 1-few noble[2] trees every few hundred metres (at least every suburban block). Together (once these patches are matured – adding shelter, producing fruit and nectar) these potentially generate and maintain an effective 'halo effect' where all receptive spaces (usually where there is overhead cover, shade, bare ground or litter within the matrix between patches) are potentially visited by bush birds, and are successfully seeded by bird-dispersed propagules.

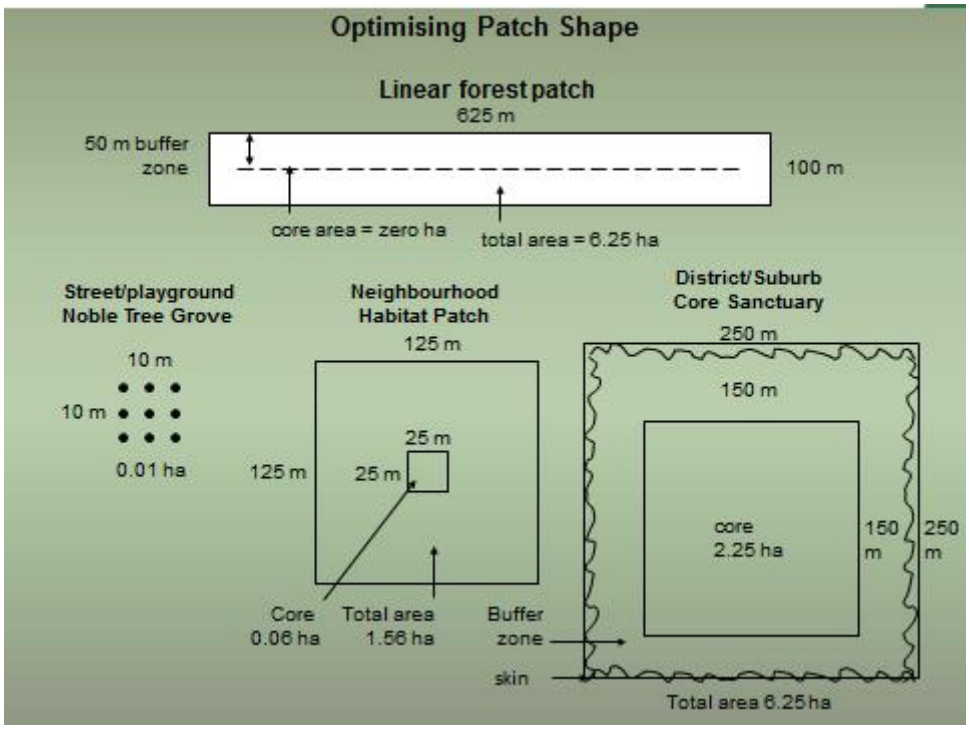

Figure 3: The principles of buffer zones in habitat patches – showing the relative proportion of patches occupied by edge effect in narrow and iso-diametrical patches respectively.

This configuration of patches, corridors, intervening matrix and living spaces is depicted in the following graphics (Fig. 4, 5). Patches are easily accessible to wildlife and to people. It is fundamentally based on the field observation that (bird-dispersed) native tree seedlings have been found up to 2.5 km from known seed sources. Two specific cases were under nurseries of exotic willow and Douglas fir, both of which produce Spring leaf shoots that specifically attract kereru to feed. Ample research in England and elsewhere demonstrates the importance of accessibility of nature to people for their well-being (Box & Harrison

[2] Noble tree is a European concept referring to the large, long-lived regal (usually deciduous) trees – namely oaks, elms, linden, maples, cedar, etc., It is important at our point in history to apply this concept to our own trees and these would be kauri, podocarps (totara, matai, miro, kahikatea, rimu, cedar, pukatea, hinau, pohutukawa, northern rata, rewarewa, puriri, tawa, taraire, kowhai),

1993, Harrison et al. 1995, Mitchell & Popham 2008, Roe 2016, http://researchbriefings.files.parliament.uk/documents/POST-PN-0538/POST-PN-0538.pdf).

One other relevant statistic is that the above arrangement represents just 3 % of total land area (3.125 ha from 6.25 ha patches, 18.72 ha from 1.56 ha patches, and 10.68 ha from 0.036 ha groves, all divided by 1082.5 ha) (Fig. 4). Other studies suggest that a 10-20% proportional threshold corresponds to the point at which there is a major drop-off of biodiversity in the landscape. Accordingly, there is scope within the Whau Board area, due to its natural advantages, to achieve a better than bare minimum biodiversity outcome.

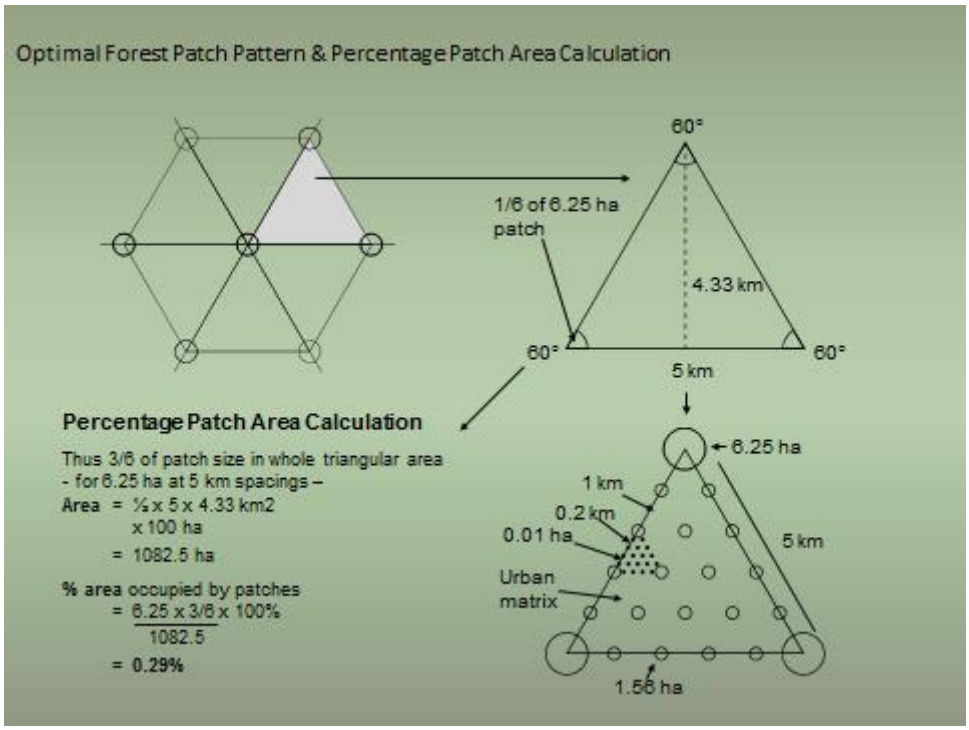

Figure 4: Theoretical/ideal arrangement of patches of different sizes scattered evenly across a cultural landscape. Note that based on these figures and an area of 356m^2 per grove (3 x 3 noble trees, 5 m apart with a 3 m radius canopy spread), the total percentage cover of forest habitat modelled here is 3%.

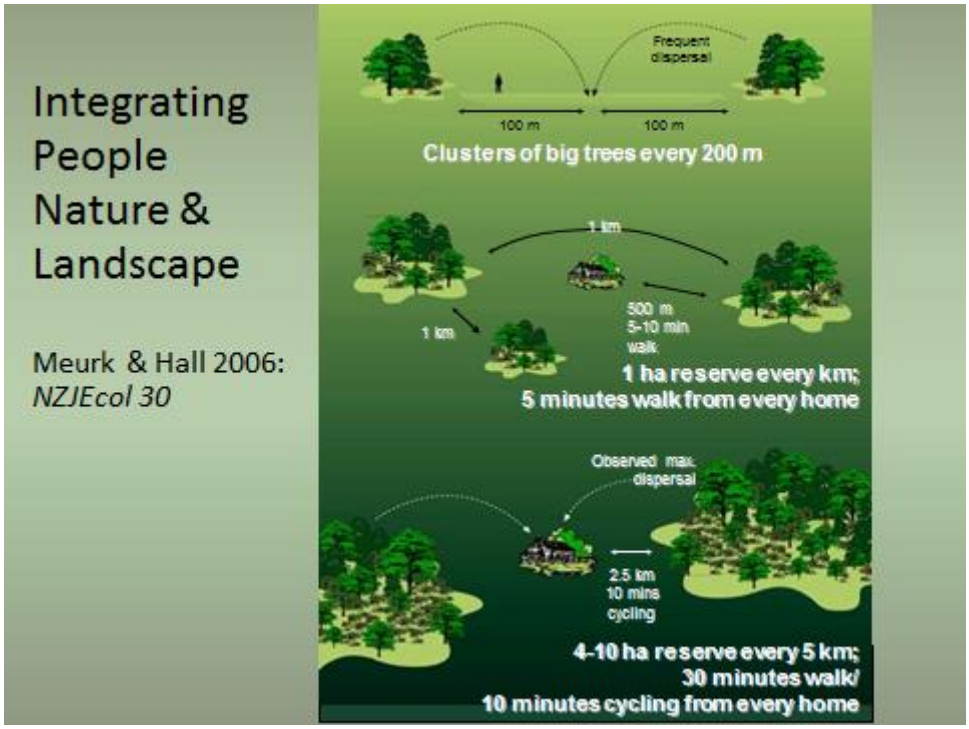

Figure 5: Achievement of ecological integrity and social connectivity (From Meurk & Hall 2006).

Methodology

This evaluation and consequential strategic guidelines are based on existing reports and references, general knowledge of the district and specific field examinations, discussions with Chris Ferkins (AC biodiversity advisor), access to GIS and printed maps depicting vegetation of various grades (stature, protection, patch size, broad composition/conservation status) and spatial configurations (distances between patches/corridors of bush vegetation). The focus was on forest habitat and the basic model for evaluation and enhancement of connectivity is Meurk & Hall (2006).

I am especially grateful to Hugo Geddes (AC) for generating the GIS maps that form the basis for the report.

An initial scan of maps indicated a quite dense pattern of urban trees, patches and linear riparian bush. The exercise then became one of identifying any significant gaps within a 100 m buffer around remnant forest habitat patches (> 1ha). This is a far higher standard than the maximum spacing recommended for forest patches by Meurk & Hall (2006) - to achieve propagule saturation in all intervening spaces. However, they show that there is a dramatic drop off of seedling establishment beyond 100 m from source, so it seems reasonable to work to this higher standard.

The second step was to recommend potential public (or private) lands where these gaps could be filled and patches connected (via streams, roads or railways). Thirdly a sequence of actions is provided to plant or regenerate mature forest types in such locations, faithful to their respective sites. Finally, options for urban residents to contribute to an enhanced matrix that supports ecological integrity of the catchment (Ignatieva et al. 2008) are highlighted.

To achieve this final step, a 200 m grid was superimposed over the district, with a view to providing a neighbourhood and suburb scale framework for setting minimum target values for incorporation of biodiversity, habitat and connectivity between populations, patches and people.

Results

Original vegetation

The Potential (Historic) Vegetation (AC Geomaps, 15/8/2016) in the Whau District is mapped as Mangrove Forest/scrub (SA1) around the Waitemata Harbour edge; Oioi restiad rushland-reedland (WL10) of coastal/brackish wetlands; Pohutukawa-puriri broadleaved coastal forest (WF4) (or Pohutukawa/flax/rock treeland (CL1)) in Blockhouse Bay and cliffs fringing SA1; Puriri forest (WF7) on fertile downlands; Kauri-podocarp-broadleaved forest (WF11) in uplands; and Manuka-grass tree/*Machaerina*-sedge gumland (WL1) at the Waikumete Cemetery Reserve. Other vegetation types either too small or narrow to map or are locally extinguished are flaxland (WL18), Raupo reedland (WL19), shoreline communities (SA4, SA5, SA7) and kahikatea-pukatea forest (WF8) on alluvial floodplains (critically endangered).

With urban development these original forest types have become fragmented and decimated and displaced or degraded by weeds and dense exotic ground covers that prevent regeneration. The main secondary native vegetation is kanuka forest or other regenerating mixes, but including podocarps (Figs 6, 7, 8). Native wildlife has been compromised by introduced mammalian predators.

Nevertheless, there is a large body of native trees and shrubs both as remnants and as garden plants throughout the western suburbs and the Whau catchment, moderately well connected with the much larger blocks of bush in the Waitakere Ranges, Titirangi and Blockhouse Bay (Figs 9, 10). The previous examples of natural regeneration (especially of the noble totara, kahikatea, puriri, etc.) in small parks and patches of both native and exotic cover are testimony to the huge regenerative force and connectivity that already exists. This is due to proximity of natural seed sources and birds capable of dispersing seed.

Figure 6a, b: Natural regeneration of indigenous hardwoods, and in particular totara, in a golf course border secondary/exotic forest (a), and small neighbourhood park, Portage Road (b).

Figure 7: Titoki seedlings establishing under exotic deciduous (oak) canopy in riparian zone of Whau River. There are also self-established native forest sedges as ground cover.

Figure 8: Spontaneous seedlings of *Coprosma arborea* in golf course border forest of pines and kanuka. Other self-established seedlings include kahikatea, totara, five-finger, mahoe, *Pseudopanax lessonii*, patete, karo, houhere, pigeon wood, shining karamu, puriri, hangehange, red mapau, small-leaved coprosmas, *Cyathodes fasciculatus* and silver fern but also various weeds such as monkey apple, privet, wattle, fatsia, climbing asparagus, tradescantia and veldt grass.

Evaluation of contemporary habitat

The District comprises now a fine-grained tapestry of suburban gardens and (mainly) exotic trees bounded by road and rail corridors some of which are lined with avenues of (primarily) exotic trees (AC Urban Forest 2012 Vegetation Height (LiDAR) – 5/6/2018). Some large green spaces (golf courses, parks, race courses) are primarily grass turfs and therefore do not reach the 1.6 m threshold for vegetation height in this analysis. Similarly the commercial and light-industrial precincts are expectedly devoid of tall trees and are therefore the main sources of green gaps. The various streams feeding into the Waitemata Estuary, including the Whau, mostly are tree-lined, although predominantly formed by exotic trees. However, some remnant, secondary, planted and/or spontaneous regeneration across the District represents a 'ghost' of the once contiguous forest cover. These include kanuka forest/scrub (VS2), manuka-kanuka scrub (VS3), broadleaved forest/scrub (VS5), WF4, mixed evergreen forest (EG?), some extensive exotic forests (EF), and other mixed treeland (TL). These are mainly along gullies or on steep hill slopes.

Figure 9: Large bush patch (distance) at head of catchment (Blockhouse Bay) with mixed podocarp, kauri, and hardwoods?

Figure 10: large coastal bush patch, Blockhouse Bay overlooking Manukau Harbour – coastal hardwoods including pohutukawa.

Patch distribution and Gap Analysis

The Gap Analysis Maps (Auckland Council 15/8/2016 – native >1ha; 20, 100 and 500 m buffers; 18/6/2018 – mixed >0.05ha; 10, 25, 50 and 100 m buffers) provide an indication of the relative isolation of forest habitat patches and places where there are significant gaps. It needs to be noted that that the buffers around the northern estuarine shore (15/8/2016) are heavily influenced by salt marsh and mangrove (native) vegetation which is extensive in area (>1ha) but low statured, so will not have great significance as stepping stones or corridors for frugivorous or nectar-feeding bush birds. The 18/6/2018 maps (with much smaller source patch limit), and also the linear habitat (along streams) may over-emphasise connectivity, even though they qualify by total area of patch (spread along a stream) and height of vegetation (>4m) in this analysis.

There is, in much of the discourse about restoration and connectivity, a preoccupation with 'riparian planting'. It often seems like, "so long as we do a bit of riparian planting we're done". But the key need for biodiversity conservation is compact blocks of (forest) providing core habitat that is buffered from edge effects. And for these to be close enough to each other (or physically connected) to provide for migration, dispersal and foraging across a wider landscape.

Meurk & Hall (2006) used empirical data to demonstrate that there is a 'decay curve' that describes the (successful) dispersal of propagules from a source population; that the drop off (inflection) is acute from about 100 m away from the source, but that there is a long tail

which is quite detectable out to 2.5 km and which is more clearly defined for bird- compared to wind-dispersed species. By 'successful' I am referring to observed seedlings that have been dispersed, germinated and established (Fig. 6, 7, 8). One might say that the halo effect for plants and their dispersal agents extends 2.5km but that 90% of dispersal occurs within the first 100m. Of course, for more sedentary or grounded species, continuous corridors are necessary and translocation can be applied where there is discontinuity in existing landscapes.

On the basis of this modelling, we propose that the ideal, ecologically functional cultural landscape (urban or rural where there is a human-induced matrix distinct from patches and corridors) should have large enough source patches, which have an inner buffered core (Fig. 3), at a maximum spacing of 5km. But that smaller, intermediary stepping stone patches should exist at 1km spacings (every neighbourhood); and yet smaller groves of a few native noble trees every two hundred metres (in every street).

This configuration achieves two complementary outcomes – a landscape with ecological integrity and connectivity; and one with legibility to local residents who are then connected to nature through continual visibility and accessibility. They therefore have the experiential familiarity and understanding from which they can continue building and improving on, hence reinforcing the eco-structure of their neighbourhood (Figs 4, 5).

In the Whau district, using the patch designation criteria that includes saline marshes and mangroves and forested stream edges; there is no place that is greater than 1km from another patch (>1ha) although some areas on the Patiki peninsula are mainly associated with mangrove and salt marsh. Apart from those, the largest gaps are in Rosebank area, Avondale Racecourse area, Maloro Street, Clark Street, and SE of Glendene.

However the finer scale (smaller patch and finer buffers) shows only Clark St, Avondale, Rosebank and Glendene as sparse – with gaps of around 750 m across. However the patches on which this is based are small and mixed, species poor and weedy.

An underlying purpose of the exercise is to look at connectivity between the Whau and the NW Wildlink, and although the analyses show a strong corridor north of Te Atatu South, this is based mainly on mangrove and open parkland. With respect to the role of the Whau Biodiversity Hub, The Boffa Miskell Report focuses very much on the 'Wildlink Wonders' which include marine/estuarine assets in and around the lower Whau, with some adjacent terrestrial forest links, and the relatively smaller coastal forest overlooking the Manukau Harbour. These latter do connect tenuously to the much larger forested areas to the west in Titirangi and Waitakere Ranges and strengthening these connections to a more robust indigenous urban forest is one goal. There is acknowledgement of the important role of the Whau River corridor for birds commuting between the Waitemata and Manukau Harbours.

Other linkages to the North West Wildlink are via patches or streams running near to Te Atatū peninsula in adjacent board districts. The links that can be fostered are from various tongues of forest running down from the Waitakere Ranges to Blockhouse Bay (southern coastal forest), and through the Glendene and Waikumete areas into the Henderson catchment. From there and via rail and/or motorway links there is the Swanson forested areas and tenuous links through Kumeu to Riverhead Forest. Then to the east are forest remnants near Paremoremo, Bayview and Albany Heights feeding through or from Whangaparaoa Peninsula. Although some of these require a jump, there appears to be no gap greater than 5 km which is well within the range of most bush birds.

But to pursue this forested connectivity there will need to be a continuing and building commitment by the various community groups identified in the Boffa Miskell report to not only establish suitable habitat, but also to expand the pest animal control along the corridors and out into the urban matrix. I would argue a very strong case for developing wider forest connectivity across not only this District but to extrapolate to the whole super city. Much of the spatial eco-infrastructure, growing conditions and bird traffic already exist to achieve this. To realise the vision, there will need to be a gradual transition from pests and exotic trees (which have little ecosystem service value to native bush birds) to an environment that better provides for these indicator species of native ecosystem health.

Action Plan

There are 3 broad aspects to strategic recommendations for the Whau Board area. These are filling the medium scale patch gaps, creating physical connections through riparian (and other) corridors, and managing the urban matrix (including what people may do on their own properties). All these three domains are underpinned by specific actions including providing proper protection of remnant (even degraded) habitats, acquisition of land where there are patch or corridor gaps to be filled or edges to be buffered, weed control, pest animal control, and planting of missing elements - especially NZ noble trees. A next step, putting milestone/timelines against each of the specific actions will depend on resources and community commitment.

Filling the Gaps in the Eco-Structure

Most of the identified patches and corridors in the 18/6/2018 gap analysis first need to be secured or preserved through purchase, covenant and/or designation. Primary or self-established secondary vegetation on uncultivated or uncut/filled soils are of greatest

conservation value and are the foundation for conservation and recovery in the wider landscape.

All public forest patches are best protected and enhanced by weed and pest management by informed neighbourhood groups promoting and nurturing selective regeneration. Enrichment planting can then be carried out with significant missing elements, beginning with canopy trees then over the years working down to understorey elements, ground covers, vines and epiphytes. The species guidance for this will be provided within the rebuilt *Nature Services* decision support tool for sequentially staged planting, and with support from Council, University and community experts. Once the habitat is improving many of these fine-scale elements should begin to colonise under their own steam from primary sources.

New sites within the 'gap' areas referred to above should be found and protected or restored. Sports parks should be surveyed for land surplus to the needs of future recreation and designated for forest-patch restoration – even if it is only in corners not critical to the main recreational function of the park.

Some existing patches are dense strands of exotic trees filled with weeds (Fig. x) whereas others are well on the way to being indigenous forest through an old pine canopy (Fig. x).

The action here then is to improve the quality and ecological health of existing patches and plant intervening patches within the larger forest gaps.

Figure 11: Quarter hectare patch in suburbia of almost pure, dense bamboo with thick cover of tradescantia penetrating in from the margins.

Figure 12: Dense understorey of regenerating native hardwoods (whauwhaupaku and shining karamu), podocarps and ferns (silver fern) under pines and secondary kanuka along border of golf course.

Corridors

Corridors appear to be generally well protected in that there is little intention to build into them due to their dynamic characteristics, and city planning that forbids this. Only some of the woody vegetation is indigenous; however all the exotic-dominated river corridors are able to be converted over time with appropriate weed control, selectively encouraged regeneration, and informed planting – especially of indigenous noble trees.

This will need to be carried out in accord with the typology of river styles and their hydrological dynamics as formulated in the adjacent Twin Streams district (Reid et al. 2009). They identified nine (natural) fluvial river styles and three engineered river styles. The controlling features appear to be the degree of confinement (and lack of floodplain) of the stream, the substrate type and texture, the degree of sinuosity of the channel, and the vegetation stature/density. Hard structures, ponds and pipes typify the engineered forms.

River trajectories have been characterised as developing from ‘intact’ to ‘degraded’ and then sometimes to becoming (re)-‘created’ (Reid et al., 2009, 2010). See Fig. 13a, b with mix of stream banks, floodplain, and terrace scarp with varied planted, spontaneous, indigenous and exotic (weedy) vegetation.

Figure 13a, b: Whau River with planted and regenerating indigenous harakeke, shrubs and trees, but potentially large spaces being occupied by willow, alder and swamp cypress or dawn redwood. These should be avoided and gradually eliminated as they have limited resource value (berries and nectar) to indigenous bush birds. This shows a relatively unconfined (lower) reach with infill alluvium (floodplain) suitable for either swamp flaxland

with cabbage trees or later mature kahikatea-pukatea forest with rimu-matai forest on the terrace scarp.

Figure 14: Exotic palm seedlings – a potential danger to the integrity of naturalised riparian corridors and bush patches – as they are bird-dispersed, shade tolerant and evergreen (the worst combination in terms of invasiveness). Other typical examples of weedy understorey trees and shrubs are ivy, holly, monkey apple, privet, and blackberry.

Ideally encouragement should be given to beginning remediation and restoration from the very top of the catchments and moving downstream as weed control is accomplished at a given level. Progressive removal of weeds (Figs 11, 14) is the first step and the main barrier to natural regeneration. These should be prioritised according to their known invasiveness (Fig. 14) and blanketing tendency.

Restoration will be guided by the style of stream reach one is dealing with. Much of this will depend on cooperation from landowners along the streams. They should be incentivised, assisted under the proviso that some level of protection is afforded the provision of public resources.

In general the broad first stage revegetation patterns, where there is limited natural regeneration occurring, in freshwater reaches of streams will be:

Open banks – tussock sedges, Carex geminata or similar

Open floodplains – harakeke, toetoe, cabbage tree, manuka, swamp maire, mikimiki, Astelia

Terrace scarps – houhere, kanuka, manuka, pittosporums, karamu, *Pseudopanax* spp, etc.

Closed banks – Machaerina, gully fern, kiokio, sedges

Closed floodplains (e.g. under willow or 2nd stage) – kahikatea, pukatea, ground and tree ferns, sedges, *Gahnia*, *Microlaena avenacea, Astelia.*

Terrace Scarps second stage – totara, matai, rimu, miro, puriri, Griselinia, titoki, hinau, kauri.

As identified by Reid et al. (2009) there are some reaches and rivers that have low recovery potential because of very constrained channels that are overwhelmed by flood waters or due to excessive deposition of alluvium from historical and continuing erosion in the headwaters. Such cases will require individual assessment (Reid et al. 2010), but it is likely that the only sustainable vegetation will be rhizomatous sedges, rushes and slow evolution towards floodplain forest – possibly via initial willow canopy.

Overall Landscape Structural Goals – Managing the matrix

A continued educational programme should be carried on with communities, iwi, schools and businesses to get them on board with working in their own properties or neighbourhoods to create groves of even a few noble trees; or more refined niche restoration – on walls (buildings and stone), roofs, lawns, rock gardens, street trees, round-abouts, etc.

The booklet on *Putting Nature into your Neighbourhood* (Ignatieva et al. 2008) provides a useful framework for reinstating these biotopes[3] and there are many resources from Waitakere and Auckland Councils to advise on appropriate plants and habitats (see Nature Space website) for restoration. A reinstated 'Nature Services' will also provide online specific advice for restoration and landscaping with nature conservation in mind.

The following minimum targets are based on the 200 m grid overlain across the District (Fig. x), although at the finest scale the target is likely to be the component biotopes within individual properties or land uses. These are primarily the responsibility of landowners which may include iwi, council or other public agencies such as NZTA, NZ Railways, etc.

Grid square scale targets will be the responsibility of neighbourhoods, streets residents in conjunction with park and school ground managers. Kilometre square clusters will be the responsibility of community boards in conjunction with their constituent communities and

[3] Biotopes are specific vegetation types that are more or less uniform in composition and stature and have a discrete boundary. These vegetation types are determined by the underlying micro-environment (topography, aspect, substrate, hydrology) and by management (grazing, mowing, cutting, mulching).

iwi; and finally the larger scale (5km) squares will be addressed by Council, Community Boards, iwi, and suburban communities.

For each **200 m grid square** the minimum target shall be a grove of noble NZ trees as described previously. This might involve up to a dozen large trees at about 3-5 m spacing established in pocket parks, roundabouts, supermarket or factory grounds, etc. For the **1 km grids** the target will be a 1 ha patch of indigenous forest that is more or less compact in shape (one in every 25 grid squares), and at the larger grid scale, a **5 ha sanctuary** will be the target (one in every 625 squares). These latter two cases will have the original/potential forest vegetation of the land type as the model or reference site.

Connectivity will be inherent in the spacing of these stepping stones, but for less vagile organisms, river corridors will provide the dispersal routes between patches.

There will need to be widespread consultation and engagement and explanation of these principles in order to achieve buy-in and then active support and incentives from Council since its success will depend on all these partners working together.

Recommendations

Effort should be made to reinvigorate the notion of North West Wildlink that connects the forested habitats deep into the Whau district and into the consciousness of local citizens. There is already a strong directive to **maintain the wild wonders of the estuarine and mangrove ecosystem**.

The natural infrastructure and functionality is already largely present and intact and gaps between stepping stones and corridors are well below the thresholds for disconnection that empirically-based theory prescribes.

Existing patches and corridors can be enhanced and enriched over time through **standard techniques of weed and pest management**, recommended species **under-planting** (of native noble trees, ground covers and vines) or **full restoration** where required, and ongoing vigilance and **maintenance**.

Main **corridors** include demarcated stream edges – some of which will require support from landowners, but roads, railways and coastal edges also act as linear natural routes through the landscape as the strongly indigenous motorway corridors throughout Auckland amply demonstrate. Even shrubs and pohuehue vines along **fence-line boundaries** with utilities can provide connectivity for smaller creatures, but their success will eventually depend on predator control – including hedgehogs and domestic pets.

Some **strategic gap filling** can be implemented in a few areas to enhance the connectivity to an even higher standard than is absolutely necessary for forest ecological function.

Residents shall be encouraged and incentivised to raise the ecological quality of the **Matrix** – in their own gardens and properties. As Ignatieva et al. (2008) demonstrate there are many more species and niches that can be employed to support even rare indigenous plants and their dependent insects within the urban matrix in quite small spaces. This will be achieved through neighbourhood groups taking informed ownership of their patch. The Friends of the Whau (or current name) have been and will continue to be instrumental in developing this culture.

A proposed set of **minimum targets** is based on the Meurk & Hall (2006) model for optimised patch configurations for cultural landscapes. This can be **implemented by using a 200 m grid overlay** across the District that prescribes at least one grove of noble trees per grid square, ca. 1 ha forest patch per square km and a ca. 5 ha sanctuary per 25km^2.

In general, such a pattern and the **involvement of community** in getting there will raise awareness and **shift the culture** of local government, boards, businesses and the wider community towards a stronger identity and sensitivity and protectiveness towards their natural heritage, their taonga. This will in due course contribute to **legibility of landscape and sense of place** among citizens – that relates specifically to Whau - Tamaki-Makaurau – Te Ika a Maui - Aotearoa.

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Maps Links

GAP analysis performed on the Whau Local Board Area.

https://1drv.ms/f/s!AuPtHXVofKImizFt11hs-rkkkPV6

The analysis is based vegetation height data extracted from LiDAR;

- Vegetation >4m or greater was extracted selected (any lower and non-vegetation features are frequently pulled out despite buildings having been removed);
- Of these, only vegetation clusters greater than 500m^2 used for the buffer analysis;

- This vegetation clusters includes both exotic and native vegetation;
- Buffers of 100m, 50m, 25m and 10m created;
- Two maps created, one with Local Parks and one without;
- Note: As the shaded greyed areas only excludes vegetation clusters smaller than 500m2 and lower than 4m some caution should be taken when making any assumptions. For instance this area may contain tall isolated vegetation or clusters greater than 500m2 but shorter than 4m in height;