Christchurch City Council	Resource Management Act 1991 Christchurch District Plan Plan Change 14 – Tree Canopy Cover and Financial Contributions Section 32 Evaluation	14

TREE CANOPY COVER / FINANCIAL CONTRIBUTIONS TO ADDRESS THE EFFECTS OF DEVELOPMENT IN RESIDENTAL AREAS ON THE ENVIRONMENT

Overview

The following report has been prepared to support the Financial Contributions section of Plan Change 14 to the Christchurch District Plan, which proposes to introduce tree canopy cover / financial contributions provisions to address adverse effects of residential development and intensification on the city's environment.

The Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021 (Amendment Act) and National Policy Statement – Urban Development 2020 (NPS-UD) require the Council to change the District Plan to enable housing intensification. Intensification will lead to:

i. Increased carbon emissions;
ii. Increased stormwater run-off;
iii. Increased heat island effects;
iv. Loss of biodiversity and amenity.

As part of the package of amendments to the RMA, the Amendment Act introduced additional provisions enabling councils to make rules requiring a financial contribution for permitted and other classes of activities. The Council proposes to introduce new provisions that are intended to require that developers carrying out subdivision that provides for or enables new dwellings, either:

- Retain or provide an appropriate level of tree canopy cover for each allotment, with the tree canopy cover to be secured through a consent notice; or
- Provide an equivalent financial contribution so that the necessary tree canopy cover can be provided elsewhere.

Retaining Christchurch City's existing tree canopy cover, and providing for an increased tree canopy cover, will improve the ecosystem/ regulating services that trees provide and help to mitigate the adverse effects of development.

Christchurch City's canopy cover is comparatively low and decreasing. The recently undertaken survey of the tree canopy in Christchurch, using aerial imagery of the city from 2018/2019, indicates that the city tree canopy covers 13.5% of land in Christchurch, which is a 2% decrease since the last 2015/2016 survey. The report also looked at canopy cover by land ownership and found that Christchurch City Council owned land had 23% tree canopy cover, Crown land had 16% canopy cover and private land had 11% canopy cover. Privately owned properties constitute 70% of all land ownership in Christchurch and that land has 57% of the city's canopy cover on it. Consequently, changes in the number of trees on private land would greatly affect the overall tree canopy cover in Christchurch.

Although some of the 2% decrease in the tree canopy cover is a result of harvesting in the Bottle Lake Forest plantation and the recent Port Hills fires, much of the tree canopy loss is attributed to property

redevelopment and intensification. With the enabling provisions of the Medium Density Residential Standards and the likely increase in residential intensification, that canopy cover is under threat of further losses.

For full details of the proposed changes refer to the Plan Change document.

LIST OF ABBREVIATIONS USED IN THIS REPORT

Amendment Act	Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021
CRPS	Canterbury Regional Policy Statement
DC	Development contribution
FC	Financial contribution
IMP	Maahanui Iwi Management Plan
MDRS	Medium Density Residential Standards
NPS	National Planning Standards
NPS-UD	National Policy Statement - Urban Development 2020
PC14 - FC	See 'the plan change'
RMA	Resource Management Act 1991
the Act	See 'RMA'
the Amendment Act	Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021
the Council	Christchurch City Council
the Plan / District Plan	Christchurch District Plan
the plan change/ Plan Change 14/ PC14;	Proposed Plan Change 14 – Housing and Business Choice, including the Tree Canopy Cover / Financial Contributions section of Proposed Plan Change 14

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1 Introduction

1.1 Purpose of this report

1.1.1 The overarching purpose of section 32 (s32) of the Resource Management Act 1991 (RMA / Act) is to ensure that plans are developed using sound evidence and rigorous policy analysis, leading to more robust and enduring provisions.

1.1.2 Section 32 requires that the Council provides an evaluation of the changes introducing tree canopy cover and financial contributions requirements, proposed in the financial contributions section of Plan Change 14 (PC14 – FC) to the Christchurch District Plan (the Plan). The evaluation must examine whether the proposed objectives are the most appropriate way to achieve the purpose of the RMA, and whether the proposed provisions are the most appropriate way to achieve the proposed and existing objectives of the Plan. The report must consider reasonably practicable options, and assess the efficiency and effectiveness of the provisions in achieving the objectives. This will involve identifying and assessing the benefits and costs of the environmental, economic, social and cultural effects anticipated from implementing the provisions. The report must also assess the risk of acting or not acting if there is uncertain or insufficient information about the subject matter of the provisions.

1.1.3 The purpose of this report is to fulfil the s32 requirements for the proposed Tree Canopy Cover / Financial Contributions section of Plan Change 14 – Housing and Business Choice. In addition, the report examines any relevant directions from the statutory context including higher order documents.

2 Resource management issues

2.1 Council's legal obligations and strategic planning documents

2.1.1 Sections 74 and 75 of the RMA set out Council's obligations when preparing a change to its District Plan. The Council has a responsibility under Section 31 of the RMA to establish, implement and review objectives and provisions for, among other things, achieving integrated management of the effects of the use, development, or protection of land and associated resources. One of the Council's functions is to control the actual and potential effects of land use or development on the environment, and to do so in accordance with the provisions of Part 2.

2.1.2 Part 2, section 5 outlines the purpose of the Act which is "to promote the sustainable management of natural and physical resources" which means:

> "*managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*
>
> *(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*

(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment."

2.1.3 Section 7 requires that particular regard shall be had to:

"(c) the maintenance and enhancement of amenity values:

(d) intrinsic values of ecosystems:

(f) maintenance and enhancement of the quality of the environment:

(i) the effects of climate change:"

2.1.4 These matters are of relevance to consideration of the proposed tree canopy cover and financial contribution provisions in relation to:

a. the effects of intensification on the environment,

b. the ecosystem values of trees and the role they play in addressing the effects associated with climate change,

c. the quality of urban environment, including its biodiversity and amenity, and

d. the effect changes in that environment may have on the health and wellbeing of residents.

2.1.5 As required by s74 and s75 of the RMA, a Plan Change must specifically give effect to, not be inconsistent with, take into account, or have regard to the following "higher order" documents / provisions which provide directions for the issues relevant to this plan change:

Document	Relevant provisions	Relevant direction given effect to/ taken account of in Strategic Directions objectives, Chapter objectives / the objectives proposed by this Plan Change
National Policy Statement on Urban Development 2020 (NPS-UD)	Objective 1:	New Zealand has well-functioning urban environments that enable all people and communities to provide for their social, economic, and cultural wellbeing, and for their health and safety, now and into the future.
	Objective 7:	Local authorities have robust and frequently updated information about their urban environments and use it to inform planning decisions.
	Objective 8:	New Zealand's urban environments: a. support reductions in greenhouse gas emissions; and b. are resilient to the current and future effects of climate change.
	Policy 1:	Planning decisions contribute to well-functioning urban environments, which are urban environments that, as a minimum: (...) e. support reductions in greenhouse gas emissions; and f. are resilient to the likely current and future effects of climate change.
	Policy 6:	When making planning decisions that affect urban environments, decision-makers have particular regard to the following matters: (...)

Document	Relevant provisions	Relevant direction given effect to/ taken account of in Strategic Directions objectives, Chapter objectives / the objectives proposed by this Plan Change
		e. the likely current and future effects of climate change.
Canterbury Regional Policy Statement (CRPS)	Chapter 5 - Land-use and infrastructure Objective 5.2.1 Location, design and function of development (Entire Region)	Development is located and designed so that it functions in a way that: 1. (...) 2. enables people and communities, including future generations, to provide for their social, economic and cultural well-being and health and safety; and which: a. maintains, and where appropriate, enhances the overall quality of the natural environment of the Canterbury region, including its coastal environment, outstanding natural features and landscapes, and natural values; b. (...)
	Chapter 6 – Recovery and Rebuilding of Greater Christchurch Objective 6.2.1 Recovery framework	Recovery, rebuilding and development are enabled within Greater Christchurch through a land use and infrastructure framework that: 1. (...) 5. protects and enhances indigenous biodiversity and public space; 6. maintains or improves the quantity and quality of water in groundwater aquifers and surface waterbodies, and quality of ambient air; (...)
	Objective 6.2.3 - Sustainability	Recovery and rebuilding is undertaken in Greater Christchurch that: 1. provides for quality living environments incorporating good urban design; (...) 5. is healthy, environmentally sustainable, functionally efficient, and prosperous.
	Policy 6.3.2: Development form and urban design	Business development, residential development (...) is to give effect to the principles of good urban design below, (...): 1. Tūrangawaewae – the sense of place and belonging – recognition and incorporation of the identity of the place, the context and the core elements that comprise the place. Through context and site analysis, the following elements should be used to reflect the appropriateness of the development to its location: landmarks and features, historic heritage, the character and quality of the existing built and natural environment, historic and cultural markers and local stories. (...)

Document	Relevant provisions	Relevant direction given effect to/ taken account of in Strategic Directions objectives, Chapter objectives / the objectives proposed by this Plan Change
		6. Environmentally sustainable design – ensuring that the process of design and development minimises water and resource use, restores ecosystems, safeguards mauri and maximises passive solar gain.
	Chapter 9 Ecosystems and Indigenous Biodiversity Objective 9.2.1: Halting the decline of Canterbury's ecosystems and indigenous biodiversity	The decline in the quality and quantity of Canterbury's ecosystems and indigenous biodiversity is halted and their life-supporting capacity and mauri safeguarded.
	Policy 9.3.3: Integrated management approach	To adopt an integrated and co-ordinated management approach to halting the decline in Canterbury's indigenous biodiversity through: 1. working across catchments and across the land/sea boundary where connectivity is an issue for sustaining habitats and ecosystem functioning 2. promoting collaboration between individuals and agencies with biodiversity responsibilities 3. supporting the various statutory and non-statutory approaches adopted to improve biodiversity protection (...)
	Policy 9.3.4: Promote ecological enhancement and restoration	To promote the enhancement and restoration of Canterbury's ecosystems and indigenous biodiversity, in appropriate locations, where this will improve the functioning and long term sustainability of these ecosystems.
Mahaanui Iwi Management Plan (IMP)	5.4 PAPATŪĀNUKU Ngā Paetae Objectives	(5) Inappropriate land use practices that have a significant and unacceptable effect on water quality and quantity are discontinued. (7) Subdivision and development activities implement low impact, innovative and sustainable solutions to water, stormwater, waste and energy issues
	Subdivision and Development Guidelines	7.3 Indigenous biodiversity objectives to include provisions to use indigenous species for: (i) street trees; (ii) open space and reserves; (iii) native ground cover species for swales; (iv) stormwater management network; and (v) home gardens.

Document	Relevant provisions	Relevant direction given effect to/ taken account of in Strategic Directions objectives, Chapter objectives / the objectives proposed by this Plan Change
	Stormwater Ngā Kaupapa / Policy P6.1	To require on-site solutions to stormwater management in all new urban, commercial, industrial and rural developments (zero stormwater discharge off site) based on a multi-tiered approach to stormwater management: (...) (d) Discharge to land based methods, including swales, stormwater basins, retention basins, and constructed wetponds and wetlands (environmental infrastructure), using appropriate native plant species, recognising the ability of particular species to absorb water and filter waste.
	5.5 Tāne Mahuta This section addresses issues of significance pertaining to indigenous biodiversity and mahinga kai; the flora and fauna that make up the domain of Tāne.	Ngā Paetae Objectives (1) Regional policy, planning and decision making in the takiwā reflects the particular interest of Ngāi Tahu in indigenous biodiversity protection, and the importance of mahinga kai to Ngāi Tahu culture and traditions. (2) The customary right of Ngāi Tahu to engage in mahinga kai activity is recognised, protected and enhanced, as guaranteed by Article 2 of Te Tiriti o Waitangi, and the NTCSA 1998. (3) The presence of indigenous biodiversity on the Canterbury landscape is enhanced, both in rural and urban environments. (4) The taonga value of indigenous ecosystems as natural capital and provider of essential ecosystem services is increasingly valued in the community.
	Mahinga kai Policy TM1.4	To promote the principle of Ki Uta Ki Tai as a culturally appropriate approach to mahinga kai enhancement, restoration and management, in particular: (a) Management of whole ecosystems and landscapes, in addition to single species; and (b) The establishment, protection and enhancement of biodiversity corridors to connect species and habitats
	Indigenous biodiversity Policy TM2.1	To require that local authorities and central government actively recognise and provide for the relationship of Ngāi Tahu with indigenous biodiversity and ecosystems, and interests in biodiversity protection, management and restoration, including but not limited to: (a) Importance of indigenous biodiversity to tāngata whenua, particularly with regard to mahinga kai, taonga species, customary use and valuable ecosystem services;
	Policy TM2.8	To require the integration of robust biodiversity objectives in urban, rural land use and planning, including but not limited to: (a) Indigenous species in shelter belts on farms;

Document	Relevant provisions	Relevant direction given effect to/ taken account of in Strategic Directions objectives, Chapter objectives / the objectives proposed by this Plan Change
		(b) Use of indigenous plantings as buffers around activities such as silage pits, effluent ponds, oxidation ponds, and industrial sites; (c) Use of indigenous species as street trees in residential developments, and in parks and reserves and other open space; and (d) Establishment of planted indigenous riparian margins along waterways.
Tree Policy (CCC)	Policy 1.1	We will actively seek and create new tree planting opportunities in suitable locations to maximise canopy cover and deliver ongoing environmental, economic and social benefits.
	Policy 1.5	For trees planted in the road reserve, the species selected must have sufficient space to grow into mature and healthy specimens without causing significant damage to existing infrastructure (provided no reasonably practical engineering solutions are available). Trees will be planted under power lines only where the species selected is able to grow to maturity without requiring line clearance pruning that results in poor tree form or structure.
	Policy 1.8	The cost of planting and establishing street and park trees within new subdivisions will be covered by the developer for at least 24 months.
Biodiversity Strategy 2008-2035	05 Goals and Objectives	Goal 1, Objective: Ecosystems, sites and habitats supporting biodiversity are protected and restored. Goal 3, Objective: Community and private initiatives to protect and enhance biodiversity, including on private land are supported.
Christchurch Climate Resilience Strategy 2021	Climate Change Goals; Action Programmes	Goal 1: Net zero emissions Christchurch (by 2045) Goal 4: We are guardians of our natural environment and taonga - By restoring the natural environment, we will reduce the impacts of climate change, as trees, soils, and wetlands absorb large amounts of carbon dioxide that would otherwise further heat the atmosphere.

2.1.6 The higher order documents identify the resource management issues relevant to the district and provide direction in resolving these issues. A number of objectives and policies, in the documents identified above, are broadly relevant to providing for community's social and economic wellbeing, and their health in well-functioning urban environments.

2.1.7 While the main focus of the NPS-UD is on provision of sufficient housing and business land to enable opportunities for future growth in a coordinated way, the objectives and related policies aim to ensure that, among other things, urban environments are of high quality, provide for people's health and their social, economic and cultural well-being, support reductions in greenhouse gas emissions, and are responsive to the current and future effects of climate change

(Objective 8; Policies 1 and 6). Local authorities need to rely on "robust and frequently updated information about their urban environments and use it to inform planning decisions" (Objective 7). This applies not only to making appropriate decisions about urban growth but also to the state of the urban environment in a broader sense, including the health of its natural environment and its ability to respond well to the climate change challenges.

2.1.8 The Canterbury Regional Policy Statement (CRPS) also seeks to provide for diverse, well designed and quality living environments that function in a way which:

a. provides for people's social, economic and cultural wellbeing, as well as their health and safety, and at the same time;

b. maintains and enhances the overall quality of the natural environment of the region, including natural values, and

c. protects and enhances indigenous biodiversity and the quality of water and ambient air.

2.1.9 Good quality residential and business environment is to be developed following good urban design principles, be environmentally sustainable and healthy, safeguard mauri (life force) and restore ecosystems to enhance their life-supporting capacity. The CRPS also seeks to adopt an integrated and co-ordinated approach to halting the decline in Canterbury's indigenous biodiversity to better sustain habitats and improve ecosystem functioning.

2.1.10 The Mahaanui Iwi Management Plan (IMP) seeks to implement appropriate land use practices that have low impact on the environment, including through better water and stormwater quality management. The Plan also seeks to improve indigenous biodiversity and ecosystems as providers of mahinga kai and essential ecosystem services, which includes protection and enhancement of biodiversity corridors to connect species and habitats.

2.1.11 The Council's Biodiversity Strategy 2008-2035 and the Christchurch Climate Resilience Strategy 2021 seek to protect and restore our natural environment, both on private and public land. By restoring and enhancing our biodiversity, including trees, wetlands and soils, they aim to reduce our greenhouse gas emissions and help mitigate the impacts of climate change on our environment.

2.1.12 There are no other relevant national policy statements or national planning standards to give effect to (section 75(3)) in the case of this plan change. The proposed Plan Change is not inconsistent with any Water Conservation Orders or any regional matter under a regional plan.

2.1.13 The Council is in the process of finalising the Urban Forest Plan which, based on the recent tree canopy cover surveys and associated urban forest canopy cover research, will provide the strategic framework for increasing tree planting on Council land, incentivise tree retention and planting on private land, and set realistic targets for improving the tree canopy cover in the city. The proposed provisions in this Plan Change have regard to the Council's Tree Policy and aim to align with the tree canopy targets for the city that have been identified through research[1] as appropriate for the Christchurch environment. These targets will be formally confirmed in the Urban Forest Plan later this year, however, this Plan Change adopts the 20% city canopy cover target for residential zones.

2.1.14 No other management plans or strategies prepared under other Acts are considered relevant to the resource management issues identified.

[1] J Morgenroth, Urban Forest Canopy Cover, 2022

2.1.15 As mentioned above, the RMA prescribes certain requirements for how district plans are to align with other instruments. Whether the District Plan objectives and provisions relevant to addressing adverse effects of development on tree canopy cover do that will be discussed in section 5 of the report.

2.2 Problem definition - the issues being addressed

2.2.1 ISSUE 1 – Loss of tree canopy cover through development/urban intensification and insufficient replacement tree planting, particularly in residential zones.

2.2.2 Christchurch City's canopy cover is comparatively low and decreasing. The recently undertaken second survey[2] of the tree canopy in Christchurch for 2018/2019 indicates that the city's tree canopy covers 13.56% of land in Christchurch, which is approximately a 2% decrease since the last 2015/2016 survey. As a comparison, at 30.61%, Wellington has the greatest canopy cover, while Auckland has 18% cover. Christchurch's 2018/2019 canopy cover is illustrated on this map:

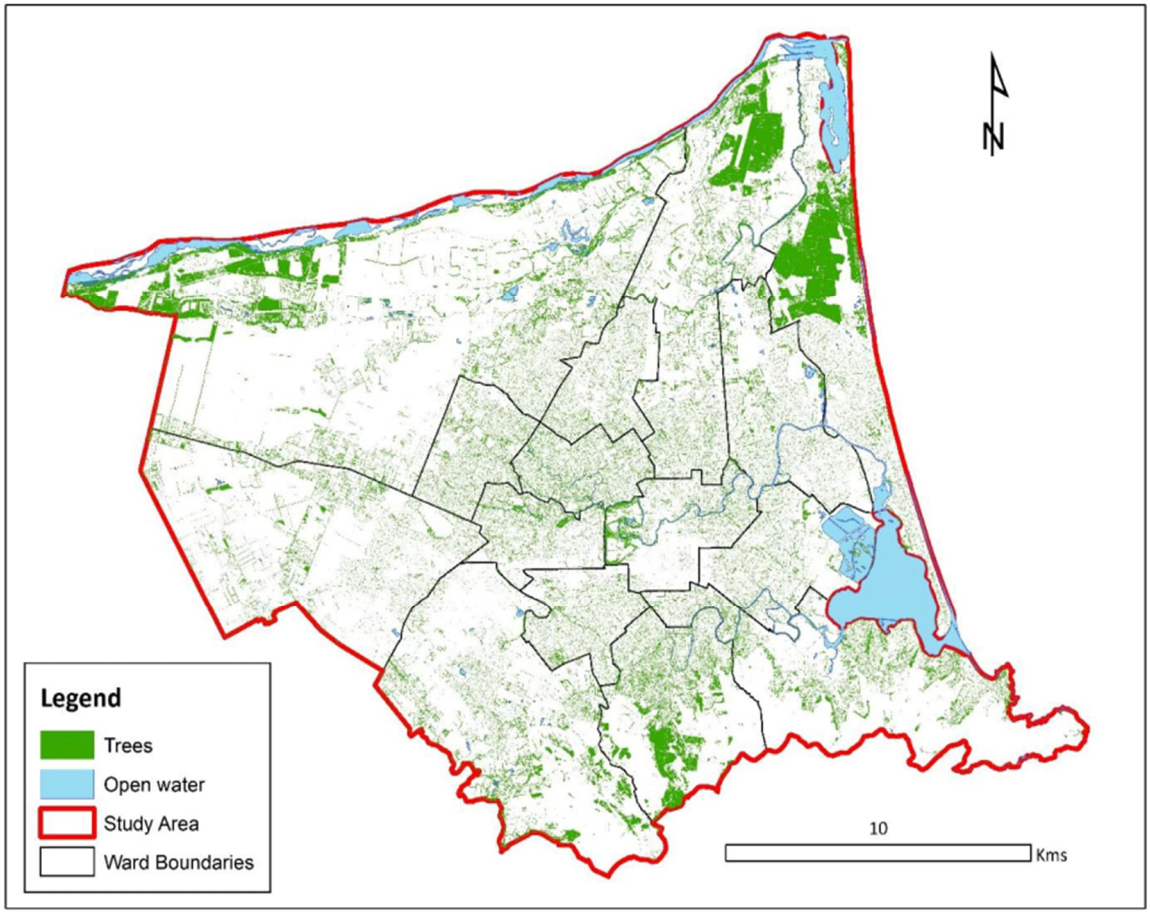

Figure 1 – Tree cover in Christchurch. Source: J Morgenroth, Tree Canopy Cover in Christchurch, New Zealand 2018/19, (2022)

2.2.3 The survey report analysed canopy cover by land ownership and found that the Council owned land had 23% tree canopy cover, Crown land had 16% cover and private land had 11%. The tree canopy cover on all public land dropped by approximately 1% whereas on private land that drop reached 2%.

[2] Morgenroth, J. (2022), *Urban Forest Canopy Cover*.

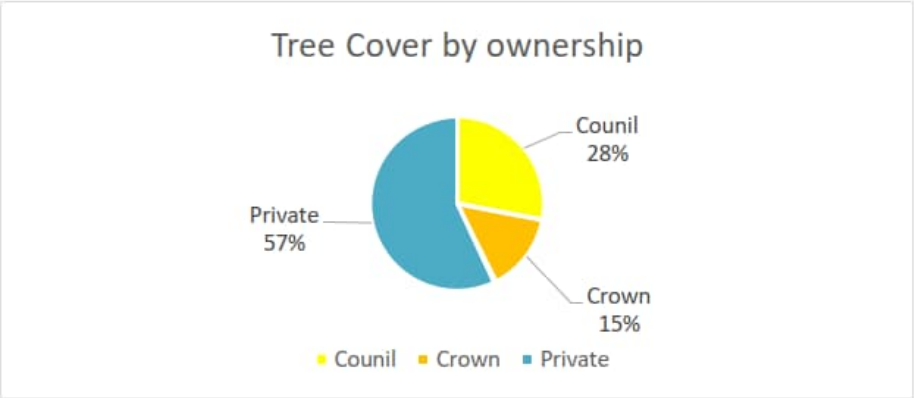

Figure 2 – Tree cover by ownership. Source: J Morgenroth, Tree Canopy Cover in Christchurch, New Zealand 2018/19, (2022), Figure 7 – Tree cover breakdown on privately- and publicly-owned land.

2.2.4 Privately owned properties contain 57% of all canopy cover in Christchurch (as shown in Figure 2 above), consequently, the loss of tree cover on private land will greatly affect the overall tree cover in Christchurch. This is particularly important in light of the fact that 69% of all land in Christchurch is in private ownership (as shown in Figure 3 below).

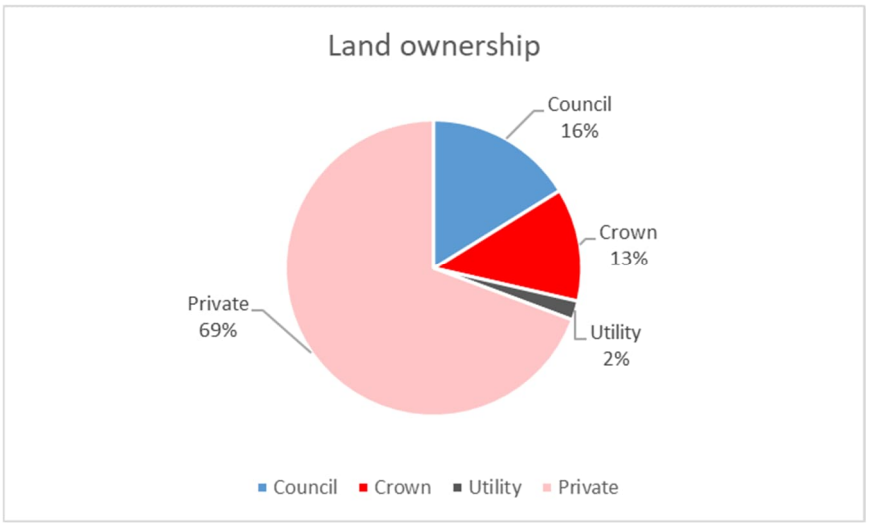

Figure 3 – Land ownership in Christchurch. Source: J Morgenroth, Tree Canopy Cover in Christchurch, New Zealand 2018/19, (2022)

2.2.5 In order to make a more accurate comparison of the canopy cover data, the 2018/2019 canopy cover area was overlaid with the boundaries used in the 2015/2016 survey with the following results showing the change in the percentage of land with tree canopy cover:

	2015/2016	2018/2019
Privately owned land	13%	11%
Publicly owned land	25%	24%
Total canopy cover	16%	14%

2.2.6 Although some of the overall 2% decrease in the tree canopy cover is a result of harvesting in the Bottle Lake Forest plantation and the recent Port Hills fires, much of the tree canopy loss is

attributed to property redevelopment and intensification[3]. With the provisions of the Medium Density Residential Standards (MDRS), introduced by the Amendment Act, and the likely subsequent increase in residential intensification, that canopy cover is under threat of further losses. While the new MDRS require that 20% of the site area is set aside for landscaping, there are no requirements to retain or plant any trees on the development site, unlike in the current provisions of the District Plan which require that at least 50% of landscaping in multi-unit developments or medium density residential zone shall be planted with trees and shrubs.

2.2.7 ISSUE 2 – Insufficient and/or inappropriate tree planting on residential development sites and in the future road reserves of new subdivisions in the greenfield or brownfield development areas.

2.2.8 The current residential zones rules require tree planting within the landscaping area of multi-unit or medium density developments, but planting of trees on a single dwelling development site in the Residential Suburban zone is voluntary and is left up to the owners of the property. The property owners may opt for grass and/or shrubs so as to avoid tree maintenance, seasonal leaf fall or potential shading from trees.

2.2.9 Planting of the wrong tree species in the wrong place is not uncommon on private properties. This often leads to the tree being cut down when it gets too big for the space or when it does not do well in the limited or inappropriate space provided. The removed trees are not necessarily replaced with a more suitable species, and often give way to shrubs, other smaller plants and/or easy care gardens dominated by hard surfaces.

2.2.10 While developers often undertake voluntary tree planting in the future road corridors to improve the amenity of the subdivision, and its appeal to potential buyers, the number of trees planted in the road corridors varies from subdivision to subdivision and is not always sufficient to ensure meaningful benefits from tree canopy cover. The tree species choice is not always appropriate for the berm space they are planted in, which in many cases leads to stunted tree growth, sickness and/or death of the tree. Large trees planted in an inappropriate place or on the wrong side of the road may cause nuisance, infrastructure damage and shading of the adjacent properties. Such trees are often cut down and even if they are replaced with another tree, the young trees will take years to catch up to the size of the original trees.

2.2.11 ISSUE 3 – Inadequate soil volume/ tree pits to allow trees to grow healthily to maturity while avoiding damage to infrastructure, and poor tree maintenance.

2.2.12 Adequate growing conditions for trees are essential to ensure they grow healthily to achieve their ultimate size at maturity while avoiding any damage to infrastructure networks or buildings. Different tree species require different volumes of uncompacted soil and all trees need to be adequately maintained (watering/staking/pruning) in their early growth stages. They also require access to rain water, therefore, the tree base/roots should not be covered with impervious surfaces.

2.2.13 Street tree planting may require engineered tree pits to ensure the roots of the growing tree are directed to the right layer of soil, and do not cause damage to underground services and the road corridor infrastructure such as pavements. The principle of 'the right tree for the right place' also needs to be applied to ensure healthy and enduring tree canopy cover. There are known examples of developers choosing to plant London plane trees, capable of reaching 25 metre height and a crown about 20 metres wide, in a 1 metre wide grass berm of the future road

[3] City-wide canopy cover decline due to residential property redevelopment in Christchurch, New Zealand, 2019, *T. Guo, J. Morgenroth, T. Conway, C. Xu,* Science of the Total Environment, ISSN: 0048-9697

reserve. Such trees will either outgrow their limited space provided, and potentially damage the road or underground infrastructure, or their health and vitality will be affected.

2.2.14 ISSUE 4 - Diminishing number of trees and canopy cover in urban environment contributes to the following adverse effects of urban intensification:

a. Reduced carbon sequestrations;

b. Increased stormwater run-off;

c. Increased heat island effects;

d. Reduced biodiversity and amenity.

2.2.15 Trees provide valuable ecosystem services, including carbon sequestration, stormwater runoff mitigation, and provision of shade to reduce the higher temperatures of the built urban environments. They also contribute to biodiversity through maintaining and/or increasing the tree species variety, including indigenous species, and supporting many species of fauna and flora. Urban amenity is greatly improved by the presence of trees, as is people's health and wellbeing. For Christchurch, trees also help to maintain the 'garden city' image which is important to tourism. Improving the balance of indigenous planting is of great importance to the Ngāi Tahu framework for managing natural resources which is based on Kaitiakitanga (the inherited responsibility of mana whenua to manage the environment and natural resources) and which acknowledges that people are part of the world around them and not masters of it.

2.2.16 Overall, trees provide many essential environmental, economic, cultural and social services and benefits. Excepting scheduled significant trees, however, most of the trees on private properties are not protected in any way and often fall victim to people's neglect or preferences for easy care gardens, no leaf fall or shading.

2.2.17 The declining tree canopy cover in Christchurch will adversely affect the ecosystem services they provide as well as the city's biodiversity and amenity. This in turn will affect the city's ability to support reductions in greenhouse gas emissions and to create resilience to the current and future effects of climate change, thus creating an inconsistency with the directions of the NPS-UD, Objectives 1 and 2, and the CRPS, Objectives 5.2.1 and 6.2.3. Diminishing tree canopy cover would also be inconsistent with the environmental and cultural outcomes sought in the IMP.

2.2.18 Implementing the Medium Density Residential Standards (RMA, Schedule 3A) without additional provisions for tree planting would leave the Plan deficient in its ability to maintain and increase the city's declining tree canopy cover, particularly on private land, and ensure the higher order objectives outlined above are achieved. Declining tree numbers, whether due to their removal through intensification, inappropriate growing conditions or insufficient tree planting in areas of urban growth, are less able to offset the adverse effects of intensification on the environment. Insufficient tree canopy cover will adversely affect the functioning of urban environments and their effectiveness in providing for people's social, economic and cultural well-being, and for their health and safety. Not only are more trees needed in Christchurch but they also need to be protected from removal.

2.2.19 The proposed tree canopy cover and financial contributions provisions of Plan Change 14 seek to address the gap between the desired outcomes and the status quo.

3 Development of the plan change

3.1 Background

3.1.1 The resource management issues set out above have been identified through the following sources:

a. primary research undertaken for the Christchurch and Wellington City Councils by Associate Professor Justin Morgenroth from University of Canterbury and published in a technical report entitled 'Urban Forest Canopy Cover' in 2022;

b. Tree Policy, Christchurch City Council;

c. public feedback and comments through various sources including public engagement, the media, annual residents' surveys;

d. matters raised in various internal Council forums by Councillors, executive leadership team, Council staff;

e. issues identified in other documents and plans, including those described above.

3.1.2 The proposed provisions for financial contributions have been enabled by legislative changes to the RMA, specifically by the Amendment Act.

3.1.3 For the past few decades, many larger residential properties in Christchurch, as in the rest of the country, have been the subject of subdivision and infill development. With time, the development trends and housing demand have changed. Instead of adding one more dwelling to the existing property, usually through subdividing off the back yard containing a garden and/or trees, the entire properties are now often cleared to make way for higher density development of multiple residential units. With the clearing in preparation for development, all or most trees that grew on the site are removed. The new landscaping on the development sites, however, tends to be minimal, uses more hard landscaping and makes little provision for trees.

3.1.4 New greenfield subdivisions tend to have smaller sections with larger houses on them, leaving less room for multiple trees in the back yard. As a result, there is a noticeable decline in the city's canopy cover. This has been confirmed by the two tree canopy surveys undertaken for the Council since 2015. The 2% overall drop in the tree canopy cover in Christchurch is significant when you consider that this cover was at 16% and is now only at 14% of all land. Put another way, that reduction amounts to around 12.5% of the total existing canopy cover being lost.

3.1.5 The new legislation introducing medium and high density residential standards across the city, to enable intensification, is likely to exacerbate the problem of diminishing tree canopy cover. The tree clearing trends associated with infill and/or redevelopment outlined above are likely to be evident in such developments. Moreover, the minimal front, side and back yard setbacks required by the proposed medium and high density standards, combined with a lack of minimum site size for developments prior to subdivision, do not encourage setting aside sufficient space for garden and/or tree planting. This is likely to lead to a number of adverse effects on the environment and the community, as outlined in the issues above.

3.1.6 The Council has commissioned technical advice from external and internal experts to assist with assessing the effects of more intensive development, and the likely further tree loss, on the environment, as well as the potential options for mitigating these adverse effects. The advice includes the following:

Table 1: Technical Reports informing the Tree Canopy Cover / Financial Contributions section of Plan Change 14

	Title	Author	Description of Report
a.	Urban trees and their ecosystem services (Appendix 1)	Justin Morgenroth, University of Canterbury	A review of the current state of knowledge on urban trees and their services of carbon storage, sequestration, stormwater runoff attenuation, and urban heat island mitigation.
b.	Tree canopy cover benefits affected by urban intensification – Biodiversity and related issues (Appendix 2)	Colin D Muerk, University of Canterbury	The report explores mitigating the effects of urban intensification from a biodiversity (indigenous) 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).
c.	Landscape Qualities of Trees and their Canopies within an Urban Landscape (Appendix 3)	Hilary Riordan, Christchurch City Council	An overview of the landscape attributes trees and their canopies can have within urban landscapes, the benefits of urban tree canopy cover in terms of maintaining and improving landscape amenity, and how increased urban intensification may affect the amenity values of trees.
The following reports and articles were also referenced:			
d.	Urban Forest Canopy Cover	Justin Morgenroth, University of Canterbury	A technical report presenting independent research conducted by the University of Canterbury as commissioned by the Christchurch City Council and the Wellington City Council. The report undertakes a literature review on urban forest canopy cover and provides recommendations for canopy cover targets for New Zealand's cities.
e.	Tree Canopy Cover in Christchurch, New Zealand 2018/19	Justin Morgenroth, University of Canterbury	The report provides a snapshot of tree canopy cover in Christchurch between 2018 and 2019, corresponding to the dates of acquisition of both aerial imagery and LiDAR data used in the analysis.
f.	City-wide canopy cover decline due to residential property redevelopment in Christchurch, New Zealand	T. Guo, J. Morgenroth, T. Conway, C. Xu, Science of the Total Environment, 2019, ISSN: 0048-9697	Urban redevelopment influences urban forests, with consequences for ecosystem service provision. The study quantified the effect of residential property redevelopment on canopy cover change in Christchurch. Tree canopy cover losses were more likely to occur in meshblocks containing properties that underwent complete redevelopment.

3.1.7 The 'Urban trees and their ecosystem services' report by J Morgenroth (Appendix 1) focuses on a range of benefits, called ecosystem services, that urban forests and trees provide. A subset of the ecosystem services are regulating services, including carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation. The report quantifies the

degree to which trees contribute to these regulating services and explores the factors that influence the trees' contribution. About 100 scientific articles split across the three regulating services were reviewed. These articles were used to quantify and qualify the role of trees in providing the regulating services outlined above.

3.1.8 The review showed that above-ground carbon storage density for trees averaged 11.5 kg of carbon per square metre of tree canopy cover (range 1.7–28.9 kg C m^{-2}), while total carbon (above and below ground) storage density for trees had an average value of 7.95 kg/m^2 (range 0.8–36.1 kg C m^{-2}). Carbon storage was greatest in species with high wood densities that had large biomass (both wood and leaf/needle biomass) and were able to live into maturity. The greatest values of carbon storage and sequestration were shown in cities or areas with more canopy cover, greater tree density, and lower forest fragmentation (more groups of trees as opposed to isolated trees). Further details are shown in section 3.2 and Table 1 of the Morgenroth report (refer Appendix 1).

3.1.9 Impervious surfaces (buildings and other hard surface) reduce the ability of rainfall to infiltrate into the soil. They also increase the speed at which rainfall runs off the surface. This increases peak discharges, the incidence and duration of flooding, and water quality. Trees reduce stormwater runoff, primarily by intercepting and storing between 9% and 61% of total rainfall in their canopies and root systems (provided the surface is permeable). The intercepted rainfall is returned to atmosphere through evaporation and slowly infiltrated into the soil through the root systems. The soil water stores are then absorbed by the trees to support tree growth and functions, and eventually transpired back into the atmosphere during photosynthesis. As with carbon sequestration/storage, rainfall interception was influenced by leaf and plant surface area, canopy structure, and tree species. Trees with greater leaf or needle density and surface area were the most effective in rainfall interception. That effectiveness was greatest during short, low-intensity storms.

3.1.10 Urban areas often experience higher temperatures than rural areas, mostly referred to as heat island effect. This is due to built environments, comprising concrete, brick, asphalt or tile pavements, roof tiles and iron, absorbing sunlight and storing heat. Heat island effects are associated with higher surface and air temperatures, decreased air quality, increased energy consumption, elevated emissions of air pollutants and greenhouse gases, human discomfort, respiratory problems, heat strokes and dehydration, and accelerated deterioration of urban infrastructure, including road or pavement surfaces.

3.1.11 Trees, in contrast, reflect more radiation and do not store heat. Moreover, their canopies provide shade, thus preventing the surfaces underneath from absorbing sunlight, and their leaves and needles transpire, thereby cooling the surrounding atmosphere. They provide greater thermal cooling and comfort to humans than artificial sources. Ground surface temperatures were found to be 0.6–22.8°C cooler and air temperatures 0.8–7°C cooler beneath trees than in the surrounding non-treed environments.

3.1.12 The report shows that the variation in carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation is related to the quantity of trees, (expressed in tree density or canopy cover), their configuration (fragmentation, clustering), and their structural characteristics such as height, crown volume and shape, stem diameter, leaf area or density, and wood density, the latter of which is influenced by tree species and age. The regulating services, researched in the report, will improve with more trees or tree cover, particularly in clusters, and with greater total biomass and wood density. In contrast, development intensity and increased impermeable surfaces (buildings and/or hard surfaces such as pavements), which are associated with reduced tree cover, threatened the provision of the ecosystem/regulating services such as

carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation by trees.

3.1.13 In his report 'Tree canopy cover benefits affected by urban intensification – Biodiversity and related issues' (refer to Appendix 2), C Muerk explores a complex array of values that trees represent and the role they play in the local biodiversity framework, with a particular focus on indigenous species and their benefits. The report provides support for mitigating the impacts of urban intensification on tree cover from a biodiversity perspective, specifically considering "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)" (C Muerk (2022), p3).

3.1.14 The intrinsic/existence values of biodiversity are demonstrated by human behaviour and preferences or choices made. They also relate to well-being which is "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". Trees, indigenous trees in particular, also provide habitat for native wildlife, and have indirect economic values, from tourism, health, and education benefits, that could be quantified. To avoid impacts on human well-being, on wildlife, and to stop the "6th great extinction"[4], adequate tree canopy cover that supports ecological integrity and legibility needs to be maintained and improved in our urban environment.

3.1.15 All of these factors contribute to our biodiversity which, the report defines as 'indigenous contribution to global diversity' and is distinguished from 'species richness', which is the total number of species regardless of origin. While species richness contributes to resilience and provision of important ecosystem services, indigenous species are specifically related to natural habitat, hosting or servicing indigenous microbes, invertebrates, birds and lizards, and providing pest and pollinator regulation. They also play an important role in providing cultural services to tangata whenua.

3.1.16 Indigenous trees and forest patches, particularly those rich in species, outperform exotic or un-treed residential environments in terms of indigenous wildlife and provide critical food resources, e.g. berries and nectar, at different times of the year. Good tree diversity and numbers are necessary to support native bush birds throughout the year.

3.1.17 Improvements in the balance of indigenous species versus exotics in the city's tree canopy cover may be best achieved in larger areas of planting. It may not be appropriate to require a percentage of indigenous species in tree canopy cover rules for residential developments as most developments are likely to require only one or two trees per site. Species requirements in such situations could be viewed as too restrictive.

3.1.18 According to the report, the goal for the city's tree canopy cover should be more aspirational than the 20% proposed. That figure should be regarded as a medium-term minimum, but a higher target ought to be set for the future. Mr Muerk is of the view that the 20% goal, justified by Christchurch being a grassland biome, is not strictly valid due to the city's environment containing many wetlands and indigenous forest remnants. Therefore, Christchurch has elements of the forest biome and that should be reflected in its overall canopy cover of between 25-30%, with a positive bias towards indigenous biodiversity.

[4] The 6th great/mass extinction - an ongoing extinction event of a high percentage of biodiversity, or distinct species—bacteria, fungi, plants, mammals, birds, reptiles, amphibians, fish, invertebrates during the present Holocene epoch (also called Anthropocene) as a result of human activity, primarily driven by the unsustainable use of land, water and energy use, and climate change.

3.1.19 The report supports the option of retaining valuable species/trees, removal of those constituting a biosecurity risks and replacing them with appropriate indigenous species. Safe havens need to be created for common, declining and endangered locally extinct wildlife that would feed, through 'stepping stones' and corridors of trees into the wider matrix. Trees on private properties and the streets can create such corridors linking larger areas of tree canopy on public land. Such measures would gradually lead to rebuilding the city's ecological integrity, landscape legibility, and ultimately ecological literacy, identity, and protectiveness (or kaitiakitanga by Mana Whenua) for our natural heritage and taoka.

3.1.20 While it is difficult to express the biodiversity benefits of trees in monetary terms, some of them can be evaluated by proxy, e.g. tourism gains from the garden city image. International estimates, however, show that for every $1 invested in trees an average of $2.25 are returned per annum in other benefits such as carbon sequestration.

3.1.21 The 'Landscape Qualities of Trees and their Canopies within an Urban Landscape' report (Appendix 3) provides a high level overview of the landscape attributes that trees and their canopies can contribute within urban landscapes. The report focuses on how urban tree canopy cover maintains and improves landscape amenity and how urban intensification may affect the amenity values of trees.

3.1.22 H Riordan defines "amenity", as per the Oxford Dictionary, as "a desirable or useful feature or asset of a building or place", and "the pleasantness or attractiveness of a place". She explains that what is "desirable", "pleasant", or "attractive" is evoked by human emotions, feelings, and senses which contribute to the concept of "amenity", including all sensory perception.

3.1.23 In physical terms, trees come in a variety of sizes, forms, shapes, textures and colours and these can change according to the environment, stage of maturity, seasons or human modification. Tree's varying form, shape and textures contribute to the amenity and landscape values of a place by providing interest, a landmark, or the experience of seasonal change. Trees can screen or enhance built environments, create green walls, naturalise built environments by softening harsh outlines of buildings, and reduce visual pollution. They can be used to create, enhance and define architectural or natural features such as doorways or riverbanks.

3.1.24 Recognised as 'green infrastructure', trees in public and private realms contribute to visual amenity of the streets, benefitting both the residents and other users. If trees are removed from private properties and reliance to provide amenity is placed solely on trees within public spaces, both landscapes may become undesirable ones. One devoid of natural interest and harsh, the other, in an attempt to compensate for loss of trees, becoming too dark and dense.

3.1.25 Mature trees, particularly those with substantial canopies, can make a noticeable physical impact on the landscape while smaller young trees will take several years to provide a meaningful canopy cover which will be enjoyed by younger generations. It is important to retain mature trees while also planting young trees. Retention of mature trees within urban landscape ensures that the existing level of amenity, biodiversity and other values are retained, whereas, regular tree planting ensures age diversity of trees and mitigates the risk of the City's tree population reaching the end of life at the same time.

3.1.26 The report also explores the associative and perceptual values of trees, and the way they contribute to the 'liveable city' concept. People prefer to live in urban landscapes with more trees as their presence enhances public perception of visual quality of the city. This is particularly true for residential environments where urban greening has quantifiable correlation with property values.

3.1.27 Trees spread through private and public land encourage physical activity and provide more visually enjoyable environment, including shade and greenery. Through a connection to nature, trees provide health benefits such as stress reduction, evoking positive emotions and a sense of well-being. Street trees with denser canopies create a calming effect as they provide a sense of enclosure and road narrowing, thus reducing traffic speed, and have beneficial effects on social interaction while reducing crime levels.

3.1.28 The report highlights that indigenous trees and vegetation are critical to Ngāi Tahu's sense of identity, culture, connection with the natural environment, and their ongoing ability to keep tikanga and mahinga kai practices alive. The use of indigenous trees, 89% of which are endemic, strengthens the sense of place for Ngāi Tahu, enriches food sources for humans and local fauna, and provides wayfinding functions, either as groups or individual trees.

3.1.29 Overall, the supporting evidence highlights numerous ecological services, biodiversity, cultural and amenity benefits of urban tree canopy cover, and provides support for enhancing Christchurch's tree canopy. This is particularly important in light of the likely effects of residential intensification on the city's urban and natural environments.

3.2 Current Christchurch District Plan provisions

3.2.1 The current Plan's Strategic Directions objectives, chapter objectives and provisions relevant to this plan change include Strategic Objectives 3.3.1, 3.3.3, and 3.3.9 as they relate to the values of natural environment. Residential Objective 14.2.4, Policies 14.2.4.1, 14.2.4.2, new 14.2.4.3, Objective 14.2.5 and Policy 14.2.5.4, Objective 14.2.7 and Policy 14.2.7.1, some of which are proposed to be changed through those amendments of Plan Change 14 that implement the NPS-UD and MDRS directions as specified in Schedules 3A and 3B, are relevant to the extent that they outline the outcomes sought for residential environments.

3.2.2 The relevant / parts of these objectives and policies are shown below for ease of reference. It should be noted that the changes shown in bold underline and bold strikethrough below are not proposed by this section (Tree canopy cover/financial contributions) of PC14. They are proposed by that part of PC14 dealing with the NPS-UD (development capacity for housing) and MDRS implementation and are analysed in the related section 32 report.

3.3.1 Objective - Enabling recovery and facilitating the future enhancement of the district

a. The expedited recovery and future enhancement of Christchurch as a dynamic, prosperous and internationally competitive city, in a manner that:

i. *Meets the community's immediate and longer term needs for housing, economic development, community facilities, infrastructure, transport, and social and cultural wellbeing; and*

ii. *Fosters investment certainty; and*

iii. *Sustains the important qualities and values of the natural environment.*

*3.3.3 Objective - Ng**ā**i Tahu mana whenua*

a. A strong and enduring relationship between the Council and Ngāi Tahu mana whenua in the recovery and future development of Ōtautahi (Christchurch City) and the greater Christchurch district, so that:

i. (...)

iv. Ngāi Tahu mana whenua's historic and contemporary connections, and cultural and spiritual values, associated with the land, water and other taonga of the district are recognised and provided for; and

v. (...)

vi. *Ngāi Tahu mana whenua are able to exercise kaitiakitanga.*

3.3.9 Objective - Natural and cultural environment

a. *A natural and cultural environment where:*
   i. *People have access to a high quality network of public open space and recreation opportunities, including areas of natural character and natural landscape; and*
   ii. *Important natural resources are identified and their specifically recognised values are appropriately managed, including:*
      A. *outstanding natural features and landscapes, including the Waimakariri River, Lake Ellesmere/Te Waihora, and parts of the Port Hills/Nga Kohatu Whakarakaraka o Tamatea Pokai Whenua and Banks Peninsula/Te Pātaka o Rakaihautu; and*
      B. *the natural character of the coastal environment, wetlands, lakes and rivers, springs/puna, lagoons/hapua and their margins; and*
      C. *indigenous ecosystems, particularly those supporting significant indigenous vegetation and significant habitats supporting indigenous fauna, and/or supporting Ngāi Tahu mana whenua cultural and spiritual values; and*
      D. *the mauri and life-supporting capacity of ecosystems and resources; and*
   iii. *Objects, structures, places, water/wai, landscapes and areas that are historically important, or of cultural or spiritual importance to Ngāi Tahu mana whenua, are identified and appropriately managed.*

14.2.4 Objective - High quality residential environments

a. *High quality, sustainable, residential neighbourhoods which are well designed~~, have a high level of amenity, enhance local character and reflect~~ to reflect the planned urban character and the Ngāi Tahu heritage of Ōtautahi.*

14.2.4.1 Policy - Neighbourhood character, amenity and safety

a. *~~Facilitate the contribution of~~ Provide for individual developments ~~to high quality residential environments~~ in all residential areas (as characterised in Table 14.2.1.1a), ~~through design~~ which contributes to a high quality environment through a site layout and building design that:*
   i. *~~reflecting the context, character, and scale of building anticipated in the neighbourhood~~ ensures buildings and planting have a greater prominence from the street than car parking and servicing areas;*
   ii. *(...)*
   vi. *provides prominent planting areas throughout communal areas and adjacent to the street;*
   vii. *incorporates~~ing~~ principles of crime prevention through environmental design.*

14.2.4.2 Policy - High quality, medium density residential development

a. *Encourage innovative approaches to comprehensively designed, high quality, medium density residential development, which is attractive to residents, responsive to housing demands~~,~~ and ~~provides a positive contribution to its environment (while acknowledging the need for increased densities and changes in residential character)~~ reflects the planned urban character of an area, through:*
   i. *consultative planning approaches to identifying particular areas for residential intensification and to defining high quality, built and urban design outcomes for those areas;*
   (...)

14.2.4.3 Policy – Quality large scale developments

a. Residential developments of four or more residential units contribute to a high quality residential environment through site layout, building and landscape design to achieve:
- *i. engagement with the street and other spaces;*
- *ii. minimisation of the visual bulk of buildings and provision of visual interest;*
- *iii. a high level of internal and external residential amenity;*
- *iv. (...)*

14.2.7 ~~5~~ Objective - ~~Residential New Neighbourhood~~ Future Urban Zone

a. Co-ordinated, sustainable and efficient use and development is enabled in the ~~Residential New Neighbourhood~~ Future Urban Zone.

14.2.7 ~~5~~.4 Policy - Neighbourhood quality and design

a. Ensure that use and development:
- *i. contributes to a strong sense of place, and a coherent, functional and safe neighbourhood;*
- *ii. contributes to neighbourhoods that comprise a diversity of housing types;*
- *iii. retains and supports the relationship to, and where possible enhances, recreational, heritage and ecological features and values; and*
- *iv. achieves a high level of amenity.*

14.2.9 ~~7~~ Objective - Redevelopment of brownfield sites

a. On suitable brownfield sites, provide for new mixed use commercial and residential developments that are comprehensively planned so that they are environmentally and socially sustainable over the long term.

14.2.9 ~~7~~.1 Policy - Redevelopment of brownfield sites

a. To support and incentivise the comprehensive redevelopment of brownfield sites for mixed use residential activities and commercial activities where:
- *i. (...)*

b. Ensure the redevelopment is planned and designed to achieve:
- *i. high quality urban design and on-site amenity; and*
- *ii. development that is integrated and sympathetic with the amenity of the adjacent neighbourhoods and adjoining sites.*
- *v.*

3.2.3 Chapter 3 - Strategic Directions provides overall directions for matters related to providing for a city environment in a way that meets the residents' well-being needs, and sustains important values and qualities of the natural environment (Objective 3.3.1, 3.3.9), including those of particular importance to Ngāi Tahu (3.3.3). Objective 3.3.9 seeks to identify important natural resources and manage their recognised values appropriately. This includes 'the mauri and life-supporting capacity of ecosystems and resources' and indigenous ecosystems, particularly those supporting indigenous flora and fauna. While the ecosystem services, biodiversity and amenity values of trees are not specifically recognised in the list of important natural resources in Objective 3.3.9(a)(ii)(A – D), this plan change is proposing to rectify that through the addition of a new clause (a)(ii)(E).

3.2.4 Chapter 14 objective 14.2.4 and the relevant policies, as listed above, seek high quality residential environments that are attractive to residents, achieve high level of amenity, and create a strong sense of place. Developments should be designed to create high quality environments through,

among other things, prominence of planting areas in the communal spaces and in areas adjacent to the street.

3.2.5 Sustainable land use and development is also sought in the Future Urban Zone (Objective 14.2.7, Policy 14.2.7.4). The policies seek that the new neighbourhoods are of high quality and amenity, are responsive to ecological features and values, and integrate well with the surrounding neighbourhoods. Redevelopment of brownfield sites (Objective 14.2.9, Policy 14.2.9.1) supports comprehensive redevelopments for mixed use residential and commercial activities which are designed to achieve high quality and are sympathetic to the amenity of the adjacent neighbourhoods.

3.2.6 Overall, the outcomes sought through the objectives and policies outlined above are generally consistent with the strategic directions of higher order documents, e.g. NPS-UD, which seek to create high quality well-functioning urban environments. These environments are to provide for the social and cultural well-being of the communities, and their health and safety, while supporting reductions in greenhouse gas emissions and resilience to the effects of climate change.

3.2.7 The District Plan promotes better sustainability through a number of measures, e.g. by directing higher density developments closer to commercial centres and transport links to reduce greenhouse gas emissions from private car travel. It also seeks to protect significant natural, historic or cultural features but it is less explicit about seeking to minimise adverse effects of development on the local ecosystems (CRPS, Objective 9.2.1) and stopping the decline of their quality and quantity. One of the measures to mitigate that decline is increasing urban tree canopy cover on residential land. Tree planting on residential sites and streets is treated more as an urban design and amenity matter, rather than as a means to improve the environment by better utilising and increasing the scope of environmental and ecological services that trees provide. That gap is proposed to be addressed through the proposed changes.

3.2.8 As 69% of land in Christchurch is in private ownership (total of 30,635.14 hectares), with residential land having a significant share of it at 10,796 hectares, halting the decline of tree canopy cover in the city and increasing it, particularly in residential areas, needs to be given more priority. The table in Figure 6 below, sourced from the Tree Canopy Cover in Christchurch, New Zealand 2018/19 report by J Morgenroth (2020), shows the tree canopy cover in different zones and the corresponding land area in more detail.

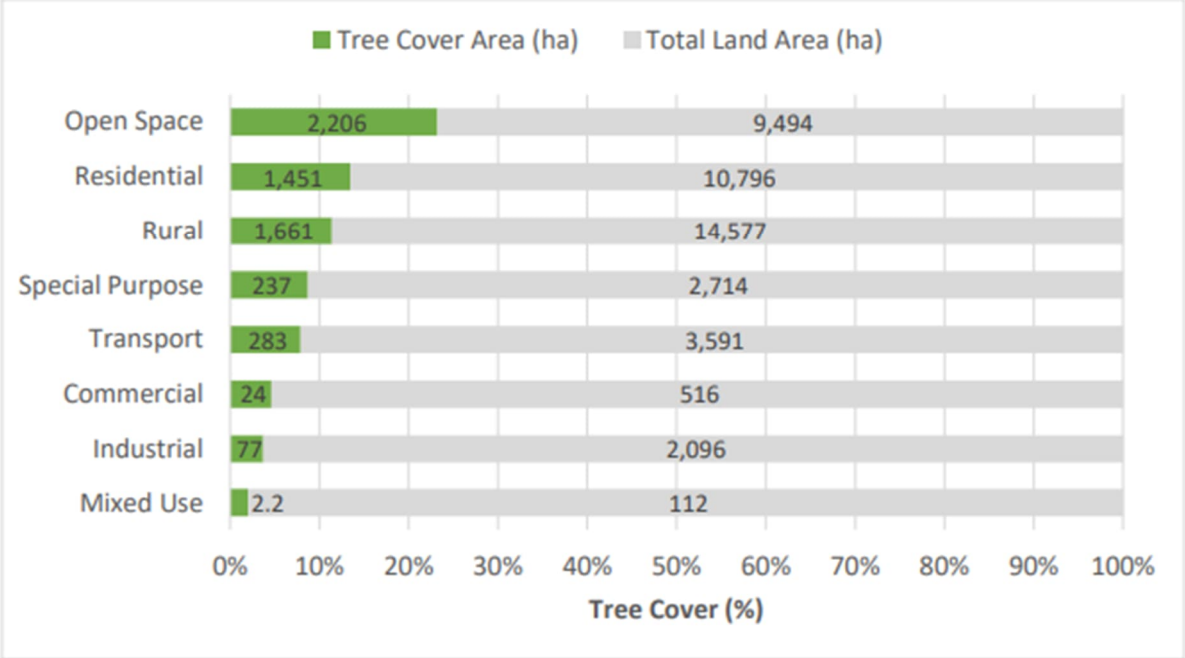

Figure 6 – Tree cover (%) within different District Plan zone types. Tree cover area and total land area within District Plan zone types are also shown as labels on the bars.

3.2.9 The matter of residential redevelopment and its effects on urban tree canopy were analysed in 'Tree Canopy Cover in Christchurch, New Zealand 2018/19' article by T. Guo, J. Morgenroth, T. Conway, and C. Xu published in 'Science of the Total Environment' in 2019. The paper found that urban redevelopment influences urban forests and that has consequences for ecosystem services provided by trees. The study quantified the effect of residential property redevelopment on canopy cover change in Christchurch and found that tree canopy cover losses were more likely to occur in meshblocks containing properties that underwent complete redevelopment, i.e. replaced an existing dwelling with a number of new residential units on the same site.

3.3 Description and scope of the changes proposed

3.3.1 This part of Plan Change 14, focused on tree canopy cover / financial contributions, proposes an addition to Strategic Objective 3.3.9(a)(ii) to ensure the goal set out in the objective (identification and appropriate management of important natural resources) is achieved by also recognising the role that urban tree canopy cover plays in providing important ecological and environmental services, and enhancing the city's biodiversity and amenity. The changes are considered necessary and appropriate to ensure that the purpose of the Act is achieved.

3.3.2 The plan change also proposes to add a new objective to Chapter 8 Subdivision of the Plan, along with a suite of supporting policies. The new Objective 8.2.6 and associated policies 8.2.6.1 – 8.2.6.3 propose to provide a framework for maintaining and enhancing urban tree canopy cover in areas of residential development in Christchurch City. The adverse effects associated with development that the objectives and policies are seeking to address are:

a. Declining tree canopy cover in urban areas;

b. Increase in greenhouse gas emissions;

c. Increased stormwater runoff;

d. Heat island effects;

e. Reduced biodiversity and amenity.

3.3.3 The plan change also proposes new subdivision rules to address the issue of declining urban tree canopy cover and to ensure that the relevant Plan objectives are achieved. The decision to include the tree canopy cover provisions in Chapter 8 Subdivision rather than Chapter 6 General Rules or another chapter, was made for two broad reasons. Firstly, subdivision rules enable the use of the consent notice regime to secure protection of the tree canopy cover into the future, which is essential to the overall scheme, and consent notice is a relatively straightforward and inexpensive mechanism. Secondly, subdivision will capture most of residential development that creates additional units.

3.3.4 New matters of control proposed to be introduced for residential subdivision, aim to increase tree planting in areas of residential subdivision and development or require that financial contributions are paid where on-site and/or on-road tree canopy cover is not achieved by the developer/site owner. The intention is that where the existing tree canopy cover is retained or the canopy cover is provided through new tree planting, it will be secured by consent notices which can be registered by the Council against the relevant titles. Financial contributions will enable the Council to carry out tree planting on public land in lieu of the required on-site tree canopy cover.

3.3.5 The changes described above include:

a. An amendment to Strategic Objective 3.3.9(a)(ii);

b. New subdivision chapter Objective 8.2.6 - Urban tree canopy cover;

c. Associated Policies 8.2.6.1 – Contribution to tree canopy cover, 8.2.6.2 – The cost of providing tree canopy cover and financial contributions, 8.2.6.3 – Tree health and infrastructure;

d. Additions to 'How to interpret and apply the rules' in 8.3.1, and to the administration (development and financial contributions) Rule 8.3.3;

e. An addition of a new matter of control (Rule 8.7.12: Tree canopy cover and financial contributions) to controlled activities C5 - C10 listed in Rule 8.5.1.2 that are relevant to residential subdivision and development. The proposed matters of control in 8.7.12 address:
   i. what tree canopy cover is required on the development site and in the road corridor, where applicable;
   ii. how to calculate the canopy cover required;
   iii. tree size and planting space requirements;
   iv. the inclusion of a consent notice, to be registered on the land title, that requires tree maintenance and prevents tree removal;
   v. how to calculate the financial contributions (for trees and land) that need to paid to the Council in lieu of on-site tree planting.

f. Additional definitions of 'heat island', 'hedge', 'maturity' (in relation to trees), and 'tree canopy cover' are also proposed.

3.4 Community/Stakeholder engagement

3.4.1 As required by the RMA Schedule 1, clause 3, the Council invited feedback on the draft proposal from the statutory bodies as defined in Schedule 1, the residents groups currently operating in Christchurch, the parties that specifically expressed interest in being consulted on particular matters, and general public. Pre-notification engagement occurred on proposed Plan Change 14 from 11 April 2022 to 13 May 2022. Draft amendments to the District Plan and a summary of the issues and evaluation of the draft options was provided on the Council's webpage specific to the

plan change (https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan/changes-to-the-district-plan/planchange/plan-change-c14/).

3.4.2 The draft provisions for tree canopy cover/financial contributions received 111 comments. Around three quarters of respondents either supported the financial contributions approach or considered it too lenient.

3.4.3 Over half of the respondents (54) supported tree canopy cover provisions. Of these, 39 provided a short supportive statement via a Generation Zero form. Others who supported the proposed approach felt that intensification development is likely to have a negative impact on the city's tree canopy cover through loss of existing trees, that protecting trees and aiming at 20% canopy cover was important, and that the proposed provisions were a way to achieve this outcome. They were also of the view that trees, indigenous species were preferred over exotic, should be planted close to the development site to offset effects such as heat island effects and to provide connectivity between vegetated areas for native birds. Many respondents thought that tree planting on residential streets and public spaces should be made a standard requirement of new developments.

3.4.4 Of the respondents who opposed the proposal, 25 considered that the proposed tree canopy cover/financial contribution provisions were too lenient. In their view, the approach would allow developers to pay some money instead of protecting/retaining existing trees, leading to further loss of exiting tree cover. Others objected because, in their view, a young tree is not an adequate compensation for the loss of a mature tree as it will take decades to mature and play a meaningful role in combating climate change or providing habitat for native birds. Some of the respondents also thought that the new trees should be planted close to where the development occurs so that climate injustice and inequality are not exacerbated.

3.4.5 Those who were of the view that the tree canopy cover/financial contribution provisions were too strict or onerous (14 comments) predominantly had first-hand development experience, and provided relatively detailed comments on a number of issues. Some argued that:

a. the scheme would be too difficult to calculate accurately and to administer;

b. financial contributions would be too costly, particularly the ones for land, and the costs would be passed on to purchasers or make the development not viable;

c. the provisions are potentially inconsistent with what the government is trying to achieve through the MDRS;

d. 20% canopy cover would lead to loss of sun/natural light and cause shading and leaf drop, potentially leading to disputes between neighbours;

e. tree placement within development sites needs to recognise the position of new private services for new residential units which could be an additional constraint;

f. flexibility is needed as to where the trees are to be planted within a subdivision to account for physical or natural constraints of the land, e.g. allow for on-site trees to be planted in a common undevelopable area within the subdivisions instead;

g. increasing the berm width in greenfield subdivisions to accommodate trees may result in additional costs to ratepayers through the cost of leaf clean-up, damage to footpaths and infrastructure.

3.4.6 Another 20 responses provided a mixture of comments, including a desire for more revenue from new developments to be set aside for green streetscaping, more public space trees and green

belts within the city as they are more effective in addressing carbon emissions and climate change effects than single trees. They proposed a fees structure that is proportionate to the significance of adverse effects on the neighbouring properties, such as shading and loss of privacy.

3.4.7 Much of the feedback emphasises the importance of retaining mature trees on development sites, with financial contributions being viewed as an 'easy way out' for developers. Some propose penalties for removal of existing mature trees. The ability of the Council to ensure that trees planted under the proposed tree canopy cover provisions are retained by subsequent owners is also questioned.

3.4.8 The draft proposal contained a requirement for a 10% tree canopy cover in industrial zones. That is opposed on the basis that such requirement would reduce the functional capacity of the available industrial land, particularly of the Lyttelton Port Company's port and depot areas, and that it would not be consistent with the outcomes anticipated by the zone rules with regard to landscaping.

3.4.9 The potential cost of the land component of financial contributions for central city developments is considered by some too high and unjustified, particularly in light of extensive open space land owned by the Council, including the former Red Zone land.

3.4.10 The Council considered the feedback provided. That consideration is reflected in the final provisions. It is acknowledged that in some instances, the physical or natural land constraints may make provision of on-site tree canopy cover difficult. The redrafted rules provide for some flexibility in terms of where the required tree canopy cover is planted, e.g. in an undevelopable gully in the hill subdivisions.

3.4.11 The draft proposal for tree canopy cover requirements in commercial and industrial zones has been removed because this plan change is concerned with adverse effects of residential development on the environment, limiting the scope of the changes proposed. Any such provisions could potentially also be in conflict with the permitted built form standards in commercial and industrial zones as they mostly permit unlimited site coverage with buildings and impervious surfaces. Some landscaping and tree planting requirements already apply in these zones, e.g. tree planting required in car parking areas or the road boundary setbacks, and that is likely to provide similar canopy cover to the 10% proposed in the draft rules.

3.4.12 Some feedback provided is concerned with the potential dollar value of the land component of financial contributions which could be high or prohibitive, and which could be passed onto the purchasers. The proposed tree canopy cover/ financial contributions rules provide developers with a choice. Retaining or planting the required trees on the site, and/or in the future road corridor where applicable, is encouraged, and it is likely to be the cheaper option for developers. The examples below will help illustrate that.

3.4.13 The MDRS provisions require that 20% of the site be set aside for landscaping (proposed Rule Rule 14.5.2.2). Some or all of it could be used to accommodate the required trees. Trees can also be planted in other areas of the site that cannot be built on (another 30% of the site), including the site frontage, along the driveway, or service areas. Urban design advice obtained in-house confirmed that most developments can be designed around existing trees on the site, and that new trees can be accommodated on residential sites comfortably. The developers will have a choice of tree species to suit their preferences as long as the canopy cover at maturity meets the required size.

3.4.14 The land area required for tree roots is considerably smaller than the tree canopy size at maturity, e.g. a small tree with canopy size of 10m^2 requires 3.8m^2 of land for planting, a medium tree with canopy of 67m^2 needs 25.5m^2 of land, and a large tree with 186m^2 canopy, requires 70.8m^2 of land. Where a developer chooses not to plant trees on the site and pay financial contributions instead, an average tree size (130m^2 canopy) is used to calculate the number of trees for which financial contributions are required, and the corresponding land area of 50m^2 for tree roots is used to calculate the amount of land for which financial contributions need to be paid. All the relevant tree canopy sizes and root land areas are provided in the proposed Table 1 in Rule 8.7.12(d)(E).

3.4.15 To illustrate the potential cost of tree planting or the amount of financial contributions, some calculations are provided for a development on a 1000m^2 section as an example. For a 1,000m^2 site size, the required 20% on-site tree canopy cover would amount to 200m^2. If the developer chose to plant three medium size trees with 67m^2 projected canopy cover (as per Table 1 in Rule 8.7.12(d)(i)), the developer would need to plant 2.98 trees. A fraction over 0.5 is rounded up, therefore, 3 trees of medium size would need to be planted on the site. They would require 3 x 25.5m^2 land area to be planted in (8.7.12(d)(i) Table 1). The overall cost would likely be limited to the cost of three trees. If the price of $200.00 per tree was used as an example, the total cost would be $600.00. Tree prices can vary depending on the species and the young tree size and range from $20.00 for a small sapling, around $100.00 for a tree about 2 metres high and up to several hundred for an established rare specimen.

3.4.16 If the developer chose to plant a mix of trees with different canopy sizes, including 2 medium size trees (at 67m^2 canopy cover each), the two trees would achieve the projected canopy cover of 134m^2. The remaining 66m^2 of the overall canopy cover required would be planted with small trees (at 10m^2 canopy cover each). 66m^2 divided by 10m^2 canopy size equals 6.6 small trees. A fraction over 0.5 is rounded up, therefore, 7 small trees would need to be planted on the site. Overall, the developer would need to plant 2 x medium trees and 7 x small trees. The cost could vary depending on the tree species chosen and their size at the time of purchase.

3.4.17 If the developer chose not to plant trees on the site but pay financial contributions instead, the 200m^2 canopy cover required for a 1000m^2 site would need to be divided by the 'average' tree canopy size of 130m^2 (Rule 8.7.12, Table 1) to calculate how many trees would need to be paid for through financial contributions: 200m^2 divided by 130m^2 = 1.53 trees. This needs to be rounded up to 2 trees and then multiplied by the $2037.00 financial contribution required per tree (refer to Rule 8.7.12(e)(i)). 2 trees x $2037.00 = $4074.00.

3.4.18 An 'average' tree with a 130m^2 canopy needs 50.00m^2 of land area to be planted in (Rule 8.7.12(d)(i), Table 1), therefore, 100m^2 of land is needed for 2 trees. The 100m^2 land area required will need to be multiplied by the value of the site per square metre (valuation will be required at the time of the subdivision application – Rule 8.7.12(e)(iv)(B)). As an example, the average residential land value per m^2 in Christchurch is estimated to be around $400 - $500/m^2. Based on the lower estimate, the financial contribution for 100m^2 of land required would be $40,000.00. After adding the $4,074.00 contribution for two trees, the total financial contributions for that site would be $44,074.00.

3.4.19 The land value is based on the market value of the site at the time of development/the valuer undertaking the valuation. That is the most common approach to valuing land and is considered to be justified as the Council would need to pay market value for any land it needs to purchase for tree planting in/near the area of development. While the Council owns some open space land, it may not necessarily be in the area of a particular development and most of it needs to be retained as open space for public recreation or sports. The Council is planning to undertake tree

planting, e.g. in the former Red Zone land or open space surplus to sports or recreation requirements, to help create an urban forest and boost our canopy cover. That, however, needs to be complemented by trees on private properties to ensure we achieve the recommended 20% tree canopy cover[5] in the city.

3.4.20 The Christchurch tree canopy cover surveys undertaken and analysed by J Morgenroth, provide some estimates of the tree canopy cover increases if we planted various areas/zones of the city at the target canopy cover rates. If the Council increased the canopy cover on all of its open space land (9493.73 hectares) to 40%, it would only increase the city's current 13.5% canopy cover by 2%, reaching 16%. The Red Zone area (600 hectares in total, including the river and wetlands) planted to the target 80% canopy cover (i.e. covering 480 hectares), would increase the city's overall canopy cover by only 1.09%.

Table showing the effects of Red Zone land on city canopy cover

	Area (ha)	Current canopy	Canopy target	Projected canopy cover (Ha)
Red Zone	600	10%	80%	480
	Canopy contribution to city			1.09%

3.4.21 The most significant impact on the city's tree canopy cover comes from an increase of that cover in residential zones. The residential zones cover 10,795.75 hectares of land. An increase of the tree canopy cover in all residential zones to the target 20% would increase the city's overall canopy cover substantially and achieve 22%.

Table showing effects of Residential land on city canopy cover

Land zone	Area (ha)	2018/2019 canopy cover	Draft canopy cover targets	Projected canopy (ha)
commercial	515.53	4.60%	10%	52
industrial	2095.77	3.68%	10%	210
mixed use	111.71	2.01%	5%	6
open space	9493.73	23.24%	40%	3797
residential	10795.75	13.44%	20%	2159
rural	14577.16	11.39%	15%	2187
specific purpose	2714.04	8.73%	20%	543
transport	3591.1	7.87%	15%	539

Projected canopy cover with residential land included	**22%**
Projected canopy cover with residential land excluded	**17%**

3.4.22 Some consultation respondents expressed concerns about the potential difficulties with calculating the required canopy cover or the value of financial contributions. The proposed rules have been expanded to include step by step instructions on how to do that. The Council is also developing an on-line calculator that will allow developers to easily check what their required canopy cover or financial contributions are going to be.

3.4.23 A blanket protection of all existing mature trees in the city, as suggested in some of the feedback, is not permitted by the RMA. Some went as far as suggesting penalties for removing mature trees

[5] Urban Forest Canopy Cover, J Morgenroth, 2020

to allow for new development. The Council does not have a database of existing mature trees, other than the scheduled significant trees, therefore it would be hard to enforce any such rule.

3.5 Consultation with iwi authorities

3.5.1 Consultation on the draft proposal was also undertaken with the local Iwi authorities Te Rūnanga O Ngāi Tahu through Mahaanui Kurataiao Limited. No feedback specific to the tree canopy cover / financial contributions section of Plan Change 14 was received at the pre-notification consultation stage.

4 Scale and significance evaluation

4.1 The degree of shift in the provisions

4.1.1 The level of detail in the evaluation of the proposal has been determined by the degree of shift of the proposed provisions from the status quo and the scale of effects anticipated from the proposal. The details of the proposed changes are described above in 3.3.

4.1.2 The degree of shift in the objectives and provisions from the status quo is not considered to be significant. However, when the operative plan provisions are considered in conjunction with the implementation of the new MDRS and high density residential zone frameworks, the new requirements for provision of tree canopy cover in all residential zones and/or payment of financial contributions may have a moderate impact on how new residential developments are designed and executed.

4.1.3 While the current strategic objective 3.3.9 seeks to protect and appropriately manage significant natural resources, including natural features and landscapes and the life-supporting capacity of ecosystems, this is not applied specifically to the tree canopy cover in the city. This plan change is proposing to rectify that in recognition of the important ecosystem services and other benefits that trees provide. This is particularly important in light of the recent tree canopy survey results that show that our canopy cover in the city is declining and that most of that decline is occurring in the residential redevelopment areas. The link between redevelopment of the entire site and tree loss has been researched in the paper referred to in paragraph 3.1.6, Table 1(f) above.

4.1.4 Currently the rules for low density residential and density transition zones do not require any tree planting in the landscaping areas for a single dwelling development. Multi-unit developments in these zones, however, and developments in the central city and medium density zone are required to provide 20% of the site for landscaping, half of which needs to be planted in trees and shrubs.

4.1.5 The new residential standards introduced by the MDRS in clause 18 of Schedule 3A of the RMA, and proposed to be implemented through PC14, require that 20% of the site is dedicated to landscaping but there are no requirements to plant trees within or outside of the landscape areas. The changes proposed in this plan change will require that trees be planted in all residential developments (where subdivision is proposed) to achieve a tree canopy cover of 20% of the net site area at maturity. The trees could be planted anywhere on the site where no buildings or impervious surfaces are proposed, including in the landscape areas. Overall, the shift from the current tree planting requirements to the proposed rules is considered not to be significant if the required trees are retained or planted on the development site.

4.2 Scale and significance of effects

4.2.1 The scale and significance of the likely effects anticipated from the implementation of the proposal have also been evaluated. The initial assessment of the environmental, economic, social and cultural effects anticipated has been verified and expanded on by the technical and specialist advice obtained. In making this evaluation regard has been had to whether the proposal:

a. will result in effects that have been considered, implicitly or explicitly, by higher order documents, and will:
   i. give effect to the relevant higher level RMA document; and/or
   ii. help implement non-statutory initiatives, strategies and plans, e.g. Tree Policy, Biodiversity Strategy 2008-2035 , Christchurch Climate Resilience Strategy 2021, and the draft Urban Forest Plan (under development);

b. will have positive/negative impact on Part 2 matters, including positive or negative effects on people's amenity, health and their economic, social and cultural wellbeing;

c. will be a significant shift from the current provisions;

d. will give better effect to the Plan objectives;

e. is of localised or city wide significance;

f. will address known concerns about tree loss in the city;

g. will affect options for people who were contemplating residential development;

h. will impose significant costs on individuals or communities.

i. is likely to positively affect those with particular interests, including Maori, and on resources of significance to iwi (matter of national importance in terms of Section 6 of the Act);

j. will have certain benefits and costs.

4.2.2 The strengthened Strategic Objective 3.3.9 and the proposed new Urban tree canopy cover Objective 8.2.6 will better reflect and give effect to the higher order directions, as outlined in 2.1.5 above, and to the purpose of the Act. Urban canopy cover will help mitigate adverse effects of development on the environment and help safeguard the life-supporting capacity of air, water and ecosystems. The proposal will also ensure the Plan provisions are better aligned with other Council strategies and plans seeking to enhance the city's natural environment and its resilience. The proposal will also address the concerns of the public, Councillors and Council staff about the declining tree canopy cover in Christchurch and the effect of the decline on our environment, biodiversity and amenity.

4.2.3 While the proposal will have some monetary and design impacts on those developing residential land, through having to retain or plant trees on the development site, the effects are not dissimilar to those currently applicable to medium density zones through the existing landscape and tree planting provisions. These costs will apply only to new residential subdivisions/developments across the Christchurch City part of the Christchurch District, i.e. they will not affect Banks Peninsula where the level of canopy cover is much better.

4.2.4 If the developer chooses not to retain or plant trees on the site, financial contributions are required to be paid in lieu, to enable the Council to plant the equivalent tree cover off-site, on Council owned land. The impact of paying financial contributions may be more significant than that of on-site tree planting as financial contributions include the cost of the Council purchasing sufficient land for tree planting. It is noted that the amount of land is measured by the size of the tree pit required to accommodate the roots of the tree, rather than the canopy size.

4.2.5 The benefits of maintaining and enhancing the urban tree canopy cover are likely to be more noticeable in a few years' time when the trees grow and reach a more substantial canopy size. They will provide additional ecological services though carbon sequestration, stormwater runoff mitigation, shading and cooling that will mitigate heat island effects, and create better links and environment for the local fauna. With the likelihood of some more indigenous planting (the Infrastructure Design Standards tree list will contain a fair selection of native species), the indigenous biodiversity will also benefit through additional food sources and better links between more substantial urban forest patches on public or rural land. The amenity of residential neighbourhoods will improve, with added benefits to the community's well-being and health.

5 Evaluation of the proposal

5.1 Statutory evaluation

5.1.1 A change to a district plan should be designed to accord with sections 74 and 75 of the Act to assist the territorial authority to carry out its functions, as described in s31, so as to achieve the purpose of the Act. The aim of the analysis in this section of the report is to evaluate whether and/or to what extent the proposed Tree canopy cover / Financial contributions section of Plan Change 14 (PC14-FC) meets the applicable statutory requirements, including the District Plan objectives. The relevant higher order documents and their directions are outlined in section 2.1 of this report. Section 3.2 above sets out the directions provided by the District Plan strategic objectives in Chapter 3 and in the Chapter 14 residential objectives, as proposed to be amended by PC14, that are specifically concerned with the quality, character, and amenity of residential areas.

5.2 Evaluation of objectives

5.2.1 Section 32 requires an evaluation of the extent to which the objectives[6] of the proposal are the most appropriate way to achieve the purpose of the Act (s32(1)(a)). This plan change proposes to amend and add new objectives to the Plan. This section of the report, therefore, examines whether the proposed objectives are the most appropriate way to achieve the purpose of the Act.

5.2.2 For the purposes of changing the District Plan, Rule 3.3.a (Interpretation) of the District Plan imposes an internal hierarchy for the District Plan objectives. Strategic Directions objectives 3.3.1 and 3.3.2 have relative primacy whereby all other Strategic Directions objectives are to be expressed and achieved in a manner consistent with those objectives. Furthermore, objectives and policies in all other chapters of the District Plan are to be expressed and achieved in a manner consistent with the Strategic Directions objectives. In this case, an addition is proposed to Strategic Objective 3.3.9 to ensure that the tree canopy cover in Christchurch maintains and enhances the city's biodiversity and amenity, and provides important ecosystem/regulating services such as carbon sequestration, stormwater runoff and heat island effects mitigation.

5.2.3 The proposed new Objective 8.2.6 is consistent with the amended Strategic Objective 3.3.9 by seeking outcomes that will achieve Objective 3.3.9.

[6] Section 32(6) defines "objectives" and "proposal" in terms specific to sections 32 – 32A. "Objectives" are defined as meaning:
(a) for a proposal that contains or states objectives, those objectives;
(b) for all other proposals, the purpose of the proposal.

5.2.4 The amendments are consistent with the overarching Strategic Objective 3.3.1 which seeks that future enhancements to the city are done in a manner that meets the community's social and wellbeing needs, and sustains the important qualities and values of natural environment. Maintaining and enhancing the city's urban tree canopy cover is consistent with these goals and will have positive effects to offset adverse effects of residential intensification.

5.2.5 The evaluation summarised in the table below shows that the proposed amendments are also consistent with the direction provided in the CRPS Objectives 5.2.1, 6.2.1, 6.2.3 and 9.2.1, and the supporting policies, which seek to maintain and enhance the overall quality of the region's natural environment, provide quality, healthy and sustainable living environments, and to protect and enhance our biodiversity, ecosystems and the quality of water and air. The proposed Objective 8.2.6 and the addition to Strategic Objective 3.3.9 will also give better effect to NPS-UD Objectives 1, 7 and 8 through supporting reductions in the city's greenhouse gas emissions, improving resilience to the effects of climate change, and creating urban environments that are healthier and better able to ensure people's social and cultural well-being.

Objective	Summary of Evaluation
Objective 3.3.9 – Option 1 – Amend the objective to recognise the values of urban tree canopy cover *3.3.9 Objective - Natural and cultural environment* *a. A natural and cultural environment where:* *i. People have access to a high quality network of public open space and recreation opportunities, including areas of natural character and natural landscape; and* *ii. Important natural resources are identified and their specifically recognised values are appropriately managed, including:* *A. outstanding natural features and landscapes, including the Waimakariri River, Lake Ellesmere/Te Waihora, and parts of the Port Hills/Nga Kohatu Whakarakaraka o Tamatea Pokai Whenua and Banks*	*a. The intent of Objective 3.3.9 is to ensure that the important qualities and values of the city's natural and cultural environment, and the important resources are recognised and appropriately managed, consistent with the CRPS Objective 5.2.1 and 9.2.1.* *b. This option additionally provides for the maintenance and enhancement of urban tree canopy cover which provides important ecosystem services, improves the city's biodiversity and people's health and wellbeing. This approach is consistent with CRPS Objective 5.2.1, 6.2.1, and 9.2.1, and gives effect to the NPS-UD Objectives 8 through supporting mitigation of greenhouse gas emissions and improving resilience to climate change effects. It is also consistent with the IMP Objectives 5.4(5) and (7), and 5.5.* *c. The proposed amendment will help implement quality and well-functioning living environment which is healthy, environmentally sustainable and functionally efficient, consistent with CRPS Objective 6.2.3 and 9.2.1, and the NPS-UD Objective 8.* *d. Proposed amended Objective 3.3.9 will promote restoration and enhancement of the city's ecosystems and biodiversity consistent with CRPS Objective 9.2.1 and supporting policies 9.3.3 and 9.3.4, IMP Objectives 5.4 and 5.5.* *e. Using updated information about the city's declining tree canopy cover (refer two Christchurch tree canopy cover surveys) to inform planning interventions is consistent with the NPS-UD Objective 7.* *f. Amended Objective3.3.9 seeks to address the following resource management issues identified earlier, namely:*

Peninsula/Te Pātaka o Rakaihautu; and *B. the natural character of the coastal environment, wetlands, lakes and rivers, springs/puna, lagoons/hapua and their margins; and* *C. indigenous ecosystems, particularly those supporting significant indigenous vegetation and significant habitats supporting indigenous fauna, and/or supporting Ngāi Tahu mana whenua cultural and spiritual values; and* *D. the mauri and life-supporting capacity of ecosystems and resources; and* *E. <u>Tree canopy cover in urban areas that maintains and enhances the city's biodiversity and amenity, sequesters carbon, reduces stormwater runoff, and mitigates heat island effects; and</u>* *iii. Objects, structures, places, water/wai, landscapes and areas that are historically important, or of cultural or spiritual importance to Ngāi Tahu mana whenua, are identified and appropriately managed.*	*i. Loss of tree canopy cover through development/urban intensification and insufficient replacement planting (Issue 1)* *ii. Insufficient tree planting in greenfield and brownfield residential subdivisions (Issue 2)* *iii. Diminishing canopy cover in intensifying urban environment contributes to these adverse effects: increased carbon emissions, stormwater runoff and heat island effects, and deteriorating biodiversity and amenity (Issue 4)* *Option 1 (Proposed amended Objective 3.3.9) would (in the context of Part 2 matters) have the following benefits:* *g. Ensure the tree canopy cover in Christchurch maintains and enhances the city's biodiversity and amenity, and provides important ecosystem/regulating services, including carbon sequestration, and stormwater runoff and heat island effects mitigation. It is consistent with the CRPS Chapter 6 and 9 objectives identified above, and the NPS-UD Objective 1 and 8.* *h. Maintain and enhance the overall quality of the region's natural environment, provide quality, healthy and more sustainable living environments, protect and enhance our biodiversity, ecosystems and the quality of water and air. (consistent with CRPS Objectives 5.2.1, 6.2.1, 6.2.3 and 9.2.1)* *i. Support reductions in the city's greenhouse gas emissions, improve resilience to the effects of climate change. (NPS-UD Objective 8)* *j. Help create urban environments that are healthier and better able to ensure people's social and cultural well-being. (NPS-UD Objectives 1)* *k. Mitigate adverse effects of (new residential) activities on the environment (Section 5)* *l. Better safeguard the life-supporting capacity of air, water, and ecosystems (Section 5)* *m. Provide for the relationship of Maori and their culture and traditions with their ancestral lands, water, and other taonga (Section 6)* *n. Maintain and enhance amenity values and the quality of the environment (Sections 7(c) and (f)).* *Option 1 (Proposed amended Objective 3.3.9) could potentially have the following disadvantages:* *o. May require some alterations to the design of development to provide sufficient space for tree roots/canopy cover;* *p. Potential additional costs to developer, particularly if they opt to pay financial contributions in lieu of on-site tree retention/planting;*

	q. The Council may not always be able to plant trees funded by financial contributions close to the development site; *r. Large trees may be viewed by some residents as a nuisance, in terms of shading and leaf fall;* *s. Does not address the deficiency of trees in existing areas that are not being redeveloped;* *t. May not address the balance between exotic and indigenous species (support for indigenous biodiversity vs better efficiency of exotics in regulating services).*
Objective 3.3.9 - Option 2 Status quo *(No specific reference to / support for enhancing tree canopy cover)* *Retention of unchanged Objective 3.3.9*	*a. The current Objective 3.3.9 is largely consistent with the CRPS Objectives 5.2.1, 6.2.1, and 9.2.1 in that it seeks to:* *i. Identify important natural features and landscapes and appropriately manage their specifically recognised values, including:* *A. outstanding natural features and landscapes;* *B. natural character of the coastal environment, wetlands, lakes and rivers, springs, lagoons;* *C. indigenous ecosystems;* *D. the mauri and life-supporting capacity of ecosystems and resources; and* *ii. Identify objects, places, water, landscapes and areas that are historically important, or of cultural or spiritual importance to Ngāi Tahu mana whenua;* *iii. Ensure people's access to natural landscapes and area of natural character.* *b. While the objective seeks to recognise important features and landscapes, and important natural resources, it does not extend to recognising the values of tree canopy cover or its role in mitigating many adverse effects of urban development which leaves a potential gap in terms of achieving the CRPS Objective 9.2.1 or IMP Objectives 5.4.* *c. The current objective supports recognition of significant indigenous ecosystems (consistent with CRPS Objective 6.2.1 , and IMPs Objective 5.4 and 5.5) but does not recognise the value of the overall tree canopy cover (which may not meet the 'significant feature' criteria) and its ecosystem/regulating services with respect to low environmental impact development, managing stormwater runoff and improving water quality.* *d. The objective does not specifically address the issue of declining tree canopy cover in the city as it does not specifically seek to enhance or appropriately manage it;* *e. The objective does not address the issue of adverse effects of residential intensification on the city's stormwater quantity and quality, or an increase in carbon emissions;* *f. The issue of increased building and impervious surfaces mass raising the urban temperatures, and the declining*

	number of trees being less effective in cooling that environment will not be addressed; *g. The role of private property and street tree canopy cover in providing links and enriching the overall biodiversity will remain unrecognised.*
Option 1 – New Objective 8.2.6 - Urban tree canopy cover *a. Tree canopy cover in areas of residential activities is enhanced through maintaining existing trees and/or planting new trees as part of new residential development to sequester carbon from emissions, reduce stormwater runoff, mitigate heat island effects, and improve the city's biodiversity and amenity.*	*a. This option provides for enhancement of urban tree canopy cover to provide important ecosystem services and improve the city's biodiversity and amenity. This approach is consistent with CRPS Objective 5.2.1, 6.2.1, and 9.2.1, and gives effect to the NPS-UD Objectives 8 through supporting mitigation of greenhouse gas emissions and improving resilience to climate change effects. It is also consistent with the IMP Objectives 5.4(5) and (7), and 5.5.* *b. The new objective is consistent with the amended Strategic Objective 3.3.9 as well the overarching Strategic Objective 3.3.1 in that it will help to sustain the important values, qualities and functions of natural environment;* *c. The proposed objective will help achieve a well-functioning living environment which is healthy, environmentally sustainable and functionally efficient, consistent with CRPS Objective 6.2.3 and 9.2.1, and the NPS-UD Objective 8.* *d. Proposed Objective 8.2.6 will promote restoration and enhancement of the city's ecosystems and biodiversity consistent with CRPS Objective 9.2.1 and supporting policies 9.3.3 and 9.3.4, and IMP Objectives 5.4 and 5.5.* *e. New Objective 8.2.6 seeks to address the following resource management issues identified earlier:* *i. Loss of tree canopy cover through development/urban intensification and insufficient tree replacement (Issue 1)* *ii. Insufficient tree planting in greenfield and brownfield residential subdivisions (Issue 2)* *iii. Inadequate soil volumes and placement to allow trees to grow healthily while avoiding damage to the surrounding environment (Issue 3)* *iv. Diminishing canopy cover in urban environment which contributes to these adverse effects: increased carbon emissions, increased stormwater runoff and heat island effects, and deteriorating biodiversity and amenity (Issue 4)* *Option 1 (Proposed Objective 8.2.6) would (in the context of Part 2 matters) have the following benefits:* *f. Ensure the tree canopy cover in Christchurch maintains and enhances the city's biodiversity and amenity, and provides important ecosystem/regulating services, i.e. carbon sequestration, stormwater runoff attenuation and heat island effects mitigation. It is consistent with the amended*

	Strategic Objective 3.3.9, the relevant CRPS Chapter 6 and 9 objectives identified above, and NPS-UD Objectives 1 and 8. *g. Maintain and enhance the overall quality of the city's natural environment, provide quality, healthy and sustainable living environments, and ecosystems. (consistent with CRPS Objectives 5.2.1, 6.2.1, 6.2.3 and 9.2.1)* *h. Support reductions in the city's greenhouse gas emissions, improve resilience to the effects of climate change. (NPS-UD Objective 8)* *i. Help create urban environments that are healthier and better able to ensure people's social and cultural well-being. (NPS-UD Objectives 1)* *j. Mitigate adverse effects of (residential development) activities on the environment (Section 5)* *k. Better safeguard the life-supporting capacity of air, water, and ecosystems (Section 5)* *l. Provide for relationship of Maori and their culture and traditions with their ancestral lands, water, and other taonga (Section 6)* *m. Maintain and enhance amenity values and the quality of the environment (Sections 7(c) and (f)).* *Option 1 (Proposed Objective 8.2.6) could potentially have the following disadvantages:* *n. May require alterations to the design of development to provide sufficient space for tree roots/canopy cover;* *o. Potential additional costs to developer, particularly if they opt to pay financial contributions in lieu of tree retention/planting;* *p. The Council may not always be able to plant trees funded by financial contributions close to the development site;* *q. Large trees may be viewed by some residents as a nuisance, in terms of shading and leaf fall;* *r. Does not address the deficiency of trees in existing areas that are not being redeveloped;* *s. May not address the balance between exotic and indigenous species (support for indigenous biodiversity vs better efficiency of exotics in regulating services).*
Option 2 - No new Chapter 8 objectives on tree canopy cover	*Option 2 would have the following disadvantages:* *a. No support for the amended Objective 3.3.9, therefore, the outcomes of subdivision/development resulting from intensification may not be consistent with the CRPS Objectives 5.2.1, 6.2.1, and 9.2.1 in that the current subdivision objective, policies and rules may not sufficiently recognise the mauri and life-supporting capacity of ecosystems supported by trees;*

	b. This option does not recognise the values of tree canopy cover or its role in mitigating adverse effects of urban development or its ecosystem/regulating services, therefore, the outcomes may not achieve the CRPS Objectives 6.2.1 and 9.2.1 and/or IMP Objectives 5.4 and 5.5; *c. The status quo option will not address the issue of declining tree canopy cover in the city;* *d. Option 2 will not address the issue of adverse effects of residential intensification on the city's stormwater quantity and quality, or an increase in carbon emissions as a result of intensification;* *e. The issue of increased building and impervious surfaces mass raising the urban temperatures and the declining number of trees being ineffective in cooling that environment will not be addressed;* *f. The role of private property and street tree canopy cover in providing links and enriching the overall biodiversity would remain unrecognised;* *Option 2 (status quo) could have the following benefits:* *g. No additional requirements in terms of development design;* *h. No additional costs to developers or encumbrances on property owners;* *i. Complaints about shading or leaf fall less likely.*
Recommendation: The evaluation shows that urban tree canopy cover plays an important role across several areas of the city's natural environment and indicates that the amended Strategic Objective 3.3.9 and proposed new Objective 8.2.6 give better effect to the relevant higher order directions seeking to provide high quality and amenity urban environment that protects and enhances the city's biodiversity and ensures the community's wellbeing. The objectives recognise the important role that tree canopy cover plays in addressing adverse effects of development through its ecosystem/regulating services. The proposed Objectives 3.3.9 and 8.2.6 are, therefore, recommended as the most appropriate way to achieve the purpose of the Act.	

5.3 Reasonably practicable options for provisions

5.3.1 In considering reasonably practicable options for achieving the objectives of the Plan, the following options for supporting policies and rules have been identified. Taking into account the environmental, economic, social and cultural effects, the options identified were assessed in terms of their benefits, and costs. Based on that, the overall efficiency and effectiveness of the alternative options were assessed.

5.3.2 Option 1 – Status quo - no provisions for tree planting to:

a. compensate for the loss of tree canopy cover through development; and

b. address adverse effects of subdivision/development on the environment.

5.3.3 Option 2 – Charge development contributions (DC), under the Local Government Act, for tree canopy cover treated as infrastructure.

5.3.4 Option 3 – Introduce a financial contribution (FC), under s77E of the Resource Management Act (RMA), to cover the costs of mitigating adverse effects of new subdivision/development through provision of tree canopy cover.

5.4 Evaluation of options for provisions

5.4.1 The policies of the proposal must implement the objectives of the District Plan (s75(1)(b)), and the rules are to implement the policies of the District Plan (s75(1)(c)). The evaluation of the identified options will examine the effectiveness of the provisions in achieving the relevant objectives of the Plan.

5.4.2 The relevant objectives and policies are outlined in more detail in section 3.2 and the changes to objectives proposed in this plan change are summarised and evaluated in section 5.2 above. The proposed changes to the rules are summarised in 3.3 above.

5.4.3 A number of Chapter 14 (Residential) objectives and policies (refer to 3.2) are relevant to this proposal in that they seek residential environments to be well designed, sustainable and of high quality. Neighbourhoods are sought to have a strong sense of place and attractiveness to residents, engage with the street and other places through design and landscaping, be functional and support and enhance ecological features and values. These objectives and policies broadly align with the outcome sought in Strategic Objective 3.3.9 to provide people with access to natural character and natural landscape, and the outcome of maintaining and enhancing the city's tree canopy cover proposed through the amendment sought in this plan change.

5.4.4 The relevant residential chapter objectives and policies also broadly align with the proposed new Objective 8.2.6 and supporting Policies 8.2.6.1 – 8.2.6.3 in Chapter 8 Subdivision that seek enhancement of the tree canopy cover in residential subdivisions/developments. There is currently a gap in the subdivision rules as none require provision of urban canopy cover in residential subdivision and development, therefore, the outcomes proposed in the amended and new objectives would not be likely to be achieved. Consequently, this Plan Change proposes tree canopy cover rules in support of the outcomes sought.

5.4.5 A detailed evaluation of the policies and rules proposed in the Plan Change, and the alternative options identified, has been carried out in terms of their potential costs and benefits, based on the anticipated environmental, economic, social, and cultural effects. The evaluation includes consideration of the overall appropriateness, based on efficiency and effectiveness, to achieving the objectives of the Plan and the purpose of the Act, as well as the risks of acting or not acting.

5.4.6 Evaluation of methods - Options 1 to 3 (Note: The costs and benefits considered include environmental, economic, social and cultural costs.)

Evaluation of Options		
Option 1 - Status Quo	Option 2 – Development contributions for tree canopy cover (DC)	Option 3 – Proposed Plan Change – Tree canopy cover requirements/ Financial Contributions (FC)
Status quo – no provisions for tree canopy cover planting to maintain and/or enhance the canopy cover and its benefits in areas of residential subdivision/development or to compensate for any loss of tree canopy cover through development. Benefits: No changes to the District Plan or the Development Contributions Policy required and no associated costs to the Council or developer. (economic) No instruments registered on the property title affecting current and future owners. (social, economic) Developers of greenfield subdivisions may continue to plant some street trees in future road corridors for amenity. (social, environmental) Costs: No specific incentive to retain existing trees during development or to plant new trees. (environmental, social/amenity) Adverse effects of urban development, including those contributing to climate change, such as: - increased carbon emissions;	Charge a development contribution (DC) under the Local Government Act (LGA) to fund the necessary infrastructure provision to service urban growth to the required level of service. The infrastructure, in this case, being trees planted on- and off-site to achieve the required tree canopy cover levels of: - 20% of net site area (residential re/development), and - An additional 15% of the future road corridor area (in residential greenfield development or brownfield where new roads are created). Charging DCs to enable the Council to provide tree canopy cover would be a novel use of the DC power. Benefits: Increase in on-site and street tree canopy cover with the associated environmental, social and cultural benefits as in Option 3. As in Option 3, adverse effects of residential subdivision/ development on the environment are addressed on-site or off-site through DCs. (environmental) Place-making benefits, urban landscape legibility. (social, cultural)	Introduce requirements for tree canopy cover provision on development sites and in future road reserves to achieve the required tree canopy cover of: - 20% of net site area (residential re/development), and - An additional 15% of the future road corridor area (residential greenfield development or brownfield where new roads are created). Consent notice would be required to be registered on the title to ensure trees are retained and appropriately maintained by all future owners. Where sufficient tree canopy cover is not retained or planted on the site or the future road corridor, payment of financial contributions (FC) in lieu of planting (RMA, s77E) would be payable to cover the costs of planting the equivalent tree cover by the Council on public land, as close as practicable to the development site. FCs would be based on: - an average cost of a tree(s), - cost of planting (may require construction of an engineered road tree pit), - juvenile tree maintenance; and - a fair and proportional cost of purchasing land for planting of the required tree(s) off-site. Benefits:

Evaluation of Options		
Option 1 - Status Quo	Option 2 – Development contributions for tree canopy cover (DC)	Option 3 – Proposed Plan Change – Tree canopy cover requirements/ Financial Contributions (FC)
- increased stormwater runoff; - increase in heat island effects; - decreased biodiversity and amenity will remain not addressed. (environmental, social, economic, cultural) Potential for further loss of tree canopy cover through intensive development enabled by the MDRS introduced by the Amendment Act and NPS-UD. (environmental, social, cultural) No provisions for tree planting (indigenous or exotic) in the landscape or other areas of the site in the MDRS, therefore, no incentive for developers to retain or plant any trees. (environmental, social, cultural) Reliance on the Council to create more urban forest patches on Council land at the ratepayers' expense. (economic) Planting of trees on available public land away from the site will not deal with the adverse effects of development on the site and the immediate surrounds as effectively. (environmental) Planting of maximum canopy cover on public land only will not achieve the 20% canopy cover target for Christchurch. (environmental, social, economic) Provision of some street trees by developers of greenfield subdivisions may continue to	Incentive to retain existing mature on-site trees or plant replacement trees on-site to avoid DC costs. (environmental, economic, social) DC charges would be included in the Development Contributions Policy which can be changed/updated as needed relatively easily. (administrative, economic) The associated Level of Service for tree canopy cover for new development would need to be set and the associated capex programme established in the Long Term Plan (LTP) providing the ability to review regularly. (administrative) The revenue collected is spent on the purpose for which it has been taken, as in Option 3. (economic, environmental, social) Costs: Additional costs to the developer/land owner (economic). DCs are used to service growth development (new or upgraded infrastructure) and are not linked to mitigating adverse effects of new development on the environment. Potential difficulty in establishing the level of service. (administrative) Tree provision may not be viewed as provision of the necessary infrastructure to service growth. (social, economic) To ensure the same level of service provision (tree canopy cover) everywhere, some rates funding is likely to be required to fund tree planting in the	Adverse effects of residential subdivision/development on the environment are addressed on-site (as the first option) or off-site (as a second option) through tree planting or FCs. (environmental) Increase of on-site and street tree canopy cover which would have beneficial effects on: - The overall target tree canopy cover for the city; - Carbon sequestration and storage; - Stormwater runoff attenuation; - Heat island effects (shade and infrastructure longevity); - Biodiversity; - Amenity. (environmental, social, cultural) Place-making benefits, urban landscape legibility. (social, cultural) Incentive to retain existing mature on-site trees or plant replacement trees on site to avoid FC costs. (environmental, economic, social) Trees would be appropriately maintained and retained in perpetuity or replaced, if diseased, through consent notice. (environmental, social, cultural) Some rules flexibility allowing consideration of taking land in lieu of FCs in subdivisions with, for example, land constraints. (economic, environmental) The revenue collected is spent on the purpose for which it has been taken (the relevant processes would be set up once the changes proposed are approved and operative) and, unlike DCs, is not driven by the Long

Evaluation of Options		
Option 1 - Status Quo	Option 2 – Development contributions for tree canopy cover (DC)	Option 3 – Proposed Plan Change – Tree canopy cover requirements/ Financial Contributions (FC)
be inappropriate (species/root space) and insufficient to offset the environmental effects of new development. (environmental) Efficiency and effectiveness: This option would be inefficient and ineffective in addressing the loss of tree canopy cover in the city through intensification and/or insufficient new tree planting to meet the recommended canopy cover target for Christchurch. Inefficient and ineffective in addressing adverse effects of development such as increased carbon emissions, heat island effects, excessive stormwater runoff, loss of biodiversity and diminishing amenity. Ineffective in achieving the relevant Plan objectives.	existing areas where no tree DCs have been collected through new development - additional burden on rate payers. (economic, social) The additional charges through rates would not be linked to mitigating the effects of new development. (social, economic) Inability to plant trees in the street adjacent or nearby to the development site and the need to plant the trees elsewhere may create a conflict with the level of service that the DCs collected are meant to achieve in the affected area. (social, economic, environmental) Inability to use consent notice as a legal instrument to protect trees in perpetuity, therefore, it would be difficult to ensure that the tree canopy cover is maintained over time. (economic, administrative) A risk that DCs for trees, being a relatively small portion of development costs, may not incentivise on-site tree retention or planting in the first instance. (environmental) As with Option 3, additional costs to the Council associated with monitoring and enforcement. (economic) Efficiency and effectiveness: If, due to increased expectations, the level of service was extended to existing properties, the DC fees collected would be insufficient to cover the cost of service provision across all areas, therefore	Term Plan spending schedules. (economic, environmental) Unlike Option 2, FCs do not create the risk of additional levies through rates as they are based on addressing adverse effects of a particular development rather than providing levels of service that may be expected to be the same across the city, regardless of the level of development in the area and related contributions. (economic, social) Costs: Additional costs to the developer/land owner. (economic) Potential effects on development design to ensure sufficient soil volume and permeability is provided for trees. (economic) As would be the case with DCs (Option 2), a potentially high cost of purchasing land for planting trees adds to the overall level of FCs. (economic) FCs, being a relatively small portion of development costs, may not be a sufficient incentive to retain on-site trees or to plant the required trees on the development site as a first option. (environmental, social, cultural) Additional costs to the Council associated with consenting, monitoring and enforcement. (administrative, economic) Efficiency and effectiveness: This option would be more effective than Option 1 in addressing environmental effects of development and addressing the issues identified.

Evaluation of Options		
Option 1 - Status Quo	Option 2 – Development contributions for tree canopy cover (DC)	Option 3 – Proposed Plan Change – Tree canopy cover requirements/ Financial Contributions (FC)
	ineffective in addressing the adverse effects of new development and potentially inequitable. Would not be as effective as Option 3 in achieving the Plan objectives, particularly because of inability to secure the tree canopy cover over time or to effectively encourage developers to plant trees on the site in the first instance. In terms of fees collected, this option could be as effective as Option 3 in areas of new development but ineffective in providing equitable level of service across the city. Likely less effective in the long-term protection of trees, as the bespoke consent notice scheme for subdivision consents would not be utilised. This option may not be as efficient as Option 3 in terms of the use of funds collected for the stated purpose due to potential LTP process inefficiencies.	Effective in achieving the relevant Plan objectives. This option would be efficient in providing funding directly for the purpose that the charges were collected for. In terms of fees collected to address adverse effects of development on the environment, this option would be as effective as Option 2 without the potential inefficiencies of the LTP process and the risk of additional rates charges to provide improved tree cover in areas with no or little development. This option is relatively simple therefore it is more efficient and effective than Option 2.
Recommendations:		
Option 1 is not recommended as it is considered inefficient in terms of the balance of costs and benefits. It is ineffective in addressing the issues identified or achieving the relevant Plan objectives.	Option 2 is not recommended as it is not considered to be as effective in addressing the issues identified in the areas most affected. More efficient and effective alternative provisions are outlined in Option 3.	Option 3 is the preferred option and is recommended as the most efficient and effective option of the alternatives considered. The recommended proposal addresses the issues identified, and the benefits of the proposed amendments outweigh the costs. It provides alternative mechanisms for developers to contribute appropriately to tree canopy cover across the city. The proposed solutions to the issues are considered more effective than the other options in achieving the relevant Plan objectives and the desired outcomes.

Evaluation of Options		
Option 1 - Status Quo	Option 2 – Development contributions for tree canopy cover (DC)	Option 3 – Proposed Plan Change – Tree canopy cover requirements/ Financial Contributions (FC)
Risk[7] of acting or not acting		
With the imminent increase in development intensification enabled by the NPS-UD and RMA Schedule 3A, the risk of not acting is far greater than the risk of acting. The recent 2018/2019 survey of the tree canopy cover in Christchurch indicates that the overall canopy cover is now at 13.5% which represents a 2% loss since 2016. CCC owned land had 23% canopy cover, crown land had 16% canopy cover and private land had 11% canopy cover. While the public land lost 1% of the cover (mainly due to plantation forest felling and Port Hills fires), the biggest loss (2%) occurred on privately owned land, predominantly where redevelopment occurred. With nearly 70% of land in Christchurch being in private ownership and 57% of tree canopy cover being on private land, the risk of further canopy loss across the city is very real. To reverse that trend and address the associated adverse effects, the tree canopy cover in the city needs to be maintained and increased. Even with the maximum planting targets on all vacant Council land (e.g. former Red Zone), the 20% canopy cover target cannot be achieved without additional tree planting on private land.		

[7] Risk is the likelihood or probability of an effect and the cost of the consequence occurring = 'likelihood times consequence'.

5.5 The most appropriate option

5.5.1 Option 3 is considered to be the most appropriate option for achieving the purpose of the Act as it is the most efficient and effective of all options considered in addressing the issues identified. The benefits of the proposed amendments outweigh the costs. The proposed solutions are considered more effective in achieving the relevant Plan objectives and the desired outcomes than the alternatives considered.

5.5.2 Through providing the opportunity to plant trees on the development site instead of paying financial contributions, this option is more economic for developers, while ensuring the trees mitigate the effects of development at source. Trees are very effective and efficient in absorbing and storing greenhouse gases, thus helping the community to minimise our contribution to climate change. Christchurch is prone to flooding and an increase in impermeable surfaces, both from buildings and hard surfaces, and consequently an increased stormwater runoff, is likely to exacerbate the problem. Trees are capable of absorbing substantial amounts of rain water, particularly in less severe weather events, and releasing it slowly into the air through evaporation. They also redirect some of the rainfall into the ground and limit the amount of polluted water being washed away through the drains into our rivers.

5.5.3 Their shade helps to keep us and our houses cool in hot summer months, while street trees prolong the life of infrastructure and have a traffic calming effect. Mature trees contribute to the amenity and pleasantness of our environment while also providing health benefits to people living, playing and walking around them. They provide wayfinding and reference points in our urban environment, and add character to our civic spaces.

5.5.4 While the proposed provisions do not require trees of particular species to be planted for canopy cover, it is likely that some of the trees planted will be indigenous species. Improving the balance of indigenous species in the city's environment is of particular importance to mana whenua, not only because of cultural and historic references but also because indigenous vegetation is important to our indigenous biodiversity and natural environment.

5.5.5 The proposal will more effectively address the issues identified and help ensure the outcomes set out in the Plan objectives, as well as those in the higher order documents are achieved. Ultimately, the Option 3 proposal is considered to be the most appropriate way to achieve the purpose of the Act.

6 Conclusions

6.1.1 This part of proposed Plan Change 14 has been prepared to introduce tree canopy cover and financial contributions provisions to address adverse effects of residential intensification development on the city's environment and its tree canopy cover.

6.1.2 Christchurch City's canopy cover is comparatively low and decreasing. The recently undertaken survey of the tree canopy in Christchurch, using aerial imagery of the city from 2018/2019, indicates that the city's tree canopy covers 13.5% of land in Christchurch which is a 2% decrease since the last 2015/2016 survey. The survey also looked at canopy cover by land ownership and found that Christchurch City Council owned land had 23% tree canopy cover, Crown land had 16% canopy cover and private land had 11% canopy cover. Privately owned properties constitute 70% of all land ownership in Christchurch and that land has 57% of the city's canopy cover on it.

Consequently, the loss of trees on private land would greatly affect the overall cover in Christchurch and the ecosystem / regulating services that trees provide.

6.1.3 Much of the tree canopy loss is attributed to property redevelopment and intensification. With the enabling provisions of the Medium Density Residential Standards and the likely increase in residential intensification, that canopy cover is under threat of further losses. Appropriate mitigation measures need to be put in place to prevent that. The recommended 20% target canopy cover is consistent with the Christchurch grassland biome and would require a 6.5% increase from the current cover.

6.1.4 Tree canopy cover is not an issue in rural or open space zones, however, the Council will be launching its Urban Forest Plan in the near future and increasing tree planting in open space zones to boost the canopy cover in Christchurch. Many non-residential zones, e.g. industrial, have sufficient landscaping and tree planting requirements in place to ensure that canopy cover is maintained in such zones to the levels commensurate with the anticipated level and type of development in them. There are, however, no tree planting requirements in the new medium density residential standards, introduced through RMA, Schedule 3A, that will be applicable to most of the residential areas in Christchurch.

6.1.5 Additional objectives, policies and rules addressing this issue are, therefore, considered necessary. The proposed rules introduce additional matters of control for residential subdivision and development that will require provision of 20% tree canopy cover on residential sites, with additional 15% cover requirement for future road corridors in greenfield subdivisions.

6.1.6 As the evaluation in this section 32 analysis indicates, the proposed rules would ensure consistency with the Plan objectives and the higher order directions outlined above. Therefore, the proposal is considered to be the most appropriate way to achieve the purpose of the Act.

APPENDIX 1 – Urban trees and their ecosystem services

RESEARCH REPORT

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Urban trees and their ecosystem services

A review of the current state of knowledge on urban trees and carbon storage, sequestration, stormwater runoff attenuation, and urban heat island mitigation

Submitted to Christchurch City Council

Prepared by Assoc. Prof. Justin Morgenroth, University of Canterbury

26 April 2022

Abstract

Urban forests and trees provide a range of benefits, called ecosystem services. A subset of these are regulating services, including carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation. The focus of this report was to quantify the degree to which trees contribute to these regulating services. Moreover, the factors that influence trees' contribution were explored. These aims were achieved by reviewing the scientific literature pertaining to these topics. The review methodology resulted in roughly 100 scientific articles split across the three regulating services. These articles were used to quantify and qualify the role of trees with respect to carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation.

The review showed that above-ground carbon storage density for trees averaged 11.5 kg of carbon per square meter of tree canopy cover (range 1.7–28.9 kg C m^{-2}), while total carbon (above and below ground) storage density for trees had an average value of 7.95 kg/m^2 (range 0.8–36.1 kg C m^{-2}). Trees also reduced stormwater runoff, primarily by intercepting between 9% and 61% of total rainfall. Finally, ground surface temperatures were 0.6–22.8°C and air temperatures were 0.8–7° cooler beneath trees than in surrounding non-treed environments.

The variation in carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation was shown to be related to the quantity of trees (e.g., tree density or canopy cover), their configuration (fragmentation, clustering), and their structural characteristics (e.g., height, crown volume and shape, stem diameter, leaf area or density, wood density), the latter of which is influenced by tree species and age. More trees or tree cover, in clusters, with greater total biomass and wood density, will improve the regulating services researched in this report. In contrast, development intensity and impermeable surfaces (buildings and/or pavements), which are associated with reduced tree cover, threatened the provision of carbon storage and sequestration, stormwater runoff attenuation, and urban heat island mitigation by trees.

1. Urban Forests, Trees and Their Ecosystem Services

Urban forests are broadly defined to include trees, shrubs, herbaceous vegetation, other associated plants and fungi, as well as the soil that supports them. However, for the purposes of this report, a narrow definition is used, focusing only on trees in urban areas.

Rapid urbanisation is needed to support the increasingly large proportion of people choosing to live in cities and towns. In the past decades, researchers and policy makers have begun to explore and evaluate the potential of urban trees to provide benefits to these urbanised populations (Roy, Byrne, & Pickering, 2012).

The benefits provided by urban forests are collectively referred to as ecosystem services, though more recently, the term 'nature-based solutions' has also been used in the scientific literature (Escobedo, Giannico, Jim, Sanesi, & Lafortezza, 2019). Broadly-speaking, ecosystem services can be categorised as provisioning, cultural, supporting, and regulating (Millenium Ecosystem Assessment, 2005). Regulating services are able to moderate natural phenomena and are the focus of this review. Specifically, this review will explore and quantify the effect urban trees have on carbon storage and sequestration, attenuating stormwater runoff, and mitigating the urban heat island effect.

2. Literature Review Methods

A review of the scientific literature was undertaken using the Scopus database and Google Scholar. Search strings were designed to return journal articles and reviews pertaining to urban trees or urban forests (specifically excluding articles on urban greenspaces, which include, but are not limited to trees) and the three regulating services that form the basis for this report, that is carbon storage and sequestration, stormwater mitigation, and the urban heat island effect. A scan of article titles and subsequent review of article abstracts identified a subset of articles that were included in the formal review. While the search was initially limited to the last decade of scientific literature, that was expanded through backward chaining; this is where an article from the past decade cited a previous article. Through the process of identifying an initial subset of articles, formally reviewing them for suitability, then using backwards chaining, a total of 27 articles were found related to urban trees and carbon storage and sequestration, 35 articles related to stormwater mitigation, and 37 articles related to the urban heat island effect.

3. Urban Trees and Carbon Storage and Sequestration

3.1. Overview and Concepts

During photosynthesis, trees sequester carbon dioxide (CO_2) from the atmosphere. Energy provided by sunlight is used to combine CO_2 with water to produce oxygen and carbohydrates, the latter of which are subsequently used to support tree function and growth, i.e., increase biomass. The sequestration and storage of CO_2 from the atmosphere is one way to reduce anthropogenic climate change and urban forests can meaningfully contribute to this objective (Nowak & Crane, 2002).

3.2. Synthesis of Reviewed Literature

Studies on urban forest carbon storage and sequestration identify variability in results, but also important trends (Table 1). Some studies only measured above-ground carbon storage density, whereas most reported total (above-ground and below-ground) carbon storage density. Carbon density is a measure of how much carbon is stored (or sequestered) within the tree per square meter of canopy cover.

Above-ground carbon storage density was reported for five cities and ranged between 1.7–28.9 kg of carbon per square meter of tree canopy cover (kg C m^{-2}), with an average value of 11.5 kg C m^{-2}. Total carbon storage density was reported for 38 cities, with an average value of 7.95 kg C m^{-2} and a range of 0.8–36.1 kg C m^{-2} (Table 1). The reason that total carbon storage density is lower than above-ground carbon storage density is because below-ground carbon storage is typically much lower than above-ground carbon (Cairns, Brown, Helmer, & Baumgardner, 1997), so including it will reduce the whole tree carbon storage density.

It is important to understand that the reported carbon sequestration and storage density values are modelled, rather than measured. Things like tree height and stem diameter may be measured directly, but these are then used in mathematical formulas (called allometric formulas) to estimate above-ground or total carbon density. The allometric formulas used differ from study to study and are generally based on the best science available at the time of the study. As a consequence, we should be wary of comparing values across studies. This also helps us interpret the changes in carbon density storage that we see within individual cities. For example, many of the American cities included in the Nowak and Crane (2002) study were also included in the Nowak, Greenfield, Hoehn, and Lapoint (2013) study, a decade later. Many of those cities show reduced carbon storage density due to a combination of improvements in the allometric formulas and better estimates of tree canopy cover due to higher resolution aerial/satellite imagery.

Table 1 – Studies showing carbon sequestration and storage density.

Locality	**Sequestration density (kg C m^{-2} of canopy per year)**	**Storage density (kg C m^{-2} of canopy)**	**Above-ground or total carbon**	**Source**
Arlington, TX		6.37	Total	(Nowak et al., 2013)
Atlanta, GA		6.63	Total	(Nowak et al., 2013)
Atlanta, USA		9.7	Total	(Nowak & Crane, 2002)
Auckland, NZ	0.17		Total	(Schwendenmann & Mitchell, 2014)
Auckland, NZ		11.175	Above	(V. Wang & Gao, 2019)
Baltimore, MD		8.76	Total	(Nowak et al., 2013)
Baltimore, USA		10	Total	(Nowak & Crane, 2002)
Boston, MA	0.05		Above	(Trlica, Hutyra, Morreale, Smith, & Reinmann, 2020)
Boston, MA		7.02	Total	(Nowak et al., 2013)
Boston, MA		9.1	Total	(Nowak & Crane, 2002)
Brisbane, Australia		11.09	Above	(Mitchell et al., 2018)
Casper, WY		6.97	Total	(Nowak et al., 2013)
Charlotte, NC		5.36	Total	(Godwin, Chen, & Singh, 2015)
Chicago, IL		6.03	Total	(Nowak et al., 2013)
Chicago, IL		12.9	Total	(Nowak & Crane, 2002)
Freehold, NJ		11.5	Total	(Nowak et al., 2013)
Gainesville, FL		6.33	Total	(Nowak et al., 2013)
Golden, CO		5.88	Total	(Nowak et al., 2013)

Hamburg, Germany		2.74	Total	(Dorendorf, Eschenbach, Schmidt, & Jensen, 2015)
Hartford, CT		10.89	Total	(Nowak et al., 2013)
Indiana, USA		8.8	Total	(Nowak et al., 2013)
Jersey City, NJ		4.37	Total	(Nowak et al., 2013)
Jersey City, NJ		4.4	Total	(Nowak & Crane, 2002)
Kansas, USA		7.42	Total	(Nowak et al., 2013)
Leicester, England		28.86	Above	(Davies, Edmondson, Heinemeyer, Leake, & Gaston, 2011)
Lincoln, NE		10.64	Total	(Nowak et al., 2013)
Los Angeles, CA		0.815	Total	(McPherson, Xiao, & Aguaron, 2013)
Los Angeles, CA		4.59	Total	(Nowak et al., 2013)
Melbourne, Australia	0.0218		Total	(Brack, 2002)
Midwest, USA		11.22	Total	(Schmitt-Harsh, Mincey, Patterson, Fischer, & Evans, 2013)
Milwaukee, WI		7.26	Total	(Nowak et al., 2013)
Minneapolis, MN		4.41	Total	(Nowak et al., 2013)
Moorestown, NJ		9.95	Total	(Nowak et al., 2013)
Morgantown, WV		9.52	Total	(Nowak et al., 2013)
Nebraska, USA		6.67	Total	(Nowak et al., 2013)
New York, NY		7.33	Total	(Nowak et al., 2013)
New York, NY		7.3	Total	(Nowak & Crane, 2002)
North Dakota, USA		7.78	Total	(Nowak et al., 2013)
Oakland, CA		1.1	Total	(Nowak, 1993)
Oakland, CA		5.24	Total	(Nowak et al., 2013)
Oakland, CA		5.2	Total	(Nowak & Crane, 2002)
Omaha, NE		14.14	Total	(Nowak et al., 2013)
Philadelphia, PA		6.77	Total	(Nowak et al., 2013)
Philadelphia, PA		9	Total	(Nowak & Crane, 2002)
Roanoke, VA		9.2	Total	(Nowak et al., 2013)
Sacramento, CA		1.54	Total	(McPherson et al., 2013)
Sacramento, CA		7.82	Total	(Nowak et al., 2013)
Sacramento, CA		36.1	Total	(Nowak & Crane, 2002)

San Francisco, CA	9.18	Total	(Nowak et al., 2013)
Scranton, PA	9.24	Total	(Nowak et al., 2013)
Seattle, WA	14	Above	(Hutyra, Yoon, & Alberti, 2011)
South Dakota, USA	3.14	Total	(Nowak et al., 2013)
Syracuse, NY	8.59	Total	(Nowak et al., 2013)
Syracuse, NY	9.4	Total	(Nowak & Crane, 2002)
Tennessee, USA	6.47	Total	(Nowak et al., 2013)
Washington, DC	8.52	Total	(Nowak et al., 2013)
Woodbridge, NJ	8.19	Total	(Nowak et al., 2013)
Xiamen, China - suburban	1.705	Above	(Ren et al., 2011)
Xiamen, China – urban	2.076	Above	(Ren et al., 2011)

The review identified some key factors that influence carbon sequestration and storage density. Studies identified tree characteristics that affected carbon storage or sequestration, including species (McPherson et al., 2013; Schwendenmann & Mitchell, 2014), wood density (McPherson et al., 2013), tree size (Mitchell et al., 2018; Nowak & Crane, 2002; Vincent Wang & Gao, 2020) and age (Schmitt-Harsh et al., 2013; Vaughn, Hostetler, Escobedo, & Jones, 2014), leaf area and density (Mitchell et al., 2018). Simply put, carbon storage was greatest in species with high wood densities that had large biomass (primarily wood biomass, but also leaf/needle biomass) and were able to live into maturity.

Carbon storage and sequestration were also greatest in cities or areas with more canopy cover (Ma et al., 2021), greater tree density (Nowak & Crane, 2002), and lower forest fragmentation (Godwin et al., 2015; Mitchell et al., 2018). Fragmentation refers to the relatively greater value of groups of trees, rather than isolated trees, the latter of which still provide carbon storage and sequestration, just not as effectively as groups of trees.

In addition to tree-related characteristics, the studies clearly showed that carbon storage density was affected by development intensity, whereby greater development intensity was associated with lower carbon storage and sequestration densities (Dorendorf et al., 2015; Godwin et al., 2015; Hutyra et al., 2011; Ma et al., 2021; Mitchell et al., 2018; Sun, Xie, & Zhao, 2019).

4. Urban Trees and Stormwater Runoff Attenuation

4.1. Overview and Concepts

Impervious surfaces reduce the ability of rainfall to infiltrate into the soil and increase the speed at which it runs off the surface. This has impacts on local hydrological cycles, including increasing peak discharges, the incidence and duration of flooding, and water quality (Jacobson, 2011; Tsihrintzis & Hamid, 1997).

Urban trees and forests attenuate stormwater runoff by intercepting and storing rainfall in their canopies. This intercepted rainfall either returns to the atmosphere through evaporation, or reaches

the ground more slowly as a result of stemflow or throughfall (Kuehler, Hathaway, & Tirpak, 2017). Trees also limit runoff by promoting infiltration into the soil via root channels (Johnson & Lehmann, 2006). Once rainfall has infiltrated into the soil, tree roots absorb it and that water is used to support growth and function, eventually being returned to the atmosphere via transpiration (loss of water vapour from the tree back into the atmosphere via open stomata during photosynthesis). Thom, Szota, Coutts, Fletcher, and Livesley (2020) showed that street trees in Melbourne, Australia transpired the equivalent of 3.4 mm of rainfall per m^2 of tree canopy per day.

4.2. Synthesis of Reviewed Literature

Studies on the effect of urban forests on stormwater runoff attenuation were rare, perhaps because of the complexity of directly measuring urban runoff in-situ. One study was able to undertake a direct measurement at the scale of a city street (Selbig et al., 2022). In that study, all street trees were removed due to an infestation from the invasive emerald ash borer (*Agrilus planipennis*), providing the opportunity to measure runoff before and after tree removal. After tree removal, runoff increased, on average, by approximately 4%, but no changes to peak discharge were detected. It was estimated that trees resulted in 66 fewer litres of runoff per m^2 of canopy during the 5 months of measurement (Selbig et al., 2022). The previous result is consistent with another study that explored the impact of trees on stormwater runoff. In that study, researchers used statistical modelling to estimate that trees caused a 2.4% reduction in stormwater runoff (Zölch, Henze, Keilholz, & Pauleit, 2017). One other study also modelled how stormwater runoff from extreme rainfall events and peak discharge rates decreased with increasing tree canopy cover at catchment scales (Loperfido, Noe, Jarnagin, & Hogan, 2014).

Other studies that quantified the effect of tree canopy on stormwater did so by measuring rainfall interception. Rainfall interception was measured in all reviewed studies, clearly identifying the important role played by urban trees in mitigating stormwater runoff. While interception was consistently identified, the scale of the effect was highly variable, ranging between 9% and 61% of total rainfall (Table 2).

Table 2 – Studies showing rainfall interception by tree canopy

Locality	**Interception (% of rainfall)**	**Interception (mm of rainfall)**	**Source**
Vancouver, Canada	49.1–60.9	20.4–32.3 mm	(Asadian & Weiler, 2009)
Raleigh, USA	9.1–21.4		(Inkiläinen, McHale, Blank, James, & Nikinmaa, 2013)
Lab experiment		0.36–0.63 mm	(Li et al., 2017)
Melbourne, Australia	29–44		(Livesley, Baudinette, & Glover, 2014)
San Juan, Puerto Rico	16.7–22.7		(Nytch, Meléndez-Ackerman, Pérez, & Ortiz-Zayas, 2019)
Oakland, USA	14.3–27		(Xiao & McPherson, 2011)
Sacramento, USA	11.1		(Xiao, McPherson, Simpson, & Ustin, 1998)
Davis, USA	15–27		(Xiao, McPherson, Ustin, Grismer, & Simpson, 2000)

Rainfall interception was influenced by leaf and plant surface area (Baptista, Livesley, Parmehr, Neave, & Amati, 2018; Livesley et al., 2014), canopy structure (Asadian & Weiler, 2009; Xiao & McPherson, 2011), and tree species (Nytch et al., 2019; Xiao & McPherson, 2011; Xiao et al., 2000). In general, species traits and canopy structure resulting in greater leaf or needle density and surface area resulted in greater rainfall interception. In addition to these tree characteristics, interception was also influenced by rainfall intensity and duration (Asadian & Weiler, 2009), as well as wind speed (Nytch et al., 2019). The effectiveness of rainfall interception by tree canopy was greatest during short, low-intensity storms and lowest as rainfall volume and intensity increased (Kuehler et al., 2017; Qin, 2020; Xiao et al., 1998). The preceding studies are indirectly related to stormwater runoff attenuation as intercepted rainfall is less likely to contribute to runoff since it either evaporates into the atmosphere or reaches the soil slowly via stemflow/throughfall, where infiltration is likely if the surface is permeable.

5. Urban Trees and Urban Heat Island Mitigation

5.1. Overview and Concepts

Temperatures in cities are often higher than in surrounded rural areas (Bowler, Buyung-Ali, Knight, & Pullin, 2010). This so-called 'urban heat island effect' is due to the differing properties of vegetated and built environments. Materials in built environments (e.g. bricks, asphalt pavements, dark roofing tiles or corrugated iron) often have low albedo, meaning they absorb sunlight and store heat. In contrast, trees generally have high albedo, meaning they reflect more radiation and do not store heat. Moreover, their canopies provide shade and their leaves or needles transpire, thereby cooling the surrounding air and improving human thermal comfort (Meili et al., 2021). Interestingly, due to transpirational cooling, trees provide greater thermal comfort than artificial sources of shade (Shashua-Bar, Pearlmutter, & Erell, 2011).

Because of these vegetation characteristics, trees can alleviate people's discomfort during periods of heat stress (Lafortezza, Carrus, Sanesi, & Davies, 2009) and their mitigation effects are greatest in close proximity to tree canopy (Hwang, Wiseman, & Thomas, 2015; Misni, Baird, & Allan, 2013).

5.2. Synthesis of Reviewed Literature

The review identified two types of study that related tree canopy and temperatures in urban areas. The first type employed direct measurement of temperature beneath, adjacent to, or away from tree canopy to explain changes in air or surface temperature at small scales. The second type used remote sensing estimates of tree cover to explain changes in air or surface temperature at larger scales.

Urban surface and air temperatures were affected by the presence of trees and also by impervious surfaces. While impervious surfaces had a heating effect, particularly at night (Buyantuyev & Wu, 2010), trees cooled their environs. This effect was greatest in summer months (Hamada & Ohta, 2010). The reviewed studies were unanimous in showing reduced temperatures beneath trees, or associated with, tree canopy cover (Table 3). In studies that measured both ground surface temperature and air temperature (air temperature typically taken 1–3 m above ground surface), ground surface temperature decreased comparably more than air temperature. Ground surface temperatures beneath trees were 0.6–22.8°C cooler and air temperatures were 0.8–7°C cooler than surrounding control temperatures. Control temperatures were typically measured away from trees above paved or grassy surfaces.

Table 3 – Studies showing air and surface temperature reduction by trees. Changes in temperatures (Δ) are relative to experimental controls, typically a measurement away from trees above paved or grassy surfaces. All values are negative, meaning that temperatures beneath trees were lower than control temperatures.

Locality	Δ surface temperature (°C)	Δ air temperature (°C)	Source
Manchester, England	-19	-5 – -7	(Armson, Stringer, & Ennos, 2012)
Lisbon, Portugal		-1 – -3	(Grilo et al., 2020)
Nagoya, Japan		-1.9	(Hamada & Ohta, 2010)
Dresden, Salzburg, Szeged, and Vienna	-13.58 – -22.69	-2.7 – -5.07	(Helletsgruber et al., 2020)
Various		-0.8	(Knight et al., 2021)
Phoenix, Singapore, Melbourne, Zurich		-3.1 – -5.8	(Meili et al., 2021)
Shah Alam, Malaysia		-3	(Misni et al., 2013)
Florence, Italy	-13.8 – -22.8		(Napoli, Massetti, Brandani, Petralli, & Orlandini, 2016)
Worcester, USA	-0.6 – -4.1		(Rogan et al., 2013)
Oslo, Norway	-7 – -10		(Venter, Krog, & Barton, 2020)
Madison, USA		-1.1 – -5.7	(Ziter, Pedersen, Kucharik, & Turner, 2019)

The factors influencing the magnitude of temperature reduction include the characteristics of individual trees, such as crown density (Rahman et al., 2020), leaf area (Napoli et al., 2016; Rahman, Moser, Rötzer, & Pauleit, 2019), and tree size (Hartigan, Fitzsimons, Grenfell, & Kent, 2021; Helletsgruber et al., 2020). These characteristics are related to species (Ballinas & Barradas, 2016; Helletsgruber et al., 2020), but also age since older trees (within a species) typically have larger crowns with more leaves, thus influencing the shade cast by trees and their transpiration. Together with albedo, these factors mitigate the urban heat island effect.

Other factors are related to the amount and configuration of canopy, including tree density (Grilo et al., 2020), canopy cover (Hart & Sailor, 2009; Kong, Yin, James, Hutyra, & He, 2014; Venter et al., 2020; Ziter et al., 2019) and fragmentation (Greene & Kedron, 2018). For example, Ballinas and Barradas (2016) showed that reducing air temperature by 1°C in Mexico City would require planting 63 large *Eucalyptus camaldulensis* or 12 large *Liquidambar styraciflua* trees per hectare. Meanwhile, a 10% increase in canopy cover in Nanjing, China would see a reduction in air temperature of 0.83°C (Kong et al., 2014). Likewise, to lower air temperatures by 1 °C in Hong Kong would require increasing canopy cover to 33% (Ng, Chen, Wang, & Yuan, 2012). In Worcester, Massachusetts, removal of tree canopy cover resulted in increased ground surface temperatures, thereby extending the duration of the summer warm period by up to 15 days (Elmes et al., 2017).

In addition to the amount of canopy cover, the configuration of canopy cover was also shown to have an effect, whereby contiguous tree canopy cover decreased temperatures more than the same amount of fragmented canopy cover (Greene & Kedron, 2018). As with individual tree characteristics, tree density, canopy cover and fragmentation all have an effect on shading and transpiration, so they too affect urban temperatures.

6. Summary

The reviewed literature identified large variability in carbon storage/sequestration, stormwater attenuation, and urban heat island mitigation by urban trees. The review showed that above-ground carbon storage density for trees ranged between 1.7–28.9 kg of carbon per square meter of tree canopy cover, while total carbon (above and below ground) storage density for trees ranged between 0.8–36.1 kg C m^{-2}. Trees reduced stormwater runoff by intercepting between 9% and 61% of total rainfall, and reduced ground surface temperatures by 0.6–22.8°C and air temperatures by 0.8–7°C.

While there was considerable variability in the reported results, it is clear that trees achieve all these regulating services to a certain degree. The scale and effectiveness of these regulating services are primarily affected by the quantity of trees (measured as either tree density or canopy cover), their configuration (fragmentation, clustering), and their structural characteristics (e.g., height, crown volume and shape, stem diameter, leaf area or density, wood density), the latter of which is influenced by tree species and age. More trees or tree cover, with greater total biomass and wood density, configured in clusters, rather than fragmented will lead to increased carbon storage/sequestration, greater stormwater runoff attenuation, and improved urban heat island mitigation. Threats to these regulating services included development intensity and impermeable surfaces (buildings and/or pavements), both of which have been shown to be associated with lower tree cover.

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APPENDIX 2 – Tree canopy cover benefits affected by urban intensification – Biodiversity and related issues

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.

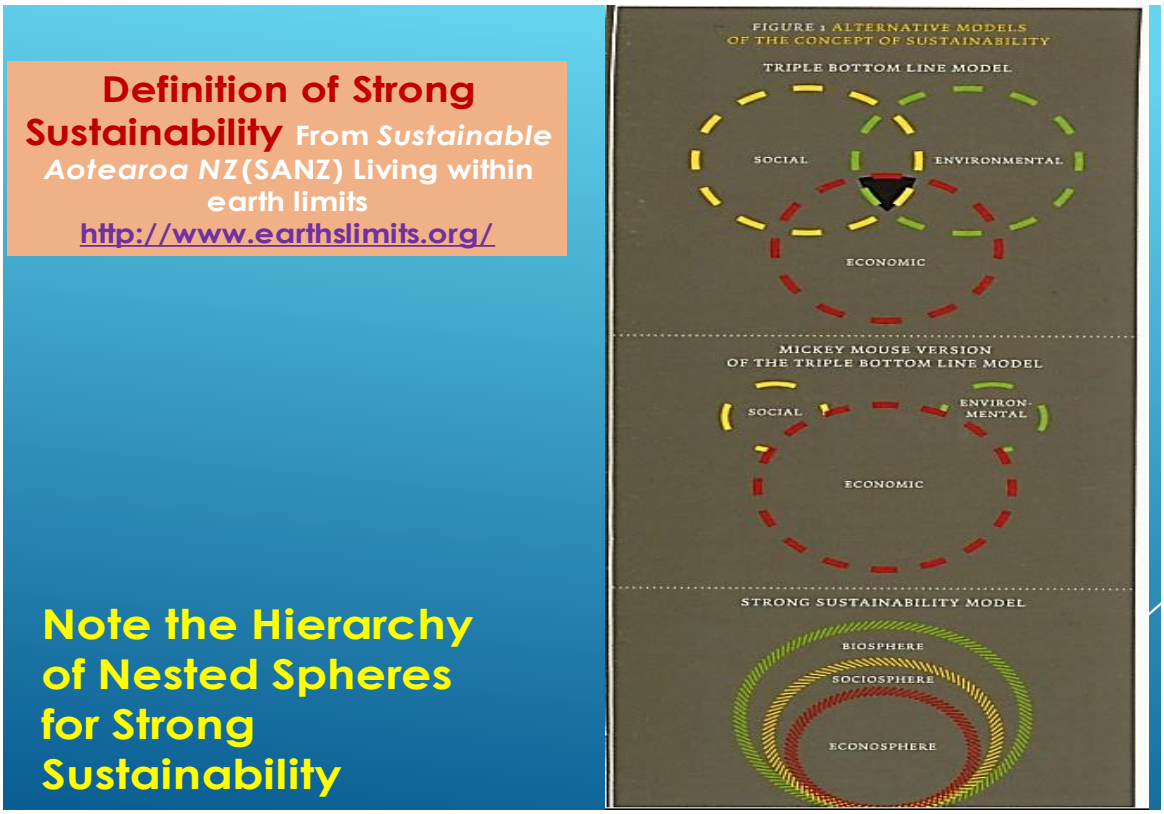


Figure 1: Inescapable reality of Interdependence of Nature and Culture. The economy is nested within the social sphere and in turn embraced by the biosphere (not the other way around) as depicted in the 'strong sustainability' model.

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.

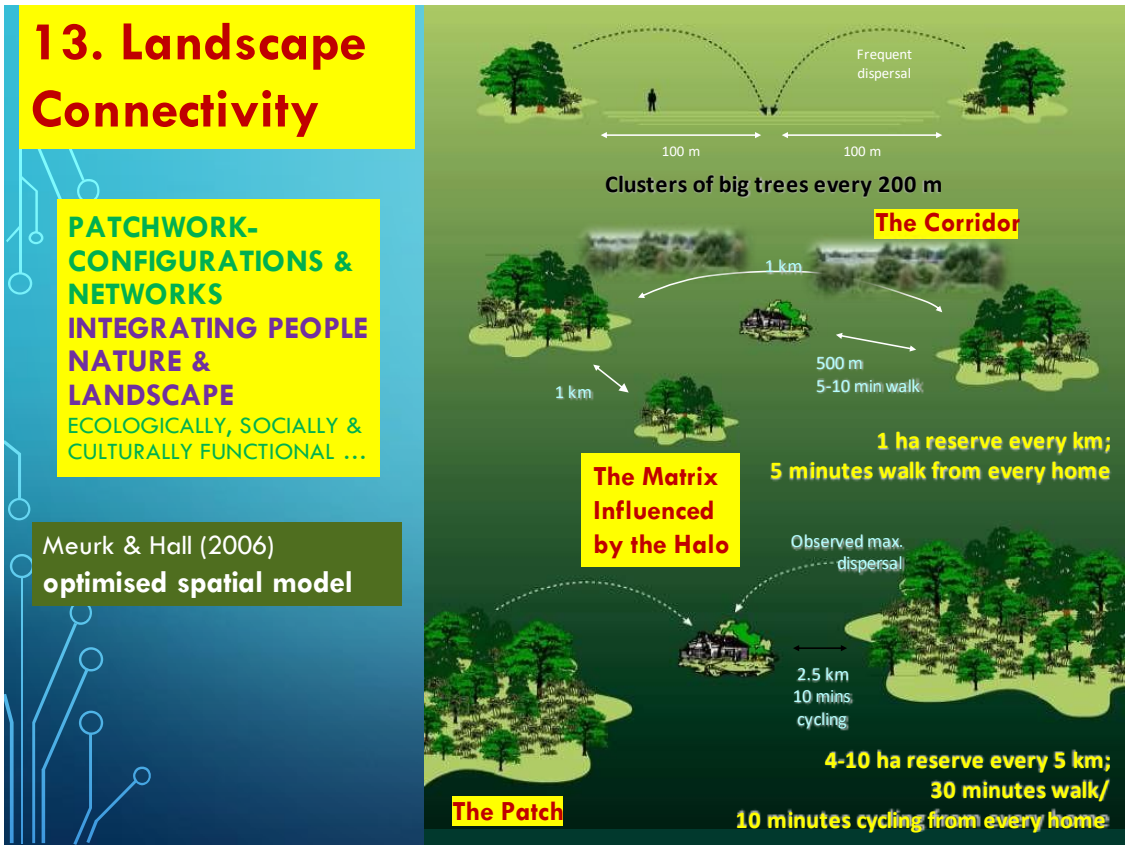
Hence street and parkland (indigenous) **trees**, in their preferred zones, provide individual habitats and steppingstones for foraging and roosting birds. Patches in parks, along rivers, and in larger properties, **protected from disturbance**, can allow for regeneration (cf Ernle Clarke and King George 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).



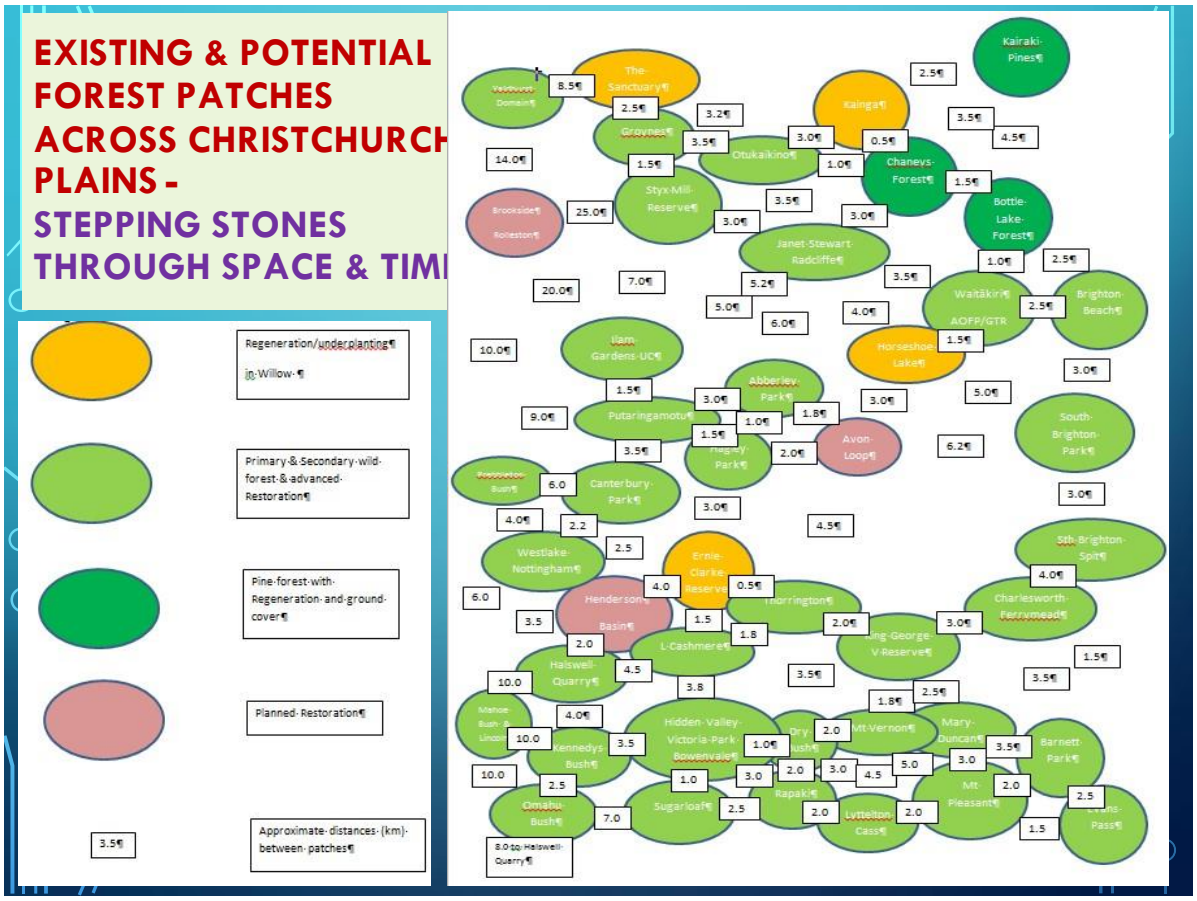


Figure 2a, b: optimised spatial arrangement of forest patches, corridors and consequent ecological integrity and legibility of landscape – in theory (a), and actually/potentially in Christchurch (b) based on existing parks and reserves. **Orange** = Regeneration/Underplanting in willow; **pale green** (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.

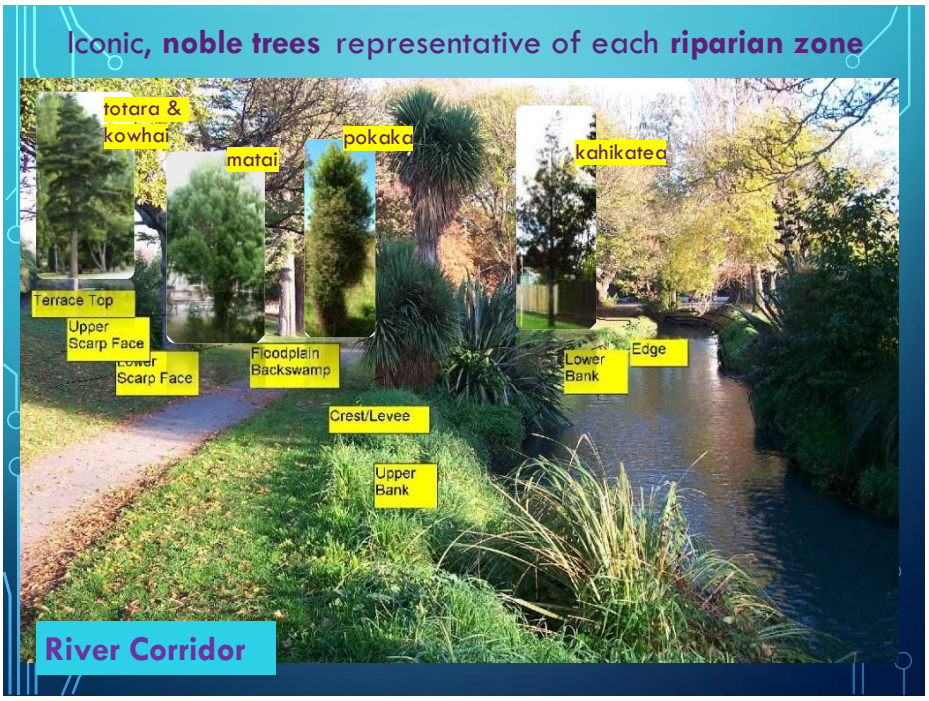


Figure 5b: a selection of indigenous species suitable for riparian corridors.

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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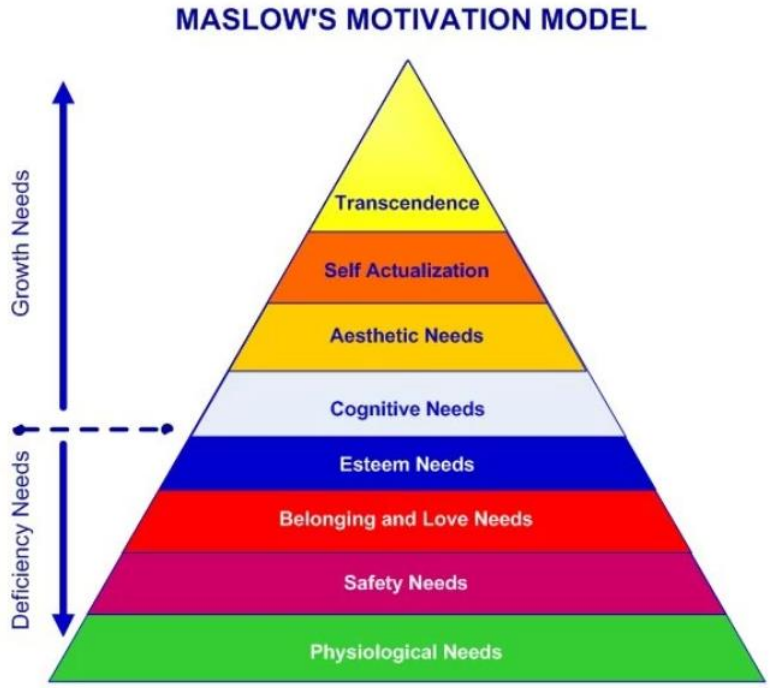

Transcendence – motivated by values which transcend the personal self (e.g., experiences of mysticism, **nature**, aesthetics, service to others, pursuit of science, religious faith, etc). Note a modern view is that there is a pluralistic process whereby multiple needs may be being

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

Colin D Meurk - 2021
University of Canterbury; Lincoln University; Manaaki Whenua Research Associate
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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.

APPENDIX 3 – LANDSCAPE QUALITIES OF TREES AND THEIR CANOPIES WITHIN AN URBAN LANDSCAPE

Landscape Qualities of Trees and their Canopies within an Urban Landscape

Landscape Report

Prepared By: Hilary Riordan (Resource & Landscape Planner) &
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Christchurch City Council, Technical Services and Design (TSD)

For: Christchurch City Council, Policy Team

Date: 13 May 2022

FINAL

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Revision History

Issue	NAME	DATE
Draft	Hilary Riordan; CCC Resource & Landscape Planner (NZILA Graduate Member)	2 May 2022
Review 1	Jennifer Dray; CCC Team Leader – Parks and Landscape Team (NZILA Registered Member)	3 May 2022
Review 2	Hilary Riordan	9 May 2022
Review 3	Jennifer Dray	13 May 2022
FINAL	Hilary Riordan	13 May 2022

Introduction

1. Christchurch City Council (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 (the Act) which will enable higher density developments across the city as a permitted activity.

2. The Council is proposing a plan change to its District Plan to address the impacts of urban development on the environment and 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. The amendments to the Resource Management Act introduced by the Resource Management (Enabling Housing Supply and Other Matters) Act in December 2021, enable the Council to charge financial contributions to address adverse effects of activities on the environment.

3. Section 7 Other matters under the Resource Management Act 1991;

   SECTION 7 Other matters

   In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to—

   - *(c) the maintenance and enhancement of amenity values;*
   - *(f) maintenance and enhancement of the quality of the environment;*
   - *(g) any finite characteristics of natural and physical resources:*

4. Landscape embodies the relationship between people and place. It is the collective characteristic of an area, how the area is experienced and perceived, and what it means to people (NZILA, 2021). Urban landscapes comprise of the physical urban environment (its topography, streets, building, processes, and activities), how people perceive it (its legibility, memorability, aesthetics) and what it means to them (its identity, history, sense of place) (NZILA, 2021).

5. The purpose of this report is to provide expert evidence at a high-level overview on the contributing landscape attributes trees and their canopies can have within urban landscapes. The report focuses on the benefits of urban tree canopy cover in terms of maintaining and improving landscape amenity, and on how increased urban intensification may affect the amenity values of trees.

Landscape Qualities of Trees

6. Professional Landscape practice in New Zealand conceptualises landscape as the overlap of its physical, associative, and perceptual dimensions. The New Zealand Institute of Landscape Architects (NZILA) have recognised that while these terms (physical, associative, and perceptual) are not perfect or definitive, they help to provide a start to capturing the complexity of relationships between people and place (NZILA, 2021). However, these dimensions overlap, and below are separated to detail the contributions trees and their canopies make in an urban landscape. The discussion below also considers the change of amenity in the urban landscape, through tree removal due to development intensification.

7. As many landscape elements can be linked to visual elements, they are often singularly considered as "amenity values". "Amenity" is defined in the Oxford Dictionary as "a desirable or useful feature or asset of a building or place", and "the pleasantness or attractiveness of a place". What is "desirable", "pleasant", or "attractive" is evoked by more human emotions, feelings, and senses which contribute to the concept of "amenity". For the purposes of these comments, the concept of "amenity" is extended to include all sensory perception.

Physical

8. "Physical" means both the natural (Geological, topography and hydrology, vegetation and soil patterns, ecological and dynamic components, naturalness) and human features (Settlement and occupation, roads circulation, land use, buildings, archaeological and heritage, tāngata whenua), in addition to their processes and their interactions over time (NZILA, 2021).

9. Tree canopy refers to the above-ground layer of tree leaves, branches, and stems. Trees canopy provides unique physical forms and details through shape, colour, texture, and size. Trees are typically placed within three shape groups;
    - Pyramid (Figure 1), which form cone-like silhouettes - these include Conifer and Podocarp species.
    - Spreading (Figure 2), these trees typically branch into a thick round or oval-shaped crown. They provide strong shade and may have such dense foliage that the branches are concealed. They are commonly used as park trees and street trees. Examples include Pohutukawa (*Metrosideros excelsa*), Maple and Ash species.
    - Columnar (Figure 3), trees which are defined by their very narrow, upright shape and typically upright branches and a single trunk. They are commonly used to enhance and define structural features like doorways or riverbanks. Examples include Cabbage trees (*Cordyline australis*), Poplars and Cypress species.

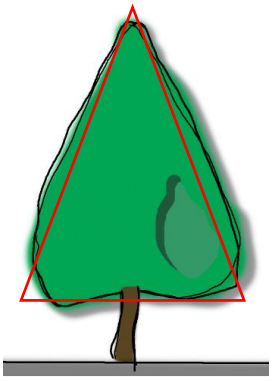

Figure 1: Pyramid

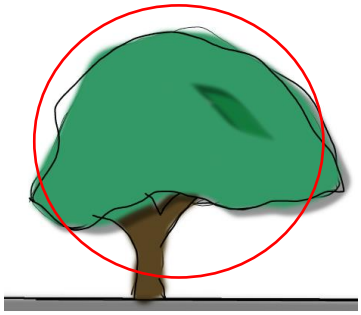

Figure 2: Spreading

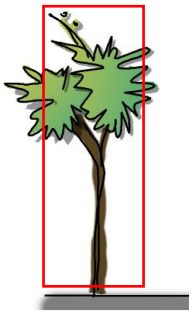

Figure 3: Columnar

10. Trees are different shapes based on natural tendencies or as responses to their environment. A Gingko (*Ginkgo biloba*) may be a spreading tree in some environments or have a pyramidal shape in others. Trees can also have a juvenile form that changes as they mature (known as Heteroblasty), such as Kowhai (*Sophora microphylla*), Ribbonwood (*Plagianthus regius*) and Lancewood (*Pseudopanax crassifolius*). Human modification, particularly within urban settings, alter a tree's silhouette through pruning, and grafting to obtain desired visual shapes, sizes and attributes. These human alterations include; limbing up, where the lower branches of the tree are removed, hedging, and heavily clipped topiary designs.

11. Trees provide colour to an urban environment. Tree's standard colour of green varies in shades from greys to greens to browns; for example Eucalyptus (*Eucalyptus*) which are silver/grey, to Kowhai (*Sophora microphylla*) which has green vegetation, to Lancewoods (*Pseudopanax crassifolius*) which have brown leaves. The colour is predominantly green based due to the presence of chlorophyll in their leaves. However, trees may provide change through seasonal variations. Deciduous trees, known for their significant colour changes in autumn to winter, provide a change from greens to yellow, orange, red and brown. Evergreen trees provide more consistent green vegetation all year round. Seasonally, trees also reproduce; creating flowers, cones, fruit and seeds.

    Trees have a varying range of texture, but are generally considered visually soft, fluid and flexible while building are visually hard, solid and sturdy. The texture of a tree can be further grouped as being fine, medium and coarse.

    - Coarse (Figure 4), texture that is bold and is highly visible from a distance. Typically with large foliage and ridged growth patterns. Examples include Cabbage trees (*Cordyline australis*), Puka (*Meryta sinclairii*), and Kawakawa (*Marcopiper excelsum*).

- Medium (Figure 5), have a mixture of both hard and soft textures within the trees from. They may have coarse branches with small leaves, such as Kowhai (*Sophora microphylla*) and Pohutakawa (*Metrosideros excelsa*).
- Fine (Figure 6), typically have a light or flowing form with soft small leaves. Examples include Pittosporum and Podocarp varieties.

Figure 4: Coarse Texture

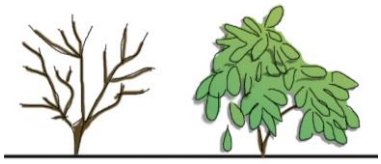

Figure 5: Medium Texture

Figure 6: Fine Texture

12. Tree's varying form, shape and varying textures contribute to the amenity and landscape values of a place. By providing specific landmarks within an urban landscape, the physical feature of a tree can help identify a specific location. Through physical responses to the environment, trees add micro changes to an urban landscape. They provide physical changes and amenity interest for people to observe on an incremental basis and experience change in the landscape daily and seasonally. They allow people to mark seasonal change over time, in comparison to urban structures that can be erected within months, but often provide very limited visual changes over time.

13. Trees can both screen and enhance built environments. Trees as hedging create green walls, and taller trees can screen windows and solid walls. Trees can be used to reduce visual pollution, screening unsightly and undesirable views such as overhead power lines and utility boxes. Trees that are able to grow to their natural shape enhance the urban landscape through naturalising built environments, softening of hard surfaces and harsh outlines of buildings, and complementing building development (Figure 7 & Figure 8). Trees that are also able to respond to their environment can create unique shapes that also enhance features of the urban landscape. Buildings without trees often considered to have a "naked look" (Appleyard, 1978). Heavily clipped trees or columnar trees are used to complement or create architectural features or to enhance and define features like doorways or riverbanks, and provide a sense of natural character (to a lesser degree).

Figure 7: Urban street with trees

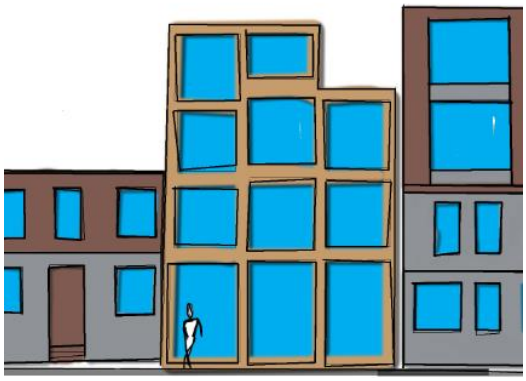

Figure 8: Urban street without trees

14. Trees in the private and public realm contribute to visual amenity. Trees are recognised assets or "green infrastructure" within public urban spaces, for example park trees and street trees (Dixon & Wolf, 2007). The appearance of trees within private properties benefits the visual amenity for the residents as well as other users. Trees planted in front yards have a direct visual benefit to the streetscape, while trees in the back yards also provide breaks in the urban environment (particularly if they extend above the height of surrounding buildings and can be appreciated from public roads). Private trees have direct visual benefits to the landowners, internally providing breaks and screening from buildings.

15. Trees within private lots that extend above buildings and are visible to the public create visual perspective and depth, and a softening of the urban form. If trees are removed from private properties and reliance is placed solely on trees within public spaces, to provide amenity, both landscapes may become undesirable ones. This is because public spaces may become too densely populated with trees (creating dark spaces), and sparse tree growth within developed areas will fail to provide visual softening and interest.

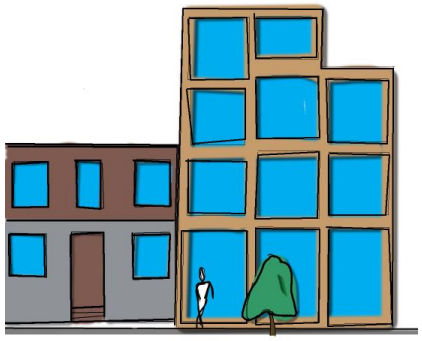

Figure 9: Example of properties with front yard tree only

Figure 10: Example of trees on private land where both front yard and backyard trees are providing softening of the urban landscape and visual depth

16. Trees introduce human scale into the built landscape. As trees increase in height, they can be limbed up and have their lower branches removed. The canopy then creates a room and usable urban space underneath (Figure 11). When located adjacent to the road corridor, trees can provide a sense of enclosure and road narrowing, thus resulting in the reduction of the speed of moving traffic.

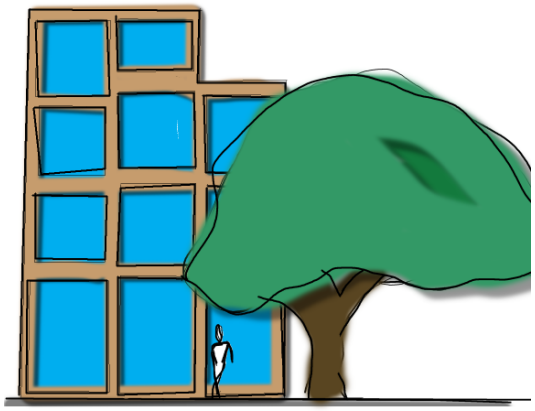

Figure 11: Example of mature tree limed up to enable the space underneath to be used

17. Trees provide physical shade and shelter within an urban landscape. Larger trees provide more substantial shade and shelter then small young trees. Mature trees in the urban landscape are often limbed up to enable people to use the space underneath to shelter for shade during warm days, and to shelter from the rain and wind. Trees with less dense canopies provide lower levels of light penetration and can display dappled shade patterns on the ground and walls. As within a rural landscape, the use of trees as windbreaks is utilised within urban landscapes. Tree canopies also provide shelter and food sources for fauna, such as birds and insects, in turn adding to the visual amenity and biodiversity that trees can provide within the urban landscape.

18. Mature trees can provide substantial canopies with a noticeable physical impact to the landscape, while young trees are much smaller and have little to no canopy (Figure 12 & Figure 13). Mature trees provide immediate mitigation effects to the urban development establishing around them, compared with the planting of new trees. New trees require a lead in time of several years (depending on species and growth conditions) to become established and provide meaningful canopy cover, while the urban built form can be established at significant heights within short time frames (months to a year). New trees under the Christchurch District Plan are currently required to be planted at no less than 1.5m in height (Built Form Standards 14.6.2.6 & 14.5.2.2).

19. Different tree species grow at different rates; some of the faster trees like Pittosporum species can grow about 1m per year while slower trees like Lancewoods (*Pseudopanax crassifolius*) only mature out of their juvenile forms after about 15-20 years (Yates, 2021; Department of Conservation, 2022). Within an urban landscape or developing urban landscape, it is important to retain mature trees while also planting young trees. The mature trees provide instant visual amenity while the younger trees are able to grow and provide visual amenity for new generations. However, it is important to note that regular tree planting

ensures age diversity of trees, and mitigates the risk of the City's tree population reaching the end of life at the same time.

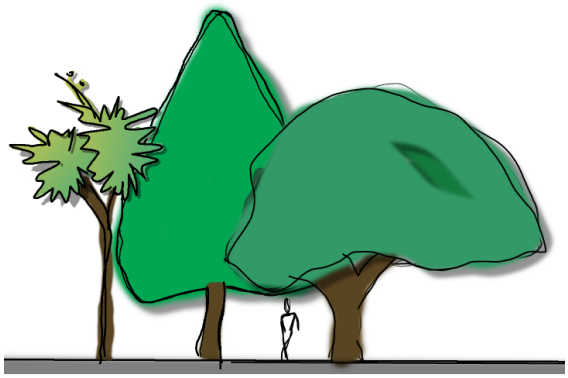

Figure 12: Mature trees which exceed 5m in height in reference to human scale

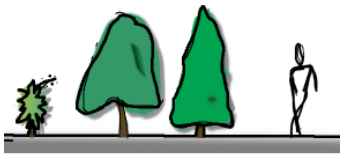

Figure 13: Young trees, approximately 1.5m-2m, in reference to human scale

20. In summary, the retention of mature trees in the urban landscape ensures that the existing level of visual amenity, biodiversity, and other values are retained. The removal and replacement of these trees, while providing amenity for new generations, and ensuring age diversity of trees, will result in a lag effect of a number of years, while these trees are maturing.

Associative Values

21. "Associative" means the intangible thing arising from the relationship between people and place – such as history, identity, customs, laws, narrative, creation of stories and activities specifically associated with a landscape (NZILA, 2021).

22. Trees are highly valued components of urban settings, a key contributor to a "liveable city" (Dixon & Wolf, 2007). Liveability is defined in the Oxford Dictionary as "*the degree to which a place is suitable or good for living in*". The term describes the conditions that frame a decent life for all inhabitants of cities, regions and communities including their physical and mental wellbeing. The "liveable city" concept has spawned a large area of research into how, or what, makes a city more liveable (Mouratidis & Yiannakou, 2022; Kuchelmeister, 2000; Dixon & Wolf, 2007; Hooper, et al., 2020). The presence of trees in urban landscapes generally enhances public perception of visual quality in cities; people express more positive emotions and judgements for urban places having trees (Dixon & Wolf, 2007). Studies have found that urban greening is valued in residential landscapes; people prefer to live in urban landscape with more trees. This is often a quantifiable element through correlations with property values (Holt & Borsuk, 2020; Kuchelmeister, 2000; Sander, Polasky, & Haight, 2010; Dixon & Wolf, 2007; Gwedla & Shackleton, 2019).

23. Trees with large canopies can provide an appealing space for people to engage in outdoor activities (places to meet, eat, play and shelter, walk) and engage with physical activities such as walking and cycling (Dixon & Wolf, 2007). Trees with the varying textures, colours, silhouettes can make physical activities more visually enjoyable, interesting and varying through time and seasons. Trees spread through private and public land encourages people to move through landscapes, enjoying the journey not just the destination. Trees associated with the streetscape, through street trees and private trees located on the street boundaries/front yard, provide shade and greenery to users. Lifestyles that are more active, combat obesity, improve cardiovascular health, and increase longevity (Dixon & Wolf, 2007). Streets with denser tree canopies are associated with road calming as they provide a sense of enclosure and road narrowing, thus reducing the speed of moving traffic (Harthoorn, 2017).

24. This association is also consistent with the benefits of walkable environments that introduce more "eyes on the streets" (Holt & Borsuk, 2020; Ministry of Justice, 2005). This in turn creates a public realm that fosters spontaneous, casual, and deliberate social interactions, increased interaction and a greater sense of community, passive surveillance and safety from crime (Hooper, et al., 2020; Holt & Borsuk, 2020). Tree canopy was significantly associated with lower levels of both violent and property street crime (Holt & Borsuk, 2020). However, too dense planting of trees can have negative effects, creating dark landscapes with little visibility and reduced surveillance, associated with feelings of being unsafe (Ministry of Justice, 2005).

25. Landscapes provide a sense of place, a particular experience and feeling that a person has in a particular setting. This experience provides a place with an identity. This identity could be at the local level, city, regional, national, or international level. Trees as individual or as a collective provide identification with a particular place, like Chestnuts in Paris, Cypresses in Rome, Palms in Hawaii, the Pohutukawa in New Zealand and Oak tree lined paths of Hagley Park, Christchurch.

26. The area of Christchurch was used and occupied by Ngāi Tahu. Their connection with the natural environment is critical to their identity, sense of unique culture and their ongoing ability to keep tikanga and mahinga kai practices alive (Mahaanui Kurataiao Ltd, 2013). The use of native, indigenous trees strengthens a sense of place with 80% of New Zealand's trees, ferns and flowering plants being endemic (Department of Conservation, 2022). The Christchurch area was a rich mahinga kai site for Ngāi Tahu and the trees in the landscape provided important navigational cues. Trees within urban landscapes can be a source of food to human and fauna, and they are able to provide wayfinding functions either as individuals or as groups.

27. Christchurch City often has links and references to being a Garden City. The title “Garden City” has been in use for more than a century, and was first coined by Sir John Gorst, a special commissioner from England at the 1906 International Exhibition. Since the Christchurch Earthquakes, promotion of the title has been less frequent, and there have been questions as to whether Christchurch can retain the Garden City title (Clarke, 2018; Newsroom, 2022; Truebridge, 2017). The Garden City concept is linked to the European ideal, the picturesque landscape; an idealised style of landscape popularised in the 18th century within urban landscape. It can be characterised by grassed lawns and large (traditionally English) canopy trees. Trees are a valuable contribution to a Garden City, and are part of Christchurch’s history. If Christchurch is to continue as the “Garden City”, trees will play an important part. Trees enhance neighbourhood character and the “Garden City” identity through seasonal colour changes, different shapes, forms, patterns, textures, flowers and seeds.

Perceptual

28. “Perceptual” means both sensory experience and direct interpretation. While the sense of sight is most typically applied to landscape assessment, sensory perception importantly includes all the senses such as sound, smell, touch and taste (NZILA, 2021).

29. Trees provide visual symbolic functions in the landscape, beyond the practical functions they offer. Trees have different meaning to different people; bound up with personal and group identity (Appleyard, 1978). Trees evoke emotion and can be connected with symbols of self and others (Dixon & Wolf, 2007). People connect with trees, as they are often identifiable as having unique personalities and similar human traits as they too change. Old trees look wise, a tree that provides shelter evokes feeling of nurturing, young trees seem fresh and sick trees evoke feelings of sadness and empathy. The human connection is also related to the human scale that trees provide within the urban landscape. Though a tree can grow to large heights, they appear less daunting than an urban building as they grow slowly (as people do), and change occurs over time.

30. People become sentimental about certain trees as they connect with people’s memories. Trees within the urban landscapes are easily accessible on a daily basis as they are located in a place where people live (in comparison to trees within the rural landscape). Private trees are often planted for sentimental or cultural reasons. For Maori and many other cultures, it is cultural practice to bury the placenta to symbolise a baby’s link to the earth. The location is often marked with a tree that is watched over and grows with the child. Public and private trees are also planted as markers, records of notable events and memorials such as

the Memorial oak tree and plaque[1] in the Park of Remembrance, Christchurch. Over time, these trees become more valuable to the community and provide a human connection with history. In addition to maintaining old trees, the planting of new trees is also essential to continue this cycle for new generations.

31. The evidence supporting how natural green infrastructure assists people to thrive is published across many journals representing numerous academic and scientific disciplines (Dixon & Wolf, 2007; Ta, Li, Zhu, & Wu, 2021). More tree cover in neighbourhoods, independent from access to green space, was found to be associated with multiple health benefits, including better overall health and better social cohesion (Holt & Borsuk, 2020). The presence of trees generally enhances public judgment of visual quality in cities, as trees are highly valued components of urban settings (Ta, Li, Zhu, & Wu, 2021). Views of trees can also help restore or improve mental health including reducing physical stress and feelings of depression, and increasing concentration, productivity and feeling of satisfaction (Lee, 2021; Dixon & Wolf, 2007; Sander, Polasky, & Haight, 2010). These studies demonstrate the importance of having nature accessible. As people spend most of their time within urban landscapes, at home or at work, trees should also be part of the urban landscape.

Summary

32. Trees and their canopies provide beneficial contribution to amenity values of urban landscapes. They provide physical attributes, but they also provide strong links with associative and perceptual dimension that humans place on landscapes as a whole or as individual features. Trees provide physical attributes to an urban landscape, through texture, colour, shape and size. They are able to provide these physical attributes over time, as they change through seasons and grow. Trees contribute to associative values, providing connections and recognition to a place. They provide a connection with nature that benefits human wellbeing, reducing stress and evoking positive emotions. Having trees within urban landscapes enable the trees and their positive attributes to be readily accessible to humans.

33. The loss of trees from within an urban landscape with increasingly larger built forms will likely create undesirable spaces. The amenity benefits of mature trees and their canopies, and creative architectural landscape responses, would be lost in the urban landscape. While planting of young trees would help to transform and soften the visual landscape, and ensure age diversity of trees in the future, they provide reduced character and amenity in their juvenile state.

[1] The oak was planted in 1924 and grew from an acorn sent back from Gallipoli in 1918 by Lieutenant Douglas Deans.

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