TREE CANOPY COVER BENEFITS AFFECTED BY URBAN INTENSIFICATION – BIODIVERSITY and RELATED ISSUES

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Executive Summary

The implementation of the National Policy Statement - Urban Development (NPS-UD) - and the Resource Management (Enabling Housing Supply and Other Matters) Act will enable higher density residential developments with probable impacts on green space and tree cover. This document provides support for mitigating these effects from a biodiversity perspective specifically under Direct Use Values (**Provisioning Services** - Natural Habitat), Indirect Use Values (**Cultural Services** – spiritual, aesthetic/amenity, cultural diversity-sense of place, health & well-being, tourism, education), and **Passive Values** (options, existence/intrinsic, bequest).

Many international publications have documented the multiple measured ecosystem service (ES) values of trees/green space in the urban environment (Biodiversity is positively related to mental health (phys.org) ; Meurk et al. 2013). Distinguishing the indigenous from generic ES values and unravelling those on public versus those on private land is more complicated as they are inevitably inter-dependent (Ausseil et al. 2011). Fundamentally these are intrinsic/existence values as demonstrated by human behaviour and choice in the marketplace (of ideas, time and spending priorities), opinion surveys, international accords, and through personal activity - 'actions speak louder than words'. These are found under Cultural and Passive Values, but indigenous trees provide habitat for native wildlife, and there are indirect economic values that could be quantified - from tourism, health, and education. These are all proxies for more quantified values that may be calculated (Roberts et al. 2015).

There is growing support for these values within our relatively affluent society. The Council then has the task, in partnership with Mana Whenua and the wider community, to plan and co-design the implementation of the public will. Well-being is fundamentally attached to 'sense of place' or identity with a place, whose layered history is legible for citizens and visitors alike. This might be equated with *Turangawaewae* – a place to stand comfortably and aware.

On the other side of the ledger, some of the 'costs' of exotic species are listed – deciduousness and invasiveness - that undermine the intrinsic values and our obligations to international conventions

on biodiversity. It needs also to be acknowledged that appreciation of nature may depend first on Maslow's (2020) basic needs being met equitably within the community.

A recommended goal, to achieve the biodiversity purposes in law and international agreement, is that by 2050 a minimum of 60% of Street, Park, Riverside, and private land trees will be indigenous and visible, thereby attracting native wildlife and providing networks or steppingstones through the urban landscape. This will be facilitated to some extent by the fact that many of our mature, largely exotic city trees, planted mid to late 19th Century will, under our benign oceanic climate, have reached their age limit and be declining. This is evidenced by the fact that dead or decaying trees from this era are already being taken out. By the same token, the million or so largely indigenous trees planted by Councils, community groups and landowners over the past few decades on both public and private land will be pushing across the 3.5 m threshold of eligibility to be recorded as 'tree cover'.

This proposed indigenous-exotic mix should be part of achieving a 20% tree cover in the metropolitan area of the City, and >25% when incorporating the greater Christchurch area including Banks Peninsula. To be equivalent to other cities these figures should be calculated separately from areas of permanent wetlands and detention basins, and ponds dominated by tussock species, reeds and open water. These wetlands are taoka and mahika kai, in their own right, and shouldn't be included in metrics that imply that the City has lesser natural value and ecosystem services than other cities. The precise figures need to be evidence-based and negotiated.

The planting of species should follow guides to 'right plant – right place – right time' (Lucas et al. 1996/7, 1998; Meurk et al. 1997; Meurk 2003, 2008). These will be reflected in the patterns and zonations according to underlying soils and hydrology, as well as amenity, aesthetics, and safety. It is important however that ecology is not sacrificed to simplistic concepts of safety and tidiness.

All of these elements and moving parts will require careful planning, design and implementation – building eco-literacy among governors, planners, engineers, landscape architects, and community. Care will be needed to ensure everyone is well-informed. There is always a danger that co-design can be over-influenced by those who are no longer connected to their natural heritage (extinction of experience phenomenon) resulting in a model that may unwittingly perpetuate the single-value focus of the past colonial era. However, a large majority of randomly surveyed citizens desire more native plants and birds in their city. Partnership with Mana Whenua and a Matauranga Maori world view will be essential. A robust, evidence-based process should ensure that the City achieves its goals of ecological integrity and legibility, and that private land contributes its share by setting aside sufficient space for large trees or making financial contributions towards mitigations. If such provision is not made, for especially lower socio-economic suburbs, then human well-being will be impacted.

Key Findings relating to Biodiversity Value of Indigenous Trees:

- The world is facing the **6th Great Extinction**

- NZ is a **biodiversity hotspot** – our country and province have an extra-ordinary duty to protect our contribution to global biodiversity – at gene, species, population, community, ecosystem, landscape, and cultural scales - and the majority of citizens support this.
- **Otautahi-Christchurch has a high number of wild indigenous species** although much is hidden and has historically contributed to an 'extinction' of experience, identity with, and therefore conservation ethic towards the indigenous flora and to trees in particular with a few notable exceptions – kowhai, lancewood/horoeka, tarata, rimu (incongruously brought over from the West Coast rainforests) and cabbage trees come to mind.
- **Trees** are here defined as woody plants that exceed 3.5 m in height, regardless of growth form.
- **'Biodiversity'** (indigenous contribution to global species diversity) is distinguished from 'species richness' (the total number of species regardless of origin). Species richness does contribute to resilience, and many exotic species provide important ES, but not those specifically related to 'natural habitat', aspects of 'pest and pollinator regulation', cultural services, and passive 'existence/intrinsic' values. This is the domain of indigenous species.
- Region-specific ecosystem values of large biomass providers (trees) are especially critical in terms of **hosting or servicing** dependent indigenous microbes, invertebrates, birds, and lizards.
- **Indigenous trees and forest patches outperform exotic** or un-treed residential environments in terms of indigenous wildlife.
- Species richness of native trees is essential to provide **year-round supply of critical food** resources. That is, berries and nectar are provided by different tree species at different times of year, and so tree diversity is a necessary ingredient for survival of native bush birds, in particular, throughout the year.
- **Our Biodiversity** is our unique contribution for which we have international duties (and local declarations) to protect; and is increasingly recognised as providing the basis for local place-making or turangawaewae.
- This **must be achieved** through protecting natural occurrences of species *in situ*, removing negative influences (biosecurity, disturbances, predation), restoring lost or degraded habitat, and creating legible landscapes that have at least co-dominant presence of native species (trees) with high visibility – overcoming the extinction of experience.
- It is possible to **monetise** physical, physiological, and sociological **ecosystem services** from trees in general (carbon, water retention, heat island effects, wind, well-being, etc) and to recognise that exotic trees can often outperform indigenous species on these metrics. International figures for medium-sized trees with different ES value ratings range from US$500 to $60 000 but intrinsic value would be a further incalculable layer on that.
- The biodiversity/intrinsic values of **native species cannot be replicated** – globally, culturally, or deep socially by exotic species.

- In the absence of clear monetisation of native trees, there are however **proxy measures** that may be employed. A significant majority of citizens wish there to be more native trees and birds, based on random and active citizen surveys, community engagement in environmental and restoration projects, choice experiments, and market dynamics. Many wish this to be within a 'garden city' framework – which implies abundant/accessible green space, plant diversity within attractive and tidy design.
- There are some indirect monetary values associated with biodiversity – in relation to **'clean green' brand** for produce and tourism, and well-being/health based on authentic reference to layered history in the daily human experience.
- The **implementation of protection and recovery of tree cover and biodiversity** has to be achieved through gradual but progressive replacement policies, innovative/creative design that maximises the benefits and minimises detrimental effects. This will come from application of landscape models that support ecological integrity and functionality. Intensification will require **Realistic compensation** for unavoidable losses of green space, tree cover (using generic ES monetary calculations), accessibility to all citizens, sustainability, and place-making within a desired garden city framework. Minimally a 'time-for-time' replacement formula, that raises the indigenous tree component, is proposed to reflect the demonstrated values. Allowance for increased early establishment maintenance of new trees, must be built into the compensation package.
- This needs to be carried out in **partnership** between public and private lands and within the context of Te Tiriti.

1 Background & Scope

The Council is in the process of implementing the National Policy Statement – Urban Development (NPS-UD) and the Resource Management (Enabling Housing Supply and Other Matters) Act which will enable higher density developments across the city as a permitted activity.

This is a laudable urban planning aspiration, especially to reduce city transport emissions and prevent continual urban sprawl onto prime agricultural land. It will however have unintended consequences if not mitigated, as highlighted in a recent report on tree cover of cities in New Zealand, including Christchurch. We, in particular, fall below the globally accepted goal (for grassland biomes) of a minimum 20% tree cover – that collectively deliver multiple ecosystem services – some increasingly crucial to future citizen well-being. However, it needs to be recognised that most of Christchurch is not a grassland biome (Appendix 1a, b) but rather a potential mosaic of permanent wetland, fen peatland (supporting at least manuka – Travis Wetland), kahikatea forest – as at Riccarton Bush, totara-matai forest on periodically wet soils, dry kanuka-kowhai-ti kouka-tumatakuru woodland, and shrubland-grassland on northwest outwash soils (cf Rakaia and McLeans

Islands), and stable coastal dunes (restored coastal bush at New Brighton, Sumner, Taylors Mistake) (Meurk 2008).

The Christchurch City Council (CCC) has identified the adverse effects associated with intensification as:

- Reduced carbon sequestration;
- Increased stormwater run-off;
- Increased heat island effects; and
- Reduced biodiversity and amenity.

One might add cultural/taonga-taoka values, that need to be addressed by Mana Whenua, but there are strong identity and place-making issues for all people. And there are commercial impacts through reducing the attractiveness of the city to a reset 'slow tourism', and even the opportunity to develop a slow-rotation indigenous forestry industry – based here on totara and matai. This would ultimately produce very high-quality timber that could be (culturally) selectively harvested once the carbon stocks have built up to a higher steady state – on a continuous canopy basis. Such resulting (heart) timber has the added advantage of avoiding the need for toxic chemical treatment as it has natural resins that resist decay.

The recent 2018/2019 survey of the tree canopy cover in Christchurch (Morgenroth 2022) indicates that the overall cover is now at 13.5% which represents a 2% loss since 2016, mostly on private land. This is most susceptible to expanded and intensified urban development.

CCC has commissioned reports to examine these adverse effects identified above and the extent to which maintaining and improving tree canopy cover may help avoid or mitigate them, including through tree retention, replacement and new tree planting on development sites and financial contributions that could be applied to compensatory reserves or tree planting. The provision of accessible green space and woods are well understood remedies for urban densification that are applied in progressive town planning rules around the world to achieve ecological and human health. These remedies are being entertained by CCC and require well-argued, evidence-based cases to be made for their implementation.

The following report addresses the need for supporting evidence to justify the proposed plan changes that **will attest to the values of especially indigenous tree cover** to counter adverse effects on biodiversity due to urban intensification.

There is an expectation that evidence shall "focus on quantifiable scientific research/proof of the benefits of urban tree canopy cover in terms of maintaining and improving biodiversity" but here employs social logic rules and proxy indicators as well. Note that carbon sequestration, storm water effects, heat island effects, and amenity values are being addressed elsewhere. But all these considerations are intertwined and inter-connected and on bulk material grounds may be supplied more measurably by exotic species.

Whereas, the tree cover condition of the city in its broadest sense may not be as dire as the recent report suggests (see reflection on assumptions in Appendix 1a), there is no doubt that a reset of tree quantity and quality is urgently needed. Every contribution we as a city make will be adding to the forward momentum in addressing the multiple emergencies facing the planet – climate, ecological, biodiversity, pollution, and social cohesion - and to which the City and Regional Councils have declared or are addressing.

2 Definition of a Tree

Since we are talking about trees, we must first define what one is. Interestingly there is no single definition – but includes woodiness, height, form, and taxonomic species definitions.

With respect to height, 5-10 m has been widely used, but Justin Morgenroth's (2022) threshold for his 'tree cover' calculations was 3.5 m. Some have argued that for a plant to be a tree it must, as well as being woody and of a height, have a particular growth form, namely a more or less clean trunk up to say 3 m supporting a spreading canopy of branches and foliage. 'Tree line' at the upper elevational limit of 'trees' may include species that form trees under milder conditions, but are reduced to krummholz or suppressed shrubs only a metre or so high on the edge of the alpine zone. As such these rank as a 'tree' – taxonomically rather than in terms of growth form.

The vagueness of the definition derives from the fact that fundamentally the concept of 'tree' is a social construct – it is a woody plant that is taller than a person and can be, more or less, walked under. Many NZ trees don't fit the ideal Northern Hemisphere definitions as the former are often multi-stemmed, branching near the base, and so lack the classic 'trunk'. With all these definitions in mind, we may for the purposes of this report and the application to Christchurch, regard a tree as any woody plant that exceeds 3.5 m regardless of form. Indeed, it is reasonable for NZ to adopt and even promote our own less rigid growth forms. This would be consistent with acceptance of a slightly less formal, more organic form of vegetation in keeping with our characteristic species 'look'. It is also in keeping with the global movement towards acceptance of a degree of 'urban wild' yet accommodated under Nassauer's (2020) 'messy ecosystems – tidy frames' (or cues for care) concept. This may challenge the conventional colonial notion that humans are here to manage nature and exercise sovereignty/dominion over it, purely for our own purposes. I will address the critical distinction between what is acceptable or desirable to a majority of the population, what is logically founded in evidence, and what we as a nation and city have signed up to. The main point is that contained wilderness can enrich urban environments within a tidy 'garden city' frame.

3 Importance of biodiversity values

An initial disclaimer – it is fashionable now to believe that a natural species from the area will be superior to, and grow better than, species from outside. Sadly, we can't honestly say that indigenous species will be superior to exotic species in providing material ecosystem services. Indeed, most exotic species – derived from the most intense evolutionary pressure in continents around the world under the impact of mammalian browsing and predation (Meurk 1995) – will inevitably outperform native species by most quantifiable measures. They will colonise quicker, grow faster, taller, produce more fruit and wood (of generally low quality), will be more competitive and breed faster than indigenous species. They will also resist the impact of introduced browsing mammals – indeed these characteristics are co-evolved.

We must therefore look for their value in other domains (Meurk 2021 – *Think like a Matai*). These are outlined below, with an indication as to how or whether their value can be quantified. It is complicated to monetise the value of biodiversity and there are generally only indirect or proxy measures.

4 Generic Value of Trees & Green Space

There are many publications that establish the ES importance of green space – e.g. 11015viv_natural_capital_account_for_london_methodology_v2.pdf . Whereas this relates to green space in total, much of the argument and approach will be relevant to the tree component.

The classic publication on the 22 benefits of street trees (Burden 2006 - untitled (walkable.org)) is summarised here.

1. Reduced and more appropriate urban traffic speeds.
2. Create safer walking environments
3. Trees call for placemaking planting strips and medians
4. Increased security.
5. Improved business.
6. Less drainage infrastructure.
7. Rain, sun, heat and skin protection.
8. Reduced harm from tailpipe emissions.
9. Gas transformation efficiency.
10. Lower urban air temperatures.
11. Lower Ozone.
12. Convert streets, parking and walls into more aesthetically pleasing environments.
13. Soften and screen necessary street features.
14. Reduced blood pressure, improved overall emotional and psychological health.
15. Time in travel perception.

16. Reduced road rage.
17. Improved operations potential.
18. Added value to adjacent homes, businesses and tax base.
19. Provides a lawn for a splash and spray zone, storage of snow, driveway elevation transition and more.
20. Filtering and screening agent.
21. Longer pavement life.
22. Connection to nature and the human senses.

Whereas, this is largely from a northern European or American, directly human perspective, additional material is found on actual design of treescapes that fulfil the above benefits generally. Specifically, items 3, 12 and 22 relate to biodiversity and wildlife.

A similar set of benefits are elicited by Fountain & Crocker (What is your Tree Worth – Appendix 3a).

Dollar values have been attempted and one such example here is reported by Michael Kuhns (Utah State University, Forestry Extension) - What is a Tree Worth? | Forestry | USU .

"According to "Growing Greener Cities", a book published in 1992 by the American Forestry Association, trees have significant monetary benefits. They have found that a single tree provides $73 worth of air conditioning, $75 worth of erosion control, **$75 worth of wildlife shelter**, and $50 worth of air pollution reduction [per year]. Compounding this total of $273 for fifty years at 5% interest results in a tree value of US$57,151".

The omnicalculator - Tree Value Calculator (omnicalculator.com) – simply multiplies the trunk diameter by tree height times the tree value (with results between about US$500 and US$10 000 for trees with 50cm trunk diameter and 10 m height, depending if a beech of value = 1 or mahogany = 20). One might imagine a similar distinction between say a cabbage tree (ti kouka) and a matai.

These cover the broad range of ecosystem services but need to be elaborated to ensure the particular importance of indigenous species is accommodated.

5 Intrinsic Value of Biodiversity

Biodiversity has intrinsic value which from a human perspective may be equated with 'existence value'. We must first clarify that 'biodiversity' refers to indigenous species, in contrast to 'species-richness' (Appendix 1a). We simply like that something exists, such as amazing creatures, landscapes, cultures, and artefacts throughout the world, as well as cosmic wonders, that adorn books and films, even if we won't ever experience them personally. But they can still inspire curiosity and awe. Species have a right to exist as reflected in the international biodiversity accords of past decades. How this translates into more than an aspiration and declaration is unclear. A high proportion of New Zealand's indigenous species are endemic and even those which are naturally

found elsewhere, are likely to have a distinct genetic make-up within the NZ populations. NZ is regarded as one of the worlds biodiversity 'hotspots' – with a high degree of endemic and globally significant biological elements due to long isolation (Ausseil et al. 2011).

With regards to the tree component – it is noteworthy that among the first 1000 of the 2432 plant species recorded from Christchurch on iNaturalist NZ, 7.2% are indigenous trees (not all local), and 7.1% are exotic trees. Of these 7% of the indigenous are deciduous compared to 47% of exotics; and ca 75% of indigenous are berry producing versus 35% of exotics. This is likely to be skewed due to the commonest exotic species tend to mimic indigenous species through being shade-tolerant, evergreen and bird-dispersed, and hence are over-represented in the wild and in gardens.

The point here is that indigenous species are distinctive and vulnerable, and important to native wildlife (Appendix 3b, c). They also need assistance for their survival against the waves of hyper-competitive/reproductive exotic species, which can dominate succession, habitat, landscape, visibility and therefore the landscape of the mind. And yet because of the purely intrinsic value of (indigenous) species, and enshrined international conventions, we have a moral and legal duty to protect, expand, and ensure they are eventually capable of self-maintenance.

The New Zealander, and one of the world's founding fathers of ecology, Leonard Cockayne, argued the importance of native plants to our national identity since the beginning of last century (Appendix 2a). The statistics from random citizen surveys (Appendix 2b), and the abundance of community groups actively improving the environment in their neighbourhoods (400 citizens turned out to plant 5000 native trees in the red zone on 3rd July 2022), invariably attracting positive responses from those passing through, demonstrate a growing recognition of these values and affiliation with indigenous species. These provide the best proxy quantification of intrinsic, or existence value placed on them by the community. It boils down to 58% wanting more native plants in their neighbourhoods, 72% wanting more native birds in their neighbourhood, and 77% wanting them within a 'garden city' format. Notably, about 85% of active walkers in parks and reserves are more accepting of indigenous nature landscaping (Appendix 2c). Importantly, 26% are supportive of more active replacement of 'English style city' with more native plants/trees, and this figure is 36% for a younger demographic (<35 years). I am aware that a recent citizen survey has been completed which shows this trend continuing. More in-depth analyses (Appendix 2d) showed very high support for nature in the city (91% for an ecosanctuary). These figures need to be considered against the tiny 2.5% proportion who want fewer native birds and 2.9% who want fewer native plants (Appendix 2b) in their neighbourhoods.

These measures of conservation value for biodiversity conform with our international duty and obligations (as responsible global citizens) to address the 6th great extinction (Holocene extinction - Wikipedia). It is recognised that this support however depends on the most basic human needs being met first (Maslow's 1970, 1987 - Maslow's hierarchy of needs - Wikipedia) – adequate food and nutrition, safe homes, clothing, work, and whanau connection. Then connectivity of the human experience with nature (including working together with other people for nature) gives rise to

ecological literacy derived from a legible landscape – one that visibly portrays and interprets the layered history of the land and the eco-cultural patterns therein. Therefore, equity and fulfilment of these survival needs, as well as direct exposure to the natural world, are essential prerequisites to achieving ecological literacy, an identity with ones' roots or whakapapa and the uniquely indigenous elements of the landscape, and ultimately a conservation ethic towards those species. This is then expressed in Maori lore as *kaitiakitanga*, within the framework of *Matauranga Maori*, and in western concepts of guardianship and stewardship. There is a place for all sides of **Te Tiriti** to look after the spirit or mauri of the land/whenua, sea, and freshwater. It should be noted that global analysis of 'happiness/contentment' in relation to GDP/capita demonstrate that 'happiness' levels out at a modest material wealth – once Maslow's basic needs are met. It is here important to acknowledge that a modern view of Maslow proposes that all these needs can be aspired to and practised together - pluralistically. Transcendence can be achieved before all material needs are fulfilled. This is clear from the engagement of volunteers for nature from all walks of life and socio-economic status, suggesting that we are talking about universal values here, and that nature restoration does indeed also restore body, soul, and community – the village if you will.

6 Ecosystem and Biosphere Value

Trees as habitat, provide sequenced food resources and hosts for wildlife – fungi, other microbes, invertebrates, lizards, birds, fish/amphibians. Complexity of ecosystems is regarded as vital to sustainability and resilience; and the model of economy subsumed by the social sphere within the biosphere (rather than other way around as depicted by the prevailing economic paradigm – Figure 1) is vital to understanding our interdependence with ecosystem functions and biodiversity.

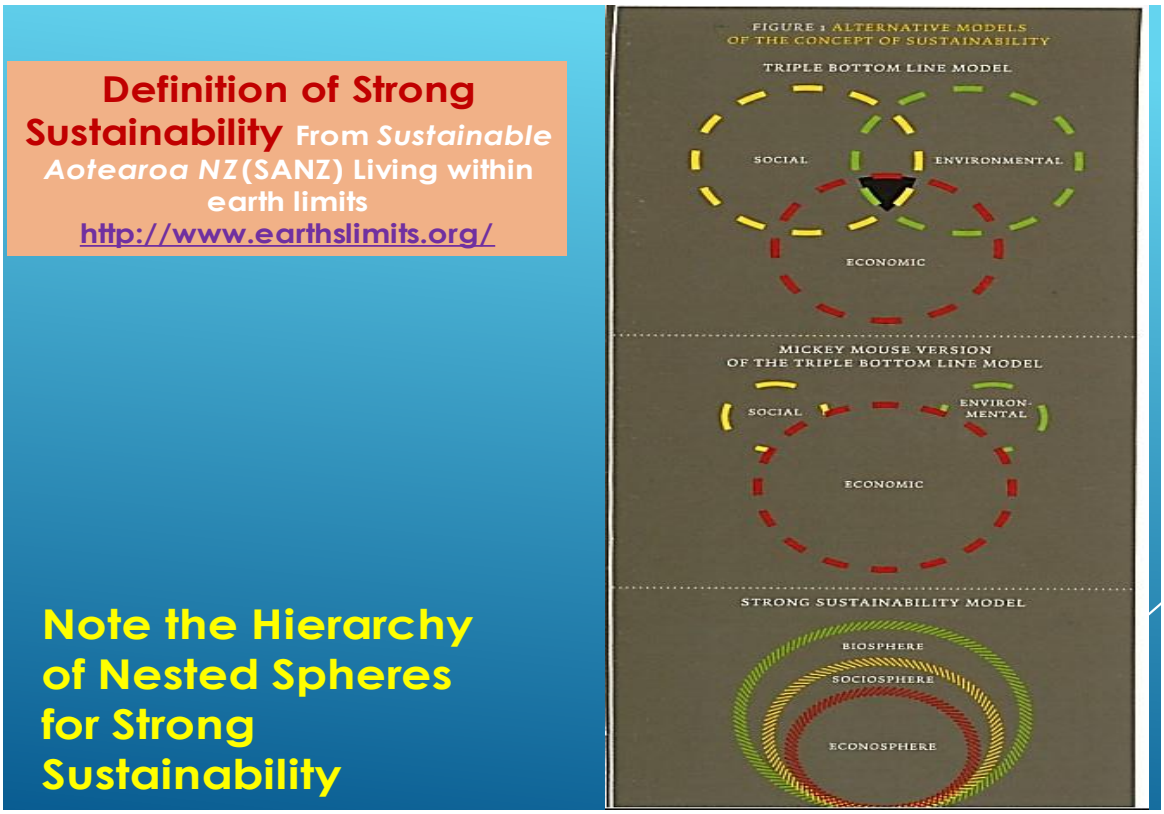


Figure 1: Inescapable reality of Interdependence of Nature and Culture. The economy is nested within the social sphere and in turn embraced by the biosphere (not the other way around) as depicted in the 'strong sustainability' model.

The wildlife and flora of any place are co-evolved and therefore co-dependent. Accordingly, apart from many host-dependent microbes and invertebrates around our flora, our surviving indigenous terrestrial vertebrate wildlife – bush birds, and lizards – are adapted and need the fruits, nectar, foliage, and roosting sites provided by indigenous trees.

The specific importance of indigenous trees is in their high proportion of berry fruit producers and nectar bearers (ca 75%) in keeping with their co-evolutionary history. Continentally derived trees have less, 25-35%, with more dry fruits co-evolved with seed eating birds and mammals (Meurk 2021). Some of our bush birds are insectivorous, and they will utilise exotic forests apparently as successfully as native forest. In particular, grey warblers and fantails come to mind, but see Appendix 3b where the stark contrast in value of native and exotic treelands is identified by Dr Jon Sullivan (pers. comm. 2022).

Some indicative calculations of the attractiveness of native trees to birds, on a per tree or area basis, are provided by Rod Hay (wildlife expert, pers. comm. 2022) and this author (Appendix 3c).

An apparent contradiction arises with the small proportion of exotic tree (and vine) species that do fulfil needs of native frugivorous and honey-eating bush birds. The few 'safe' species include some gums and proteas that provide nectar for our honey-eating birds (korimako and tui). But very few other introduced plants are ecologically safe in the NZ context in that they mimic native forest

species in being shade-tolerant, evergreen and/or bird-dispersed. That is, they are invasive, biosecurity risks to NZ native forest, threatening their ecological integrity. Classic cases, with some or all of these attributes (especially shade tolerance), are holly, ivy, yew, spindleberry, bay, cherry laurel, Douglas fir, and sycamore (deciduous).

Furthermore, a number of exotic trees, especially those that produce dry fruits, attract unwanted organisms. For example, acorns are a favoured diet of rats and mallard ducks.

One can envisage a hierarchy of indigenous forest ecosystem needs, somewhat akin to Maslow's diagram which defines the roles (structure and function) of various elements of the urban landscape through time and the human interactions.

It might look something like this (inverted):

Ingredients (right plant-right place as in Grime's (1977, 2006) species-stress-disturbance space)

Succession (right time; freedom from disturbances – fire, grazing, flooding, landslip)

Weed-free (control invasive plants)

Patch/edge (critical area, compact shape, buffering)

Spatial Connectivity – for plants and wildlife (patch density forming steppingstones and/or with corridors)

Predator control (managing predators to low level, increasing reproductive rates for native wildlife)

Sanctuary (predator elimination – providing vulnerable wildlife a safe-haven – and halo effect – a transcendent state with the mauri restored).

In the recombinant world (Meurk 2011) this transition from most basic ingredients to the transcendent sanctuary level requires human engagement, understanding, awareness and ultimately proactive involvement. This is an **eco-literacy feedback** loop. The urban environment becomes a stage where this drama is enacted – every component, spatial scale, interaction, and dynamic is inextricably interconnected. Each component is valuable to and feeds into the whole.

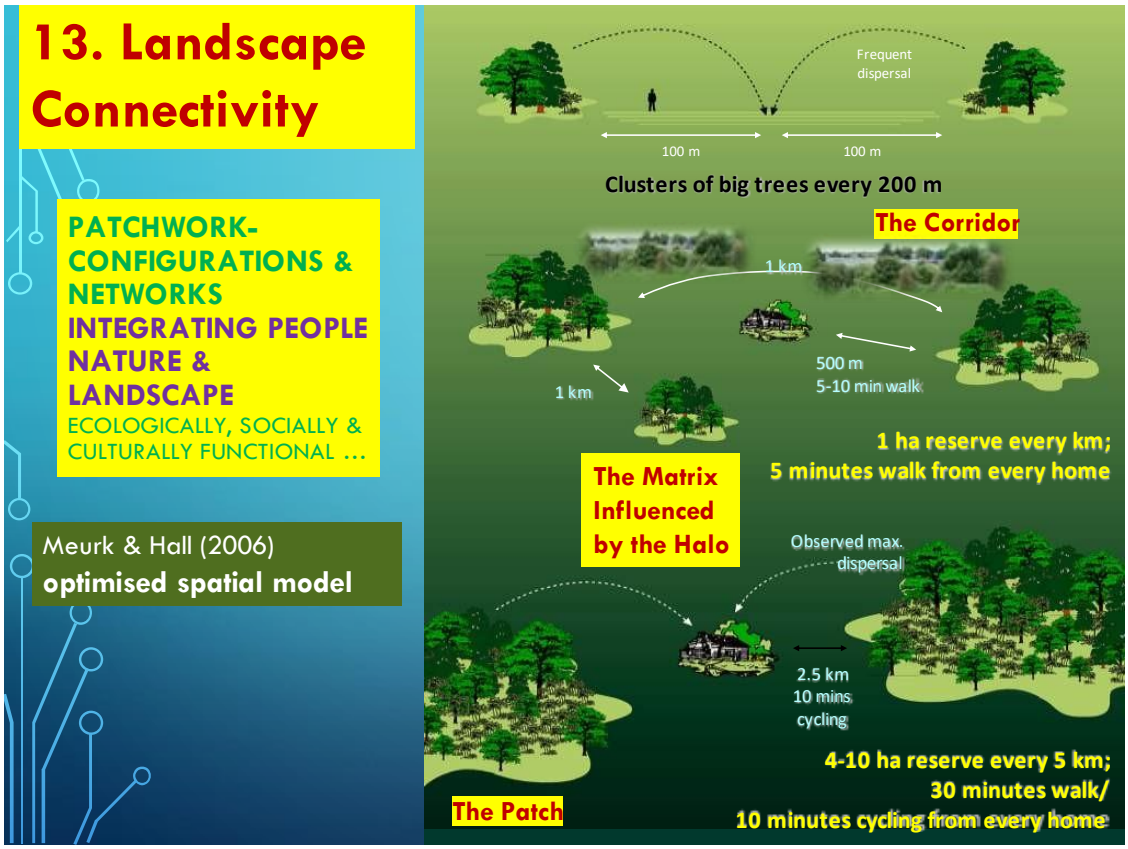
Hence street and parkland (indigenous) **trees**, in their preferred zones, provide individual habitats and steppingstones for foraging and roosting birds. Patches in parks, along rivers, and in larger properties, **protected from disturbance**, can allow for regeneration (cf Ernle Clarke and King George V Reserves) and forest succession – where the only browsing animals may be possums. Control of **invasive weeds** – including ground covers (Tradescantia, ivy, Aluminium plant, veldt grass) and shade-tolerant trees (sycamore, yew, holly) – will facilitate the germination of native forest seedlings and natural succession. Adequate patch area and/or protected boundaries will **reduce edge effects** and allow sensitive species to establish and possibly breed. This can be achieved even in relatively small but enclosed spaces such as courtyards within built or hedged environments. **Planning for landscape scale patch configurations** will ensure the steppingstones and corridors can feed out and

connect across a larger scale and provide underpinning meta-populations of wildlife species that are sustainable. These will be in parks, floodplains, and in larger properties. **Reducing introduced mammalian predators** will raise the breeding success of all wildlife – birds, lizards, and macro-invertebrates – across the board. And finally, **predator-fenced sanctuaries** (such as Riccarton Bush) and as proposed in Waitākiri/Travis will enable survival and even higher breeding capability of our most vulnerable wildlife, and feed both the **ecological and sociological halo**. All these moving parts require input from both public and private land – that is, the spaces between patches are regarded as the **matrix and the quality** of this (trees, shrubs, invasives or not, pest control) will also affect the overall sustainability and integrity of the landscape.

7 Landscape Pattern, Dynamics & Visibility

Trees are not just valuable as individuals but as populations, patches, connecting corridors and standards within the matrix. An individual tree in a 'sea' of grass, gardens or asphalt is still a habitat. The quality of that habitat will be measured in all the ways discussed in this document. The key values at stake are visibility, leading to legibility (being able to read the history of a place through various aids/devices) and connectivity – across space and through time, between trees and patches and between people and nature.

Meurk & Hall (2006) have provided a well-followed landscape framework of optimum spacings and dimensions of forest patches for NZ cultural landscapes (Figs 2a & b).



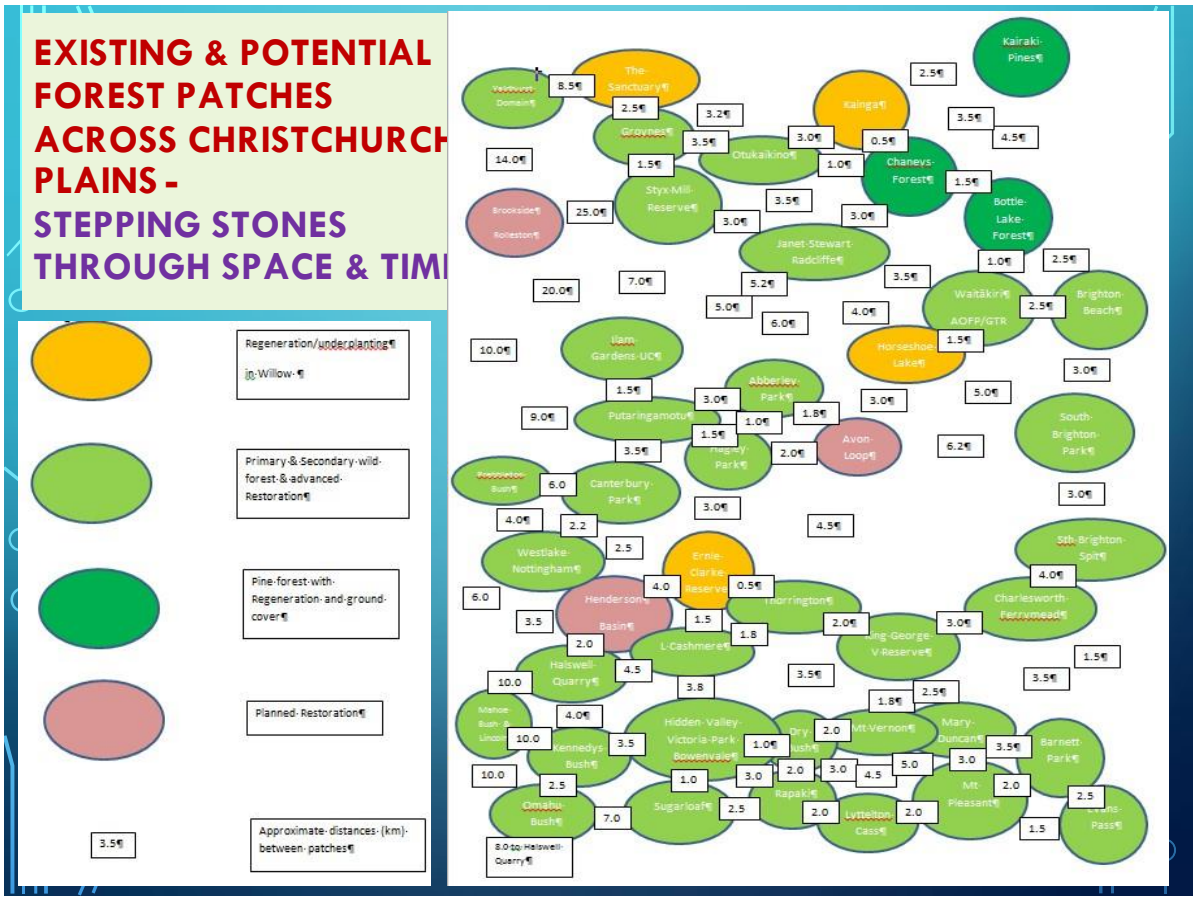


Figure 2a, b: optimised spatial arrangement of forest patches, corridors and consequent ecological integrity and legibility of landscape – in theory (a), and actually/potentially in Christchurch (b) based on existing parks and reserves. **Orange** = Regeneration/Underplanting in willow; **pale green** (primary and secondary wild forest and advanced restoration); **dark green** (pine forest with regeneration and groundcovers); **pink** (planned restoration); **boxed numbers** (approximate distances – km – between patches, demonstrating the potential for landscape connectivity across the city).

It generates both an ecological and a socio-cultural halo critical for landscape integrity and legibility, together with all the measures of well-being (see further section).

8 Place-Making & Identity

Trees being the dominant landscape entities are critical as place-makers and cultural connectors – to tangata whenua. These may also be equated with or act as markers for 'a place to stand' - *Turangawaewae*.

When most cultural landscapes of NZ (somewhat uniquely in the world) are almost devoid of indigenous local flora – certainly in terms of visible physiognomic dominants, then the populace growing up in such an environment inevitably suffer 'extinction of experience' (Louv 2005, Miller

2005). That is, by definition, most people no longer are connected to their flora (trees) because they never see them – 'out of sight, out of mind'. This is one argument for shifting the national park attitude – nature being removed from human experience except for the few who get to visit the mountains or remote islands – back in to urban, peri-urban, and rural environments. This is consistent with the somewhat disruptive notion of National Park Cities - | National Park City Foundation (Fig. 3).

Figure 3: an array of diagnostic indigenous species of Canterbury lowlands suitable for prominent landscape locations in support of a National Park City status.

Note too that Leonard Cockayne (Appendix 2a) advocated early last century that all schools should grow native plants in their yards so every child would grow up with a knowledge of their local trees. Otautahi-Christchurch can claim to be a 10K Kapital … (Fig. 3) – species that identify this place.

In terms of trees the Kowhai, Kanuka, Ti Kouka and Kahikatea, together with pokaka, totara and matai, and the array of small-leaved, divaricating shrubs (mikimiki) can be regarded as characteristic or diagnostic of Canterbury. I use the term 'shrub' here advisedly as most of these can exceed the 3.5 m threshold. These 'K' tree species flower and/or fruit prolifically, variously feeding korimako, kereru, and tui, as well as insects. HoroeKa might be added as a multi-purpose nectar and berry supply for a range of birds. Miki are also significant food sources and habitat for native geckoes. And piwaKawaKa are also characteristic insectivores.

When the 'English Garden City' concept is so embedded in our recent history there is inevitably a well-conditioned appreciation of colour, stature, and order. And these are valid and real values. So, the theme here is not about replacement, but rather integration, complementarity, reconciliation, and rebalancing. There can be no denying that the vivid flowering of kowhai through winter and spring potentially light up the city and are beginning to do so along some lucky streets and riverbanks (Fig 3, 4, 5). The Christmas flowering of kanuka, and houhere/houhi, autumn fragrance of akiraho, and fruiting of ti kouka and kahikatea, lend immense local flavour to a Garden City image,

along with the wildlife they attract. The increased role of kowhai, kanuka, horoeka, along with houhere, totara, matai, manatu, along streets and river dry embankments are highly valuable to wildlife as well as mostly being suitably in-scale with residential urban environments. Whereas there are a vocal minority of residents who dislike cabbage trees (mainly it seems because of their leaves getting caught in lawn mowers), it shouldn't be forgotten that they were regarded as a status symbol in southern England/Ireland, because they were the most palm-like plant that would grow there; indeed, they were referred to as Torquay Palms. Cabbage trees were often retained as frames around early colonial homesteads (e.g. Riccarton House).

Integrated design is important to maximise landscape legibility, wildlife support, and other ecosystem services without interfering with the Garden City image that many are also wedded to. These concepts do not have to be in conflict as often portrayed. Garden Cities (that were founded on ensuring there was adequate green space in cities to make for more healthy citizens and workers) can co-exist with eco-cities and biophilic cities. Such considerations must be brought into future urban planning and co-design that is compatible with the new imperatives the country and world face – to combat ecological and climate emergencies. This is reflected also in the wider cultural landscape where the infrastructure can be made up of a safe and valuable balance of species (Meurk & Swaffield 2000) of mixed origin (Meurk 2011) (Fig. 4).

9 Economics & Costing/Valuing/Monetising

As already stated, absolute monetising of nature, other than for ecosystem goods and services (ES) that materially benefit people (estimated as US$33 trillion/year globally by Constanza et al. 1997) is fraught. This compares with $18 trillion/year for global gross domestic product. But most of the ES is outside the marketplace. Furthermore, this figure does not account for the massive debit from externalities and now the rapid depreciation of the commons. The biodiversity component and differentiation of biodiversity from species richness, is even more problematic. Furthermore, ES, especially in a NZ context, does also cover cultural values as I have discussed (Meurk et al. 2013). But what people are willing to pay, in a market choice exercise, is very much dependent on economic and equity status of the nation. Nonetheless, under current circumstances, studies indicate very high support (91%) for an ecosanctuary experience in Christchurch (Appendix 2d).

The nearest we might get in this regard is the importance of NZ's 'clean green' image for marketing our primary produce and international tourism. We expect that such tourists are becoming more discerning as to the quality and uniqueness of their experience. We know that Asian tourists have been attracted, through targeted promotion, to 'A Little Bit of England', but a Little Bit of England in which the infrastructure is populated by indigenous species will ultimately be far more appealing and marketable, especially when the tourist market begins to uncover the green wash on which the clean green brand is based. The discerning visitor is increasingly looking for unique, 'exotic' (to them) meaningful experiences of local culture, landscape, wildlife, and flora.

There is great doubt about the future of conventional tourism – based on their massive carbon footprint. However, there is a prospect for innovation around the notion of 'slow tourism' based on high-tech sailing ships and focus on the journey as well as the destination, but the destination being of high quality, grounded in the unique natural and cultural heritage of a place. For these and the reasons provided above, the value of indigenous nature needs to be realised and built-up now.

Another measure of value is the number of volunteers and communities engaged in protection and restoration. NZ and CHCH have very high participation rates (see the EcoHub website). And it needs to be said that the planting and growth of indigenous plants is increasing. So much so, that for the past year, demand for native plants from Canterbury plant nurseries has greatly exceeded the supply. This has sadly also fed into the criminal world with stolen plants fetching a worthwhile price on the black market.

It is a truism that ecological restoration leads to social restoration – where people are working together for a common cause and seeing the accelerating benefits becomes a self-reinforcing, bonding exercise. It combines many positive feedback actions – 'gardening' which was one of the most popular recreational pastimes in recent NZ surveys, forming relationships with the whenua, and with tangata. The combining of practice and theory – a learning exercise – and building ecological literacy and seeing the fruits of your labour – much like nurturing a child.

Cost of deciduousness

There is a price to the fast growth of many exotic trees. They require continual maintenance and trimming especially in a benign urban environment. Furthermore, the annual cost of cleaning up autumn leaf-fall of exotic deciduous trees, in streets and gutters, will be significant, in comparison to the continual, but small-volume shedding of leaves by most native trees. The fossil fuel consumption in street sweepers, and blowers must be very high.

There is also a cost of mowing under spaced deciduous trees where grass continues to grow, especially in autumn and spring in our temperate, oceanic conditions. Evergreen canopies largely suppress grass growth – but also spring flowers.

Cost of invasiveness

Most introduced trees are potentially invasive at some level – of both body (ecologically) and mind (psychologically). As stated in the earlier 'disclaimer', imported species, evolved in mammal-driven continental ecosystems, will almost always be superior (in reproduction, growth, productivity, and physical services) to local ecological equivalents evolved in the absence of such pressures. This revelation 'goes against the grain' but is logically unsurprising. This is where the landscape of the mind comes in; we become conditioned to the familiar presence of trees in the landscape. They become normalised especially if their invasiveness is incremental, when suddenly it is too late to control them. The cost of control of existing invasive species is hundreds of millions each year and

even that outlay is failing to bring them under control[1]. With climate change and the lag phase of naturalised to invasive status, this discrepancy is destined to get worse, so the sooner these potentials are 'nipped in the bud' the better. This lag from benign to 'serious weed' easily leads to complacency. Even plants introduced as sterile hybrids or single sex clones (maytens, grey willow, tree of heaven) can eventually find a mate and a new potential.

The Market for Green Suburbs

Finally, it is well-established that green and treed surroundings do feed into property value as a market response – a measure of our traditionally property-owning society. When the developers of Travis Country Estates (who had previously opposed the protection of Travis Wetland) put their properties on the market, they advertised them as 'be beside the acclaimed wetland reserve'.

10 Urban Planning, Design, Mitigation & Management

Innovative design is needed to accommodate the benefits and problems associated with a greater stock and prominence of indigenous trees. This requires planning at landscape down to micro-forest scales. It will inevitably involve complementary mixes of indigenous and 'safe' and otherwise valuable exotic trees – in what are known as benign recombinant ecosystems (Meurk 2011) (Fig. 4).

[1] A recent report indicates that weeds cost NZ taxpayers over NZ$1 billion / year. And even that is not enough to hold the line. The problem is predicted to get worse with climate change, and also due to consequent reduced economic capability in future. Another report indicates the costs specifically to the primary sector: Weeds cost much more than $1.6 billion - News - Farmers Weekly ; and over $100 million for wilding conifer control Wilding conifer control in NZ | Biosecurity | NZ Government (mpi.govt.nz) . The recent 'Space Invaders' report from the Parliamentary Commissioner for the Environment highlighted the critical issue of plant pests and their control in New Zealand Media release – Turning back a silent invasion (pce.parliament.nz) . Many of these invasive species are trees.

Figure 4: Recombinant ecosystems demonstrated in Sydenham Park, with nectar-bearing kowhai coming up alongside dry-fruited deciduous European trees in winter, and nectar provision by an exotic camellia for korimako (bellbird).

The optimised **broad landscape pattern** of patches of different sizes, corridors (Figs 5a, b) and matrix is defined in the earlier Figures 2a, b (Meurk & Hall 2006) and Fig. 6. The size, shape, spacing and quality (full forest species mix) are all critical to the ecological integrity of the landscape and connectivity through steppingstones and to citizens. The species matched to underlying environments are generated from the soon to be released 'Right Plant-Right Place-Right Time' plant selector app., and also currently in the CCC streamside planting guide and Lucas, Meurk & Lynn Ecosystem maps for Christchurch. Smaller protected patches with sensitive species can be successfully accommodated in courtyards and light wells between buildings (Fig. 6).

For more threatened especially ground-dwelling wildlife, provision of habitat on its own is insufficient, and predator-proofed sanctuaries will be required in larger patches to achieve those goals. Street and Riparian corridors, that connect patches, and are linear habitats in their own right, can easily accommodate a wide range of indigenous tree species – as demonstrated in the following graphics (Fig. 5).

Figure 5a: selection of indigenous trees suitable for streets and avenues (also kowhai), according to scale and orientation.

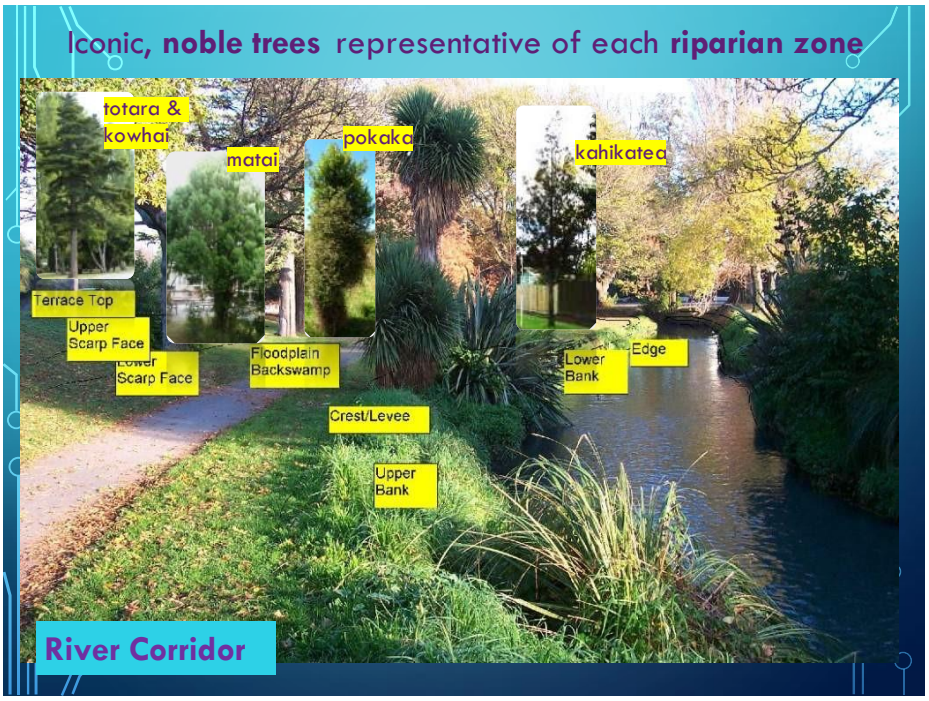


Figure 5b: a selection of indigenous species suitable for riparian corridors.

Trees need to be not only correctly matched to environment but also to human use/need/amenity.

In terms of managing shade of large evergreen native trees, these should be placed on north sides of streets and south sides of properties where they are not shading neighbouring properties. They may also be more widely spaced or interspersed with conventional deciduous trees since winter shading

will only occur for an hour or so while the sun moves across the sky. Some semi-deciduous NZ trees such as kowhai and manatu (NZ ribbonwood) and smaller scale trees like kanuka can be utilised on south sides of streets. Overall, it is recommended that an interim target of 60% of **prominent** street and park trees shall be indigenous by mid-century. This is to ensure that, in addition to wildlife foraging and steppingstones, the visibility of NZ's noble trees, and therefore influence on place-making, is rebalanced and given the profile that satisfies the above arguments, even if this takes time. The existing English tree cover took decades to mature and exert their power over the city. A rebalancing will take a similar time – noting that some exotic trees are already declining.

Biosecurity needs to be activated more strenuously – to eliminate highly invasive trees (such as grey willow and sycamore) immediately and to progressively cull other conventional park trees, that are becoming increasingly weedy (e.g., horse chestnut, birch, holly, yew, maytens), so that by say 2050 they have been replaced by established 'safer' species.

At the **property/park microscale** there is the model of the 2012 Ellerslie Flower Show Exhibit (in Christchurch) of a demonstration pocket park with a forest component occupying just 1/10 of the 100m^2 plot. The concept incorporated all the elements present in an urban residential landscape but populated entirely by indigenous plants (Fig. 6).

Figure 6: An award-winning exhibit of a pocket park with standard urban landscape elements, populated entirely by indigenous species. This includes bushy courtyard sanctuaries (behind the treatment train) – where even in a few square metres one can look out of an office window and be 'forest-bathing'.

There is a well-established English model of neighbourhood park proximity that has features that might be applied here - Access to Public Open Space and Nature by Ward - London Datastore - in order to achieve the outcomes proposed in this report, especially in terms of equitable human

health and well-being derived from human-nature connections. It is implicit that such parks and open spaces incorporate a high degree of tree cover.

Homes further away than the maximum recommended distance are considered to be deficient in access to that type of public open space (POS)[2] – and therefore the anticipated well-being.

In 2015 the recommended maximum distances for each type, are:

R - Regional Parks - 5km max (these may be equated with the large (5 ha) and sanctuary size patches proposed here (Fig. 2a, b)).

M - Metropolitan Parks = 2.4km max (say equivalent to the 1 ha patches)

D - District = 1.2km max (ca 0.5 ha patches)

LSP - Local, Small and Pocket parks = 400 metres max. (in each few streets, including playgrounds, and in some cases individual properties may contain small habitat clusters that fulfil this patch scale).

Replacement policy

As well as financial contributions, it is proposed that a higher degree of compensation would be achieved by a minimal Replacement/Offset policy for loss of any trees. This would be calculated on a 'time for time' and '(natural) taonga for (colonial) treasure' basis. This goes beyond merely replacing a tree with a tree (seedling) of the same species, which has been the conventional 'like-for-like' approach. It is contended that this is no longer fit-for-purpose as it inevitably maintains a colonial dominance in perpetuity. The above proposal is a legitimate endeavour to rectify these past anomalies and go some way to dealing with any unavoidable consequences of urban intensification.

As an example, a 100-year-old tree would have to be replaced by say twenty 5-year old (indigenous, noble) trees in prominent/visible locations, to in some way compensate for the loss of accumulated time.

As proposed above, this would lead, over time, to >60% indigenous (noble) trees in prominent places of the city – streets, parks, and riversides

Maintenance Costing: (Item d) in the proposed plan change) - 'careful maintenance' has often not been the case in the past – with large size transplanted podocarps being left to deteriorate due to

[2] For a definition of public open space types refer to the London Plan 2011, Table 7.2 http://www.london.gov.uk/priorities/planning/londonplan . Note, the distances are actual walking distance (taking into account fences, railway lines, rivers etc.) to reach access points of parks and other, generally managed, sites, usually with some facilities. This measure takes no account of the quality or facilities at each open space, but here one would be proposing that the green space of each park may be greater, but the area of forest habitat or tree clusters would be as stated above.

poor root:shoot ratio and inadequate watering regime. Maintenance needs to be factored into retrieved costs.

In summary, the preceding discourse of this report provides the context, rationale, and mechanisms for achieving compensation for projected losses of natural value from new subdivisions and urban intensification. It also endeavours to be more aspirational than a minimalist approach. The key is to start now, so as to pre-empt the losses as they might occur in the foreseeable future. The City needs to take the opportunities now to build a clearer and stronger narrative of its history, its present and future. The Appendix 4 here is one such previous endeavour to define and describe key stages in the City's journey and the important role that nature and trees play in that story, thereby contributing to their worth as indigenous taonga.

11 Conclusions and Recommendations

The world faces its 6th Great Extinction; NZ is a biodiversity hotspot; Lowland Canterbury has experienced in NZ the greatest fragmentation, degradation and loss of indigenous habitat and its visibility from the cultural landscape. Otautahi-Christchurch has the lowest tree cover (13.5%, 2% less than in 2016) of any NZ city examined in a recent report by Justin Morgenroth. However, it should be noted that the definition of Christchurch in that report does not include the hills of Banks Peninsula (gully bush is a major part of tree cover in other cities), nor does it allow for the significant area of wetlands and stormwater detention basins. CCC- owned public land has 23% canopy cover. Nevertheless, the 11% tree cover, and declining, on private land (70% of total) is disturbing.

With RMA Law change and proposed plan changes there is an opportunity to reset the urban environment to redress imbalances and losses of taoka due to colonial settlement, through enlightened design that reflects natural patterns of landform, soil and hydrology, appropriate reconciliation of indigenous and exotic species, and recognising and designing for the values, benefits, and problems of both in a human environment. 'To reverse the trends [of tree canopy loss] and address the associated adverse effects, the tree canopy cover in the city needs to be maintained and increased. Proposed City Plan Amendments are intended to "reduce the loss of existing trees and/or ensure provision of sufficient replacement trees through on-site planting or the payment of financial contributions in lieu of planting" (CCC – Scope of Works – Consultant Brief).

In the context of the scope of works …

Regarding 'tree canopy cover' currently Option 2 – charging financial contributions - is 'assessed as the most efficient and effective'. However, whereas one can theoretically compensate on a time-for-time basis (Section 10) – any amount of money or number of seedlings will fall short of establishing true equivalence of a large mature tree and its ecosystem function. The replanting option will, only when the replacements have attained the equivalent life of the lost tree, compensate for what has been lost. Always, retention and protection will be the best option.

While retention is preferable and should be encouraged, large trees are likely seldom able to be retained in such circumstances because they will either be in the way of the new buildings, or the construction logistics, or they will cast unacceptable shade on new homes clustered closer together. Provision for courtyard core forest habitat is part of the mix. The thus anticipated losses of trees during intensification of residential environments can be (minimally) compensated for either on-site, by planting sufficient replacement trees to achieve the required canopy cover at maturity (using the proposed formula for time-equivalence), or off-site by the Council planting 'replacement' trees on new open-space land, with both the trees and the land being funded through financial contributions from the developer. Replacement trees should be of the largest practicable size (5 years?) – that will achieve rapid physiognomic prominence. The *quid pro quo* is that a high level of maintenance and watering during first summers will need to be guaranteed.

Evidence has been brought to bear that shows that any reduction in tree cover and biomass is unacceptable because of the multiple benefits or crucial ecosystem services that will be lost – not to mention the urgent need for carbon-sequestration. Indeed, the goal for city tree cover should be more aspirational than the 20% proposed. That figure should be regarded as a medium-term minimum, but a higher target set for the future (expectedly, mainly on public land). I have demonstrated that in fact the 20% goal, justified by being a grassland biome, is not strictly valid (Appendix 1a).

The 'quantifiable scientific evidence' for the generic benefits of tree canopy cover have been identified here and demonstrated by Morgenroth and by CCC for amenity value. For the preferential evaluation of indigenous species (biodiversity), in contrast to species richness of any provenance, only proxy metrics are available. In particular, these include random citizen surveys of preference, choice statistics from university class and post-graduate studies, community volunteer behaviour, shortfall of supply by plant nurseries to meet native plant demand (market signal), black-market pressure, international agreements, and projected more discerning tourist behaviour.

This then provides qualitative evidence for not only maintaining and expanding equivalent generic tree value, but for a positive bias towards indigenous species when negotiating and planning replacement and compensation. This would be manifest ultimately as a greater-than-half indigenous tree frequency, and ultimately cover, and as a dominantly visible component of the City's landscape. Only such proactive policies and actions can achieve the 'improvement' of biodiversity that is sought. Much of the evidence presented here, therefore is written from an indigenous species advocacy perspective, but is based in the same logic as humanitarian and bioethical rationales that are internationally accepted.

Regarding the mitigatory measures – the best option is always to retain valuable species/trees. Biosecurity risks, and their projected future costs, should be removed as soon as possible ('one year's seeding, seven years weeding') and replaced with appropriate indigenous species. These measures will gradually rebuild ecological integrity, landscape legibility, and ultimately ecological

literacy, identity, and protectiveness (or kaitiakitanga by Mana Whenua) for our natural heritage and taoka.

Offsetting, as second-best option, (financial contributions, establishing replacement trees for losses, minimally on a time-for-time basis using largest practicable and well-managed tree stocks) should have regard to optimised landscape models (Meurk & Hall 2006), local environmental conditions (Ecosystem maps and refinements), minimal distances to green space with trees and forests - equitably accessible to all residents, and strong visibility of indigenous noble trees – in the foreground with a goal of greater than 50% dominance. All these measures, together with predator control and establishment of some fenced sanctuaries (of forest and wetlands) will provide safe havens for common, declining and endangered locally extinct wildlife, and a 'halo effect' that feeds out through steppingstones and corridors into the wider matrix.

The do-nothing option cannot be supported for all the reasons given.

In essence, the tree canopy cover targets should be fulfilled in the medium term, raised to a higher level – through time, and a strong indigenous component built in, while true climax wetlands and grasslands are discounted from the expectations and comparative statistics.

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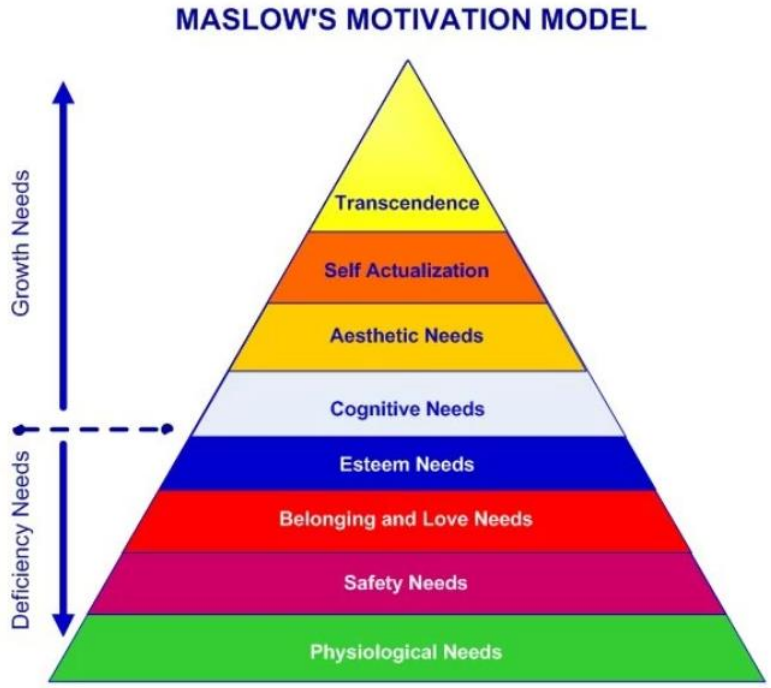

Transcendence – motivated by values which transcend the personal self (e.g., experiences of mysticism, **nature**, aesthetics, service to others, pursuit of science, religious faith, etc). Note a modern view is that there is a pluralistic process whereby multiple needs may be being

addressed at once. Higher levels of actualisation and transcendence can be found regardless of physiological needs having been met.

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Appendix 1a: Preliminary Notes on Urban Tree Evaluation

The following notes address some of the assumptions that defined the scope of works from the Issues & Options Document (CCC).

Interpretation of recent evaluation of declining tree cover

There is justified concern over extent and recent loss of tree cover in the city (Morgenroth 2022) and quality of that cover (the relative proportions of exotic species tree cover and that representing biodiversity[3]). Given that we are in the midst of the 6th great extinction on the planet (and that CCC has declared an ecological emergency) the local loss (and in some cases total extinction) of indigenous species over the past two centuries cannot be further exacerbated.

It should, however, be noted that the calculation did not include Banks Peninsula, a part of the city more comparable with other hilly cities. Second, the 20% that was originally wetland is now partly protected or indeed expanded in the form of Travis Wetland (the largest urban wetland in the country) and through formation of extensive detention ponds and basins especially in the upper Opawaho catchment. These should be regarded as positive rather than detracting from an 'ideal' forest potential cover. Indeed, wetlands are carbon sequesters, provide green space, cause evaporative cooling, contribute their own unique biodiversity, and provided amenity.

Second, much of the loss was from Bottle Lake Forest pine forest and recently near Orana Park. These areas are being replanted. The loss in residential ChCh is however more concerning.

Overall tree canopy for the city should, when compared to other cities, be calculated for the Greater CHCH area – including Banks Peninsula and excluding wetlands and detention basins. It is, nevertheless, accepted that tree cover needs to be increased across the city environment in order to achieve the multiple ecosystem services for planetary and human health.

[3] There is a common misunderstanding about what constitutes 'biodiversity'. As outlined in Ignatieva et al. (2006), there is an important distinction to be made between 'biodiversity' as the local contribution to global species number, and 'species richness', merely the number of species regardless of origin. This is starkly highlighted when contemplating the following thought experiment. Imagine our NZ indigenous flora (of around 2500 species which represent either endemic species or local genetic variants) were replaced entirely by the nearly 30 000 exotic species in the country. Some might argue that this represents a net 27500 increase in NZ's biodiversity. In fact, this is merely the increase in species richness, whereas (global) biodiversity is diminished by 2500, as is global species richness.

Appendix 1b: The Base Line Biome for the City needs to be reconsidered

Biomes are the potential vegetation type determined largely by rainfall (or moisture availability) and temperature – or the Bioclimatic Zone.

Under **'Scope - Primary outcomes b)'** it states that a **"**[proposed] 20% cover [is] based on the level typical of a grassland environment that ChCh represents". This inference is however somewhat incorrect – reinforced by the **Black Maps** which show a large proportion of the city, as first viewed by the English settlers, as grassland, fernland, and flaxland. Whereas the Black Maps depict say 25% of plains ChCh, as wetland/peatland or grass-fern-flaxland, this is not the 'natural climax state of the city area' and is successional, back to what would have been largely forested at some time in the past (The Chalice represents the buried forest). This had been largely eliminated by the time of European settlement due to floods and (Polynesian) fires and subsequently for agricultural and urban development

The actual or potential forest or woodland environment is borne out by the relative proportions of stable coastal dune lands (coastal bush) on Waimairi soils, dry plains savannah woodland/shrubland/grassland mosaic on Selwyn soils (Fig. 7), totara dry forest on Waimakariri soils, totara-matai/lacebark forest on Kaiapoi soils, and kahikatea-pokaka tall floodplain forest on Taitapu soils. Current soil maps reveal at least 70% of the Black Map flax and swamp is potential floodplain forest as at Riccarton Bush. Even fen-peat soils are potentially dominated by manuka, cabbage tree and mikimiki (Fig. 8). Only the approximately 20% that is deep swamp or fen, mapped as Waimairi, Taitapu and Te Kakahi soil, might fall outside a strict forest environment definition.

It is clear that virtually every part of the city is well capable of supporting both exotic and indigenous trees, as we have defined, and collectively in forest formations, or at the least – in open woodland.

Figure 7a, b: open kowhai woodland (a) forming a tree-shrub-grass mosaic on old sandy/stony loam riverbed; and dense canopy kowhai (*Sophora*) with tumatakuru (*Discaria*) and pohuehue (*Muehlenbeckia*) and clematis vines on old river dune (b).

Additional native species would have contributed to a denser woodland than shown here – kanuka (*Kunzea*), mikimiki (*Coprosma*), and ti kouka (*Cordyline*). The city should therefore be classified as a forest biome – and the target forest cover adjusted accordingly. The only exceptions are the stoniest recent riverbed soils (not to do with climate), mobile coastal sand dunes, continually saturated swamps and open water, and peatlands.

Figure 8: manuka and mikimiki on fen peat at Travis Wetland. The bushes are over 3.5 m tall.

The poor survival of silver tussock planted into tree environments in median strips and roundabouts – further demonstrates that most of Recent soils are forest. And the anthropogenic changes to

natural soils – land fill and drainage - have changed much of the original wetlands to a more potential forested status.

So, a 20% tree cover would be in line with a Grassland Biome if this were its natural state, and is nevertheless, a good starting point with a longer-term vision of 25% (for the greater city) in addition to the extensive fresh and saltwater wetlands.

It is however accepted that financial contributions for replacement or enhancement be affordable and practical while meeting the Government's goals of affordable housing and containing urban sprawl.

Appendix 2a: 1925 reported opinion of Leonard Cockayne (regarded as the 'father of NZ ecology') about importance of exposing young minds to their natural heritage.

New Zealand LIFE

A Popular Illustrated Review

Published Monthly by
THE TUI PUBLISHING COMPANY, Box 399, WELLINGTON.

Vol. IV. 15th September, 1925 (New Series) No. 5

NEW ZEALAND LIFE,
"The Magazine with the New Zealand Spirit."
combined with
THE NEW NATION
and
THE N.Z. FOREST MAGAZINE.
EDITED BY MAURICE HURST.
Subscription Price: 6/6 per annum.
Publishers:
The Tui Publishing Company,
Wellington.
All Communications should be addressed:
P.O. Box 399, Wellington.

"The duty of each generation is to gather up its inheritance from the past, and thus to serve the present and prepare better things for the future."

National Horticulture

DR. L. COCKAYNE ON PATRIOTISM AND PLANTS.

Dr. L. Cockayne, the foremost authority on New Zealand plants, recently gave an inspiring address, as President of the New Zealand Institute of Horticulture, on cultivating a love of our own trees, shrubs, and flowers, and of creating "New Zealand gardens."

"What could be better for boys and girls," he asked, "than learning something about the plants of their native land, and making them their friends? The love of trees, the value of forests, the reverence of Nature, and, not the least, the love of country can sink deep into the minds of children from their school gardens of native plants—their very own. Why not present, by degrees, to every school in New Zealand seedlings of certain famous trees, each district council doing its share and sending some tree or shrub of the neighbourhood, e.g., Auckland, the kauri; Wellington, the hard beech (Nothofagus truncata); Christchurch, the climbing groundsel; and Dunedin, the silver-beech (Nothofagus Menziesii)."

Dr. Cockayne then emphasised what he considered an essential function of the institute—the fostering of a national horticulture. "By this is meant, in the first place," continued the president, "the making use of those plants which the varied soils and climates of New Zealand are specially fitted to bring to their fullest development as garden plants. Necessarily, trees, shrubs, herbaceous perennials, alpines, and bulbous or tuberous plants (in the spring not merely daffodils) are the classes indicated. Too frequently a garden contains but little variety, and such as it is merely hardy or half-hardy annuals—showy enough at a certain season, but bare ground for much of the year. The city of New Plymouth, with its huge Indian azaleas and massive tree-ferns, shows to some extent what I mean by a 'national horticulture.' Every city indeed shows something of the kind, but there is too much of a general uniformity. With our many soils and climates diversity, not uniformity, should be the rule. In no case are those plants which are only half-hardy in Great Britain used to nearly the extent they deserve. How few comparatively are to be seen in New Zealand gardens of the host of beautiful Australian shrubs, which would grow famously in most localities. In the second place, the native plants are not used nearly enough.

Our Own Shrubs and Flowers.

"A horticultural visitor from overseas does not want to see beds of geraniums, zinnias, stocks or asters, though he might like to see individual plants of the first-named in their full development. It is for the plants of the country that he looks, and to the gardens which specialise in such would his steps be directed. Of such gardens there are several of high excellence in the south of the South Island, while in nearly all the public gardens of the chief centres New Zealand plants play a prominent part. I think that in this matter the institute should do its utmost to encourage the adornment of railway stations with native trees and shrubs.

"These plants of ours are also capable of great alteration—I will not call it 'improvement'—for garden purposes. When we reflect that all the thousands and thousands of garden plants are either truly wild species in some part or other of the world, or have been made from such, and that so many of our indigenous species cross in nature (208 such crosses have been reported), it becomes clear that a great future awaits New Zealand hybrids. The celebrated crimson manuka (Leptospermum Nicholsii) is a wild hybrid. What nature is doing slowly man can achieve far more rapidly, and he can cross species which never occur side by side in nature."

Appendix 2b: Results of a 2003 Random Citizen Survey on topics related to plant and landscape preferences.

Christchurch City Council Annual Survey of Residents 2003 03-032

Q7a Which statement do respondents agree with most..

		Gender		Age			Community Board					
	Total	Male	Female	18-34 yrs	35-54 yrs	55+ yrs	Shir-ley/ Pap.	Fend./ Wai-mairi	Bur./ Pega-sus	Ricca rton/ Wigram	Hagley Ferry-mead	Sprey/ Heath-cote
Unweighted Base	760	342	418	179	293	288	117	133	112	126	151	121
Weighted Base	760	359	401	257	280	223	109	131	112	135	142	129
Would like to see more native birds in my neighbourhood	547	262	285	168	196	184	83	93	68	95	108	100
	72.0	72.9	71.2	65.3	69.8	82.5	76.0	71.0	60.6	69.9	76.2	77.1
Think number of native birds in neighbourhood is right	167	74	93	66	69	32	20	29	40	30	23	26
	22.0	20.7	23.2	25.8	24.5	14.6	18.0	22.3	35.2	22.0	16.3	20.0
Like to see fewer native birds in my neighbourhood	19	7	12	5	12	2	4	8	1	1	4	0
	2.5	2.1	3.0	2.1	4.3	0.9	3.5	6.3	1.2	1.1	3.1	0.0
DK/no opinion	26	16	11	17	4	4	3	1	3	9	6	4
	3.4	4.3	2.6	6.8	1.5	2.0	2.5	0.4	3.0	7.0	4.4	2.9

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Christchurch City Council Annual Survey of Residents 2003 03-032

Q7b Which statement do respondents agree with most..

		Gender		Age			Community Board					
	Total	Male	Female	18-34 yrs	35-54 yrs	55+ yrs	Shir-ley/ Pap.	Fend./ Wai-mairi	Bur./ Pega-sus	Ricca rton/ Wigram	Hagley Ferry-mead	Sprey/ Heath-cote
Unweighted Base	760	342	418	179	293	288	117	133	112	126	151	121
Weighted Base	760	359	401	257	280	223	109	131	112	135	142	129
Would like to see more native plants in my neighbourhood	442	226	216	173	156	112	72	58	72	77	92	71
	58.1	62.8	53.9	67.4	55.8	50.3	66.3	43.9	63.8	56.7	64.6	55.0
Think my neighbourhood has right amount of native plants	265	113	152	61	108	96	27	65	33	46	44	51
	34.9	31.4	38.0	23.8	38.7	42.9	24.5	49.2	29.3	33.8	30.9	39.6
Like to see fewer native plants in my neighbourhood	22	3	19	3	8	11	6	6	2	5	0	3
	2.9	0.9	4.7	1.2	3.0	4.7	5.7	4.3	2.2	3.5	0.3	2.0
DK/no opinion	31	18	13	19	7	4	4	3	5	8	6	4
	4.1	4.9	3.4	7.5	2.6	2.0	3.5	2.6	4.7	6.0	4.2	3.5

Q8 Which of the following do respondents prefer for Christchurch's existing parks, riversides and street landscaping..

		Gender		Age			Community Board					
	Total	Male	Female	18-34 yrs	35-54 yrs	55+ yrs	Shir-ley/ Pap.	Fend./ Wai-mairi	Bur./ Pega-sus	Ricca rton/ Wigram	Hagley Ferry-mead	Sprey/ Heath-cote
Unweighted Base	760	342	418	179	293	288	117	133	112	126	151	121
Weighted Base	760	359	401	257	280	223	109	131	112	135	142	129
Retain the English garden style plantings	131	56	74	24	45	62	13	29	21	27	17	24
	17.2	15.7	18.5	9.3	16.0	27.7	12.3	21.7	18.3	19.8	12.1	18.6
Introduce few native plants but keep English style	423	192	231	137	158	128	70	74	58	76	78	66
	55.7	53.5	57.6	53.2	56.4	57.7	64.4	56.6	51.9	56.3	55.0	50.9
Replace some of English style planting with native plants	164	84	80	75	65	24	22	23	26	23	38	32
	21.6	23.5	19.9	29.1	23.4	10.8	20.6	17.2	22.9	17.2	26.5	25.1
Replace most of English style planting with native plants	30	17	13	17	8	5	3	6	5	3	8	5
	3.9	4.6	3.3	6.8	2.7	2.1	2.7	4.5	4.2	2.5	5.4	3.9
DK/no opinion	12	10	3	4	4	4	0	0	3	6	2	2
	1.6	2.7	0.7	1.6	1.5	1.8	0.0	0.0	2.7	4.2	1.1	1.6

Q10a Whether they have -
i. "Planted native plants in your garden" in the past year..

		Gender		Age			Community Board					
	Total	Male	Female	18-34 yrs	35-54 yrs	55+ yrs	Shir-ley/ Pap.	Fend./ Wai-mairi	Bur./ Pega-sus	Ricca rton/ Wigram	Hagley Ferry-mead	Sprey/ Heath-cote
Unweighted Base	760	342	418	179	293	288	117	133	112	126	151	121
Weighted Base	760	359	401	257	280	223	109	131	112	135	142	129
Yes	301	141	160	69	138	93	46	36	53	45	59	63
	39.6	39.1	40.0	26.9	49.4	41.9	41.8	27.2	46.8	33.3	41.7	48.4
No	446	212	234	186	137	123	63	93	58	86	81	65
	58.7	58.9	58.5	72.6	48.8	55.0	57.4	70.7	51.9	63.4	57.2	50.2
Don't know	13	7	6	1	5	7	1	3	1	4	1	2
	1.7	2.0	1.4	0.5	1.8	3.0	0.9	2.2	1.3	3.3	1.0	1.5

Appendix 2c: Data and interpretation of surveys and public opinion relating to Little Hagley Park & Botanic Garden Submissions – C D Meurk

8th October, 2004

The indigenous planting along the Avon River bank in Little Hagley Park has been controversial to a segment of local residents – but … the vast majority (86%) of local park walkers wish to see the native riparian planting retained. I would also note that a Maori woman and Cook Island man worked on this site during the late 90s and gained great joy from it and especially from the positive and encouraging remarks they received from passers-by. Sadly this couple died prematurely of breast cancer and kidney failure respectively. Apart from the wide community and local school involvement in this planting over the previous 12 years, the work that this couple carried out should be seen as a legacy. Another local tangata whenua has also taken on a guardian role here.

Personal Submission to CCC on tree policy and Gardens, 2006

We know that $2.25 million of rate-payer's dollars are to be spent on the tree replacement policy over the next decade. We know from the city council's own random survey that over 50% of citizens want a garden city that has a stronger indigenous component. This figure rises to 70-85% when, presumably younger, users of parks are surveyed. Less than 10% of such surveys indicate they want less indigenous plants in the city. These are more objective indicators of public opinion than relying on squeaky wheels. My view might also be regarded as a squeaky wheel if it wasn't for the fact that objective statistics indicate that it is the majority view. [It follows that this expenditure should reflect the will of especially the coming generation… and the desire of older generations for more native bush birds – that to a large degree are dependent on native forest trees. In hindsight, we know there are more indigenous tree planting across the city, but still often relegated to backgrounds or seldom visited parks (e.g. planted conifers along a path edge at Nga Punawai in front of native trees).

Submission on Brief History of Little Hagley Park, C Meurk 2016

- Submissions were made regarding the future of Milbrook Reserve which included reference to the Little Hagley indigenous plantings. These were strongly supported by a submission by Craig Pauling (Taumutu Runanga), and by the survey carried out of users of the pathway which showed 88% wished the native plantings retained. This was disputed by Council staff, who I believe were over-influenced by community squeaky wheels.
- The view of the Urban Landscapes Group, then SOC, and also of the informal CHCH Biodiversity Partnership is that the 2003 CHCH Citizen Survey (the only reliable, scientifically conducted random assessment of citizen attitudes) showed quite clearly that 56% of residents want more native plants in their neighbourhood and 71% want more native birds in their neighbourhood. This was reinforced at the 2012 Ellerslie International Flower Show when the Landcare Research pocket park exhibit (called "Transitions" – Fig. 6), of totally indigenous species, won the Supreme Award for Horticultural Excellence and was within 6 votes of the popular choice (without any promotion or marketing).

Appendix 2d: valuing ecosystem services through choice option experiments - Simon Roper 2017

Valuing Waitākiri Ecosanctuary to inform Christchurch regeneration decisions. This thesis explores the ecosystem services of Waitākiri Ecosanctuary, a proposed predator-fenced area encompassing Travis Wetland and an area of Christchurch's residential red zone. These ecosystem services are then valued using deliberative choice. **Abstract** People are entirely dependent on ecosystems and the services they provide. As ecosystem services are not measured by markets, they can go undervalued compared to market alternatives. This is particularly problematic in policymaking that affects ecosystems. To help experiments, to determine which services members of the public value the most. Results find that **participants value recreation and health services, [wildlife] introductions, research and education opportunities highly**, and are concerned about the impact of local and international tourism on the project. Waitākiri Ecosanctuary presents an opportunity to use Christchurch's residential red zone in a 'green anchor project'. Just as the existing Christchurch anchor projects aim to bring social and economic life to Christchurch, Waitākiri can attract and springboard endangered ecology throughout Christchurch. Enhancing ecosystem service provision in Christchurch is a valuable investment into the wellbeing of those living in and near the city.

Waitakiri Ecosanctuary Report. UC Geography Student Project 3: Executive Summary Context (based on about 400 respondents) (Hughes et al. 2016): The Waitakiri Ecosanctuary is proposed as a 180 hectare area including Travis Wetland and 30 hectares of Christchurch's residential red-zoned land. The sanctuary would house New Zealand's endangered species, and aims to give people in Canterbury the opportunity to interact with these species. It is hoped this will increase connections between people and native New Zealand environments, while conserving these habitats. **Research questions**: What factors of feasibility are important to the Waitakiri Ecosanctuary Proposal? Is there social support for the ecosanctuary proposal in Christchurch? **Methods**: A literature review assessing factors of feasibility was conducted to answer our first research question. To measure social support, a survey and two interviews with prominent locals with interests in the proposal were conducted. The survey was distributed online, through mailing to suburbs near Travis Wetland, and by face-to-face polling in Travis Wetland. **Key results:** Interviews highlighted some potential issues for the project that were discussed in relation to the aims of the proposal. The survey indicates majority social support, with **91% of respondents actively supporting the sanctuary proposal**, and that respondents **value the opportunity to interact with native New Zealand environments**. **Limitations:** Interview discussion could have been continued beyond two interviewees to add scope. **Waitakiri Ecosanctuary Report 4**: The Ilam electorate was over-represented in our sample, but this has been balanced by purposive sampling of suburbs near Travis Wetland. This may pose issues for applicability. **Future research/action suggestions:** To advance social support, it is recommended that further information about the proposal is widely distributed in Christchurch and to relevant tourist agencies. After this information has been distributed, it would be beneficial to re-examine social support to determine the longevity of the support this report identified.

Further Random Note on Citizen Choices: Travis Wetland now (2022) has over 144 000 visits per year, up from ca. 60 000 5 years ago.

Appendix 3a: Ecosystem Services provided by Trees: Introduction to the Valuation of Landscape Plants (From William M. Fountain & Ellen V. Cocker).

Trees provide numerous environmental, economic, and even health benefits to city residents. However, it can be difficult for homeowners to assess the value of individual trees or landscape plantings and to budget for the costs associated with their care. To help shed light on this issue, this three part series, "What is Your Tree Worth?" will introduce key concepts in assessing the value of landscape plants as well as the costs associated with repairing, maintaining, and improving their health.

Your trees are valuable

Trees in urban and suburban environments offer many benefits to citizens and landowners. Although some of these benefits are intangible, like the enjoyment of a cool summer breeze and or the relaxing sound of wildlife in the landscape, all have monetary values that can be calculated. For example:

- **Trees and landscape plantings greatly impact property values.** Good landscape designs can increase property values 4-5%. On the other hand, poorly placed or selected plant material can lower property values by 8-10%. Real estate assessors recognize that a house on a lot with trees or in a neighborhood with mature trees is up to 20% more saleable.
- **Street trees in urban business districts lead to higher retail sales** by changing consumers' shopping patterns. Shoppers are willing to pay more and are more likely to shop longer in tree-lined areas.
- **Attractive, tree-filled landscapes improve human health** in cities. They reduce blood pressure, improve emotional and psychological health, provide sun protection, and reduce exposure to airborne pollutants.
- **Urban trees make for safer cities**. Trees reduce traffic speeds and create safer pedestrian walkways. In addition, communities with an extensive urban forest have lower crime rates.
- **Trees provide many valuable environmental benefits to urban communities.** They can decrease heating and cooling costs in homes and offices, sequester carbon dioxide, mitigate ozone and other pollutants, and even reduce stormwater runoff.

As a homeowner you may recognize these many benefits and work towards maintaining and improving trees and landscape plantings on your property. However, even with the best care, your valuable trees and landscape plants may be damaged through no fault of your own. In these cases, **landscape appraisers** may be called on to assess individual plants and entire landscapes as a result of storms, human damage, destruction, and failure.\

The Value of Urban trees (C D Meurk Notes)

Numerous references in the literature demonstrate unanimous acceptance of the multiple and crucial ecosystem services provided by urban tree cover. Some of these systems monetise the value of trees although mainly for north America and Europe.

A single tree can provide food (berry fruit and/or nectar) for our frugivorous and honey-eating bush birds, a safe roosting site, and in some cases a nesting site. All trees can support insectivorous birds, whereas generally the only 'safe' trees (from a biosecurity perspective) that can provide fruits and nectar are indigenous. It is clusters of trees sufficient to provide a protected core, and/or predator buffering that allows such trees to realise their wildlife hosting potential. Beyond that, birds have varying home/breeding territories that maybe in the order of a hectare. But will be greater for larger birds and all will forage seasonally beyond such a space.

Appendix 3b: Systematic observations by Dr Jon Sullivan (Senior Lecturer in ecology, Lincoln University) (personal communication – June 22, 2022).

"Native forest birds, unsurprisingly, like native forest. That means, for the most part, NZ forest birds don't like most of Christchurch city. Native forest birds like piwakawaka, rironiro, korimako, and kereru are common in the Port Hills forests. Almost all of those birds that are found in the built Christchurch city are living or visiting small patches of native-dominated trees scattered about the city. **I can say that with confidence** because I have been counting these birds along weekly run routes through southwestern Christchurch since March 2008 (alternating between two halves of a 24 km route).

The dependence of native forest birds on native forest has been stark from the beginning of my runs. [note also the study of Williams & Karl 1996 on the preferential eating of native fruits by native birds in Nelson]. For the flat section of my run (off the hills), I have been 31.5 times more likely to see or hear a piwakawaka (fantail) in native forest (like in Ernle Clarke Reserve or the Wigram retention basin) than in suburbia or open suburban parks (like Hoon Hay Park and Gainsborough Park) dominated by exotic trees. That difference is 38.2 times for rironiro (grey warbler) and 11.4 times for korimako (bellbirds). Less than a fifth of my runs are this kind of [native] habitat, and I purposefully designed my routes to go through as many of them as I could.

These patterns make it clear that the presence of native forest birds in the built Christchurch city is strongly limited by the paucity of native forest habitat. If we want more native birds visiting our city, we need more native trees, and especially more patches of native trees. It takes a long time to grow a native tree to be big enough to be useful for native birds, so protecting those trees that we already have is paramount".

Abstracted from: Jon Sullivan (2010): Habitat use & seasonality of native forest birds in SW CHCH. This is a brief report prepared for the Spreydon-Heathcote Community Board as background for decisions on the management of Ernle Clarke Reserve and adjacent land. It describes the importance of Ernle Clarke and similar small-forested reserves for native bird populations in SW Christchurch. Key findings are summarised in the following table, showing strong preference for (native) forest.

Table 2. The number of native forest birds observed to date (1 July 2010) by habitat type. There is a strong preference for the few forest-like habitats. All habitat differences are (highly) statistically significant except for kereru ($P = 0.053$).

Bird species	Number of bird observations		
	Forest-like habitats	Cashmere hills suburbia	Plains suburbia
Fantail	141 (82%)	15 (9%)	15 (9%)
Grey warbler	57 (85%)	5 (7.5%)	5 (7.5%)
Bellbird	61 (42%)	67 (46%)	18 (12%)
Kereru	4* (23.5%)	9 (53%)	4* (23.5%)
Distance (km)	**4.34 (21%)**	**1.34 (7%)**	**14.54 (71%)**

* All 4 plains kereru were along Ashgrove Terrace, two flying about Ashgrove Reserve. All kereru in forest-like habitat were along the Valley Road-Macmillan Ave walkway.

Note – similar results have been published for Dunedin in: **van Heezik, Y., Smyth, A., and Mathieu, R. 2008**. Diversity of native and exotic birds across an urban gradient in a New Zealand city. Landscape and Urban Planning, 87:223–232.

Appendix 3c: indicative data on presence of birds in relation to residential properties on hill and plains – on a per area and per tree basis.

Hill Property: 2000m^2, > 35 trees, 25% tree cover, 75% evergreen, 33% indigenous, 500m^2 tree cover (x2 for 0.1ha tree area)

	Species	typical count / per tree / per 0.1 ha trees		
Birds:	silver eye	12	0.34	24
	Piwakawaka/fantail	4	0.11	8
	Korimako/bellbird	2	0.06	4
	Riroriro/grey warbler	1	0.03	2
	Kereru/wood pigeon	1	0.03	2
	Kotare/kingfisher	0.5	0.02	1
	+ blackbird, song thrush, house sparrow, chaffinch, goldfinch, starling, dunnock, greenfinch			

Plains Property: 900m^2, 69 trees, 40% tree cover, 85% evergreen, 75% indigenous, 360 m^2 tree cover (x 2.8 for 0.1 ha trees)

	Species	typical count / per tree / per 0.1 ha trees		
Birds:	silver eye	6	0.09	17
	Piwakawaka/fantail	2	0.03	6
	Korimako/bellbird	2	0.03	6
	Riroriro/grey warbler	0.1	0.002	0.3
	Kereru/wood pigeon	0.1	0.002	0.3
	+ blackbird, song thrush, house sparrow, chaffinch, goldfinch, starling, dunnock			

Source; Rod Hay (pers. comm. 2022), and the author (CD Meurk).

Appendix 4: An essay on the natural history of Otautahi-Christchurch

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Otautahi-Christchurch City is young, but the Place has a long, convoluted history since emerging from post-glacial ocean 6000 years ago. The urban forest we now behold is an evolving, living cloak, waxing, waning and ever unfolding, revealing many layers.
Before the first peoples stepped ashore from their waka, there was forest across the Plains and over much of what is now the City. This is captured in the Cathedral Square Chalice sculpture – fretted silhouettes of foliage and flowers of the buried forest lying beneath the earthquake-munted Cathedral. These ancient forests were engulfed in silt, sand, and stones, carried by a raging Waimakariri River. Then later, a thousand years ago, human-induced fires visited the woods and shrublands across the wider Plains, and finally the British settler farms arrested nature's slow recovery back to a dry forested landscape it wanted to be.

The celebrated Black Maps (1856) of the first English surveyors pretty much agree with modern soil maps on the location and relative proportions of original wetlands (about a third of the modern city) and drylands. Fundamentally there were fens on organic peats that supported sedge reeds and tussocks, mikimiki and manuka. There were swamps of raupo, tall tussock sedges, fern, harakeke, and ti kouka on gleyed soils (grey, steely colour of de-oxygenated iron compounds of continuously water-logged silt). In the fullness of time these flax and fern-lands on river/stream floodplains were succeeded by manuka, ti kouka, karamu and kahikatea-pokaka forest. When the Brits rolled in from the late 1840s there were only two remnants of forest that had survived flood and fire. These were 600-year old 'islands' or motu of kahikatea, matai and totara at Putaringamotu and the similar 'big bush' at Papanui. These two forests are or were on *Taitapu* gleyed soils typical of floodplains, with totara and matai more prevalent on the drier fringe with more oxidised *Kaiapoi* soils of a rusty iron hue. The latter two podocarps (Gondwana conifers) were prime, durable timber for the early building and fencing of Christchurch, and all the millable trees of these were gone in short order. It is nevertheless a modern-day miracle that Riccarton Bush was preserved by the Deans family, because the land was still prime for farming, and in fact kahikatea (or white pine as it was known because of the lack of goldy resin in the wood) proved perfect for making butter boxes – that wouldn't taint the butter. One imagines that the wet to dry soil sequence – *Taitapu* gley, *Kaiapoi* mottled, and *Waimakariri* dry soils naturally and potentially supported forests dominated respectively by kahikatea/pokaka; matai-totara/hinau-houhere-tarata; and totara/houhere-kowhai-kanuka. These podocarps, unlike northern needle conifers, have berries upon which our bush birds are dependent.

From the beginning Europe's so-called noble trees – oaks, elms, ash, linden, beech, sycamore, plane trees, horse chestnut, and cedars, and swamp cypresses and redwoods from N America, were being planted for nostalgia and their known value as fast-growing timber or amenity. American pines, Australian gums and European willows were also being planted for a rapid transformation of what, to the new settlers, appeared a somewhat desolate, swampy early Christchurch scene.

We look at the well-wooded city today and don't remember it was ever different. But from a classic tree growth curve, we can imagine the now mature northern deciduous trees might have been 10 m tall by end of 19th C, 25 m by middle of 20th C and up to 35 m now, tailing off and beginning to fall apart – having lived too fast in this oceanic climate. During this time, tree cover has increased from <1% to 7-29% today, depending on suburb or inclusion of plantations (Morgenroth 2019, 2022). The average is 12% when plantations are excluded, whereas parks and

reserves are 29% tree covered. Adoption of the 'Garden City' brand led to the populating of parks and residences with globally fashionable trees and shrubs – camellia, rhododendron, plums*, maples, holly*, fatsia*, hawthorn*, barberry*, yew*, laurels*, birch*, robinia*, wattles, alder*, privet*, ash* - some of which (*) have become invasive, along with grey willow, tree of heaven, rowan, elderberry, blackberry, maytens, and exotic vines. Adding to the recombinant mix there were always a few indigenous trees actively planted – fast-growing or distinctive ti kouka (fancied as an 'exotic palm'), lancewoods, pittosporums, akiraho, and rimu from the West Coast. This inclination has expanded due to the post-war rise in environmental awareness, local identity, and native plant nurseries. The proportion of indigenous trees has at the same time been spontaneously increasing through natural regeneration – first the common ti kouka, karamu, kohuhu, tarata, pohuehue, poroporo, broadleaf, akeake, five-finger, and horoeka; and introduced from the North and proliferating, or forming hybrid swarms with local varieties - taupata, karo, houpara, houhere, and kowhai. Because of more relaxed management, locally rare seedlings of mahoe, kaikomako, titoki, a lone tawa from a century-old, planted tree (south of its natural limit in Kaikoura), and wheki (a single observation on riverbank opposite historic plantings in Millbrook Reserve), are now also emerging. Not being a rain forest, Otautahi has always been marginal for frost- and drought-tender species apart from in very localised niches where there is continual moisture, yet not wet feet. Tree ferns, filmy ferns, epiphytes, makomako and kotukutuku fall into this category. A case at Lincoln illustrates this. In one particular season the perfect 'goldilocks conditions' prevailed – there were blackbird-dispersed konini fruits, from a planted parent tree, and germination along the sheltered, south wall of a building in an existing woodland. The seedlings capitalised on a cooler, rainier summer than usual, and became established as saplings. This happened only once, but tanekaha and mountain beech have also occasionally regenerated out of their range at this site.

Titoki at its natural southern limit on Banks Peninsula has appeared in my garden under magnolia and gum trees – suppressed but slowly will take over from the exotic perches (Fig. 9). In the past three decades, a loan titoki in Putaringamotu has spawned saplings spread throughout the bush. It is tempting to suggest this has something to do with climate change. Doody et al. (2009) found Riccarton Bush species (kahikatea, makomako, karamu, putaputaweta, ti kouka, *Coprosma rotundifolia*, rohutu, mahoe) up to 1.4km away from source in residential gardens but through being unrecognised or inconveniently located are usually eliminated. Ernle Clarke Reserve, a 100-year-old English woodland, has small groves of kahikatea and other native trees. Frequent kahikatea seedlings occur close to parents, but also up to 200m from source. Mahoe, a still rare species across Christchurch, is densely establishing in the understorey since the style of 'gardening' of the formerly privately owned woodland has changed – from 'scorched earth' to selective weeding.

Rain forest rimu and native beech do not belong in the local dry climate but there are more rimu in Christchurch than local podocarps, and similarly beech because perhaps they mimic the European noble trees. One imagines that whenever city residents go on holiday across the mountains to the rainforests of the west coast and see the beautiful young seedlings of rimu – and sensing some need for ongoing native bush bathing - dutifully bring them back to plant in their gardens. Sadly though, they never fruit in eastern Canterbury let alone give birth to any little rimu progeny. Several other forest types do however naturally occur in greater, peri-urban Christchurch – Montane cedar, beech, and mountain totara; dry totara-matai-kanuka woodland; riparian and coastal ngaio-akeake bush. The predominantly deciduous parklands, street trees, orchards, gardens, and pine plantations make up the total gamut of urban forest. Kanuka was the prevalent plains tree cover in the 1850s, seeds prolifically, is wind-dispersed and, while it grows as a suppressed turf in a mid-Canterbury asphalt country road, near a remnant stand, inexplicably it is hardly ever seen regenerating in suitable urban habitats like paths and wall cracks.

Community restoration, of habitat and people, has been adding critical mass and mother nodes of hitherto uncommon source plants (especially the long-lost native noble trees) across the city since the sesquicentennial year of 1990. Prior to this, Arbour Day plantings up in Victoria Park became a post-war thing, led by Forest and Bird. The CCC waterway enhancement programme was also an important boost from the mid-1990s. These efforts, along with Te Ara Kakariki in Selwyn District, have been steadily advancing an optimised forest patch model across the near-city landscape (Meurk & Hall 2006), connected by corridors of naturalised streams and roadsides. And a more naturally receptive urban matrix is being enriched with local forest species, planted and spontaneous, provided they escape the over-zealous gardener. I have described the rampant regeneration of the common forest elements, but a transformational point has been reached in the past 5 years as less common noble trees have matured to not only fruit but procreate young seedlings more widely across the residential matrix as hoped for. We now know how long it takes in the challenging background environment of Christchurch for full forest rebirth to be kindled – kahikatea 15-20 years to fruit and 18-29 years to seedlings; matai 20 years to fruit; yet to produce seedlings; and totara 15-27 years fruiting, and 18-29-33 years to seedlings. Pokaka and hinau fruited after 15-17-25 years (Fig. 10), but no seedlings had been seen outside of Riccarton Bush - until last year (pokaka). This regenerative forest life force or mauri of the city is arcing back to some distinctively primeval, Otautahi-Aotearoa character. It is increasingly embraced and promoted by the community and mana whenua, will support iconic wildlife – especially when adding value through predator-proofed sanctuaries, and perhaps with northern elements is resilient to climate change. Kia kaha, born-again Otautahi forest!

Figure 9: self-sown titoki seedling under Magnolia tree in south Christchurch suburb with nearest mother tree over 100 m but likely source much further. About 10 seedlings have appeared in this woodland garden over 5 years – here expanding at its southern natural limit.

Figure 10: Pokaka fruiting in March 2017, on 10 m tree planted 27 years ago at Aynsley Tce.

ADDENDUM

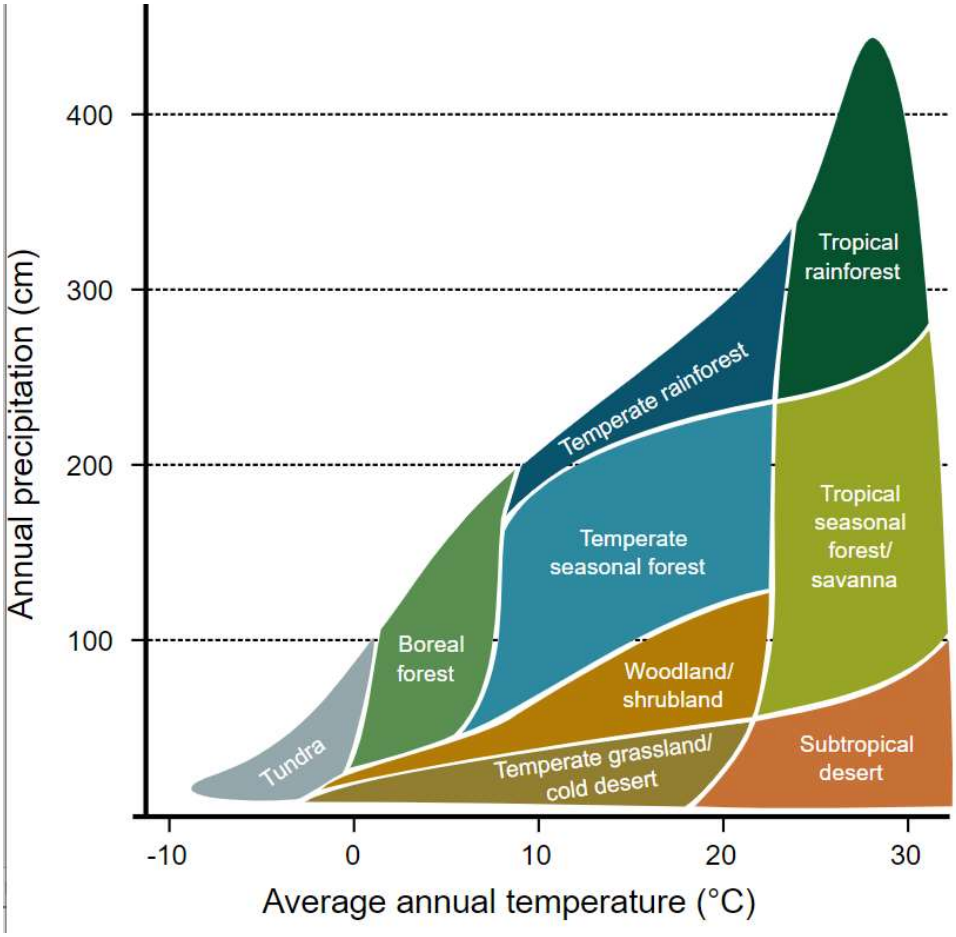
Dear Anita 24th August, 2022

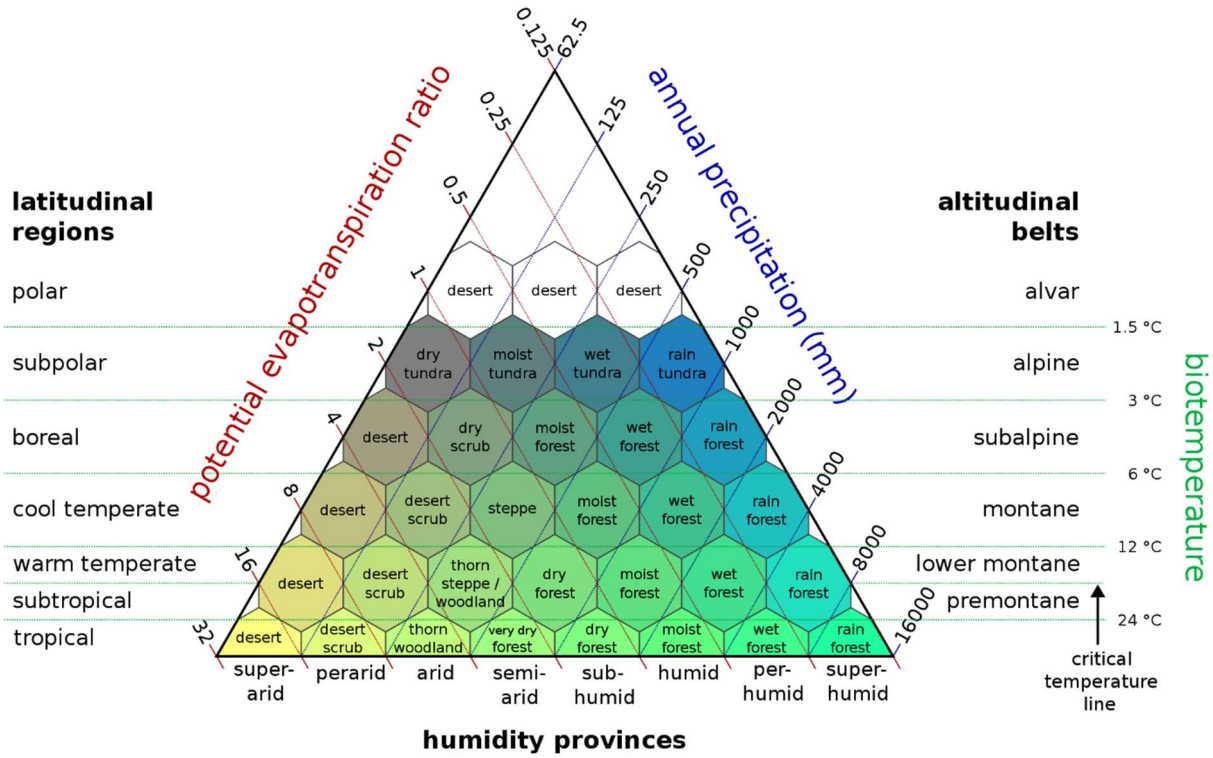
(…)

As I indicated in my recent report on biodiversity values of trees and associated correspondence, I was concerned that the base line for tree cover in Christchurch was misrepresented as 'Grassland'. This, as subsequently discussed with Professor Justin Morgenroth, may have been a misunderstanding of references to contemporary land cover – which for the Canterbury Plains certainly is a predominantly grassland ecosystem. This may be reinforced by the predominance of non-tree vegetation depicted in the surveyor's Black Maps of the 1860s or thereabouts. However, the interpretation of this to mean that Christchurch is a 'Grassland Biome' is incorrect.

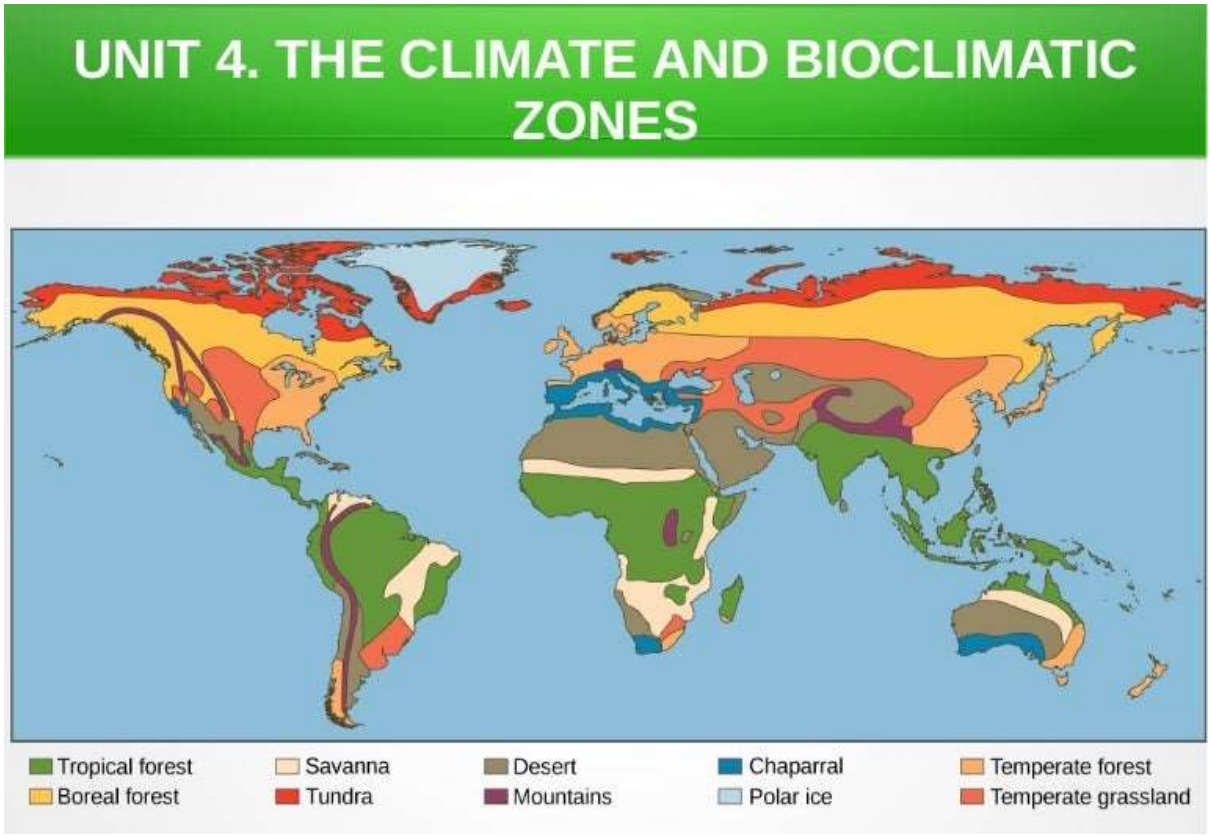
Firstly, the concept of 'Biome' is primarily about the vegetative/ecosystem potential of broad climatic zones of the Earth. This climatic regime is prescribed by precipitation, temperature, and evapotranspiration. Habitats and ecosystems are different concepts within that and vary according to underlying soil conditions, drainage, water-table, exposure, and importantly recent natural and human-induced disturbance history (fire, grazing, cutting, mowing, flooding, land movement, etc.) and the successional stage that has subsequently been achieved.

The following graphs demonstrate the application of those climatic parameters to standard Biome Names.





The above bioclimatic zones derive from Holdridge's long established Life Zone model (Holdridge life zones - Wikipedia). Note the Bio-temperature is adjusted to reduce extremes that fall outside active growth conditions (<0C & >30C). So Bio-temperature will in NZ be slightly lower than the mean annual temperature which for any given rainfall, moves it further towards forest status.



The climate and bioclimte zones (slideshare.net) .

Based on these classic Biome classification diagrams, the Christchurch/Canterbury Plains with annual precipitation of 700-800 mm and mean annual temperature of 11.5C would be classed as Woodland/Shrubland or Cool Temperate Dry to Moist Forest.

The confusion arises when one views a snapshot in time that has been subject to large disturbance. The taiga and deciduous woodland biomes of Eurasia and Europe are examples where centuries of grazing and cropping present a contemporary grassy landscape. In the case of Christchurch – major flood events from the Waimakariri River over thousands of years periodically buried pre-existing woodland and podocarp forest (cf The Chalice in Cathedral Square); and Polynesian fire over the past millennium further reduced woody vegetation, but it was always endeavouring to recover, and now intensive pastoral farming and urban development has consolidated that transformation.

The Black Maps show large areas of Christchurch as 'flax, fern, grass, swamp, raupo', etc. and only 2 moderate size patches of tall podocarp forest – Putarikamotu and Papanui. However, it can be inferred that most of the flax, fern and grass was successional to forest as it occurs mainly on Taitapu, Kaiapoi, Waimakariri or Waikuku soils.

The only soils that would be permanently/potentially climax wetland and 'grassland' would be the Aranui (Travis), Motukarara (saline), Selwyn (recent raw riverbed) and mobile foredunes. Together these make up no more than 20% of the total area of current Christchurch Plains (s-maps). The larger blocks of land would be Taitapu soils – (potentially) kahikatea forest as under Putarikamotu; Kaiapoi soils – matai-totara forest (as was on edge of the remnant forests); Waimakariri (cf older Lismore) soils – totara-kowhai-kanuka-ti kouka woodland/shrubland; and inland/back dunes (coastal bush of ngaio, akeake, akiraho). Even much of the fen peatlands would have been dominated by manuka and mikimiki (as at Travis today). Another line of evidence is the late Brian Molloy's chapters in the Natural History of Canterbury (1969) which have profile diagrams of the natural and induced woody vegetation of the Plains. The information was derived from subfossil wood remains.

It is important that, notwithstanding the pragmatics of setting realistic tree cover targets in the context of a built environment, Council should be clear that it is not arguing for this on the basis of incorrect inferences. Ideally the goals might be somewhat more aspirational and evidence-based rather than being limited by a 'Grassland' definition. How this translates into an actual realistic target figure for a city is of course another matter. We know that say 80% forest cover (the potential maximum) is not achievable. The important thing is that the decision is informed by the appropriate evidence and knowledge - which we are happy to discuss further.

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