Green Space in Wellington's Central City:
Current provision, and design for future wellbeing

Report for Wellington City Council
October 2019

Authors:
Paul Blaschke, Ralph Chapman, Elaine Gyde, Philippa Howden-Chapman, Jenny Ombler, Maibritt Pedersen Zari, Meredith Perry, Ed Randal.

new zealand centre for
Sustainable Cities
te pokapū rōnaki tāone-nui

Key points summary

- Green space is needed in central city areas to provide health and wellbeing benefits for current and future residents, commuters and visitors, and increased amenity, liveability and economic benefits. Green spaces also provide ecosystem and resilience benefits that will help mitigate and adapt the city to climate change and other environmental shocks.

- We report here on a detailed study of the provision of public green space in central Wellington City in relation to current and projected future population levels.

- The study focused on the three Census Area Units (CAU) of central Wellington City. These CAUs contain a total of 41.19 ha of public green space. More than half of the central city's public green space is located not in City parks and gardens but in road reserves or in other non-council areas, and some is of relatively low quality and poorly accessible.

- The amount of green space per capita in each CAU is highest at $41m^2$ in Thorndon-Tinakori Road CAU, $23m^2$ in Lambton CAU, and lowest at $6m^2$ in Willis St-Cambridge Terrace CAU. There is a very significant lack of greenspace within 300m of the population-weighted centre of the Willis St–Cambridge Terrace CAU.

- Green space amount per capita in central Wellington City declines substantially - by half on average - when projected population growth to 2043 for the three CAUs is considered.

- Increasing the total amount, accessibility and quality of green space in the central city will need to be achieved in order to accommodate future population growth and fulfil a vision of ***"central city green spaces that enhance community and ecosystem health".***

- A central city green space policy that achieves the maximum possible protection and optimal use of current green space, augmented by purchase of additional land in population growth areas, is most likely to meet the needs of residents and visitors, now and in the future.

Figure 1. Glover Park, Wellington (Wellington City Council)

Contents

Executive Summary

Introduction

Urban green spaces are an essential part of Wellington City, for the wellbeing of residents and the local environment, and for city resilience. We need green space in cities, and particularly in central Wellington City, for the following benefits:

- recognised health and wellbeing benefits for present and future residents, commuters and visitors;
- amenity, liveability and economic benefits for Wellington City and its residents;
- other ecosystem and resilience benefits to mitigate and adapt to climate change and other environmental shocks.

This report looks at the current provision of public urban green space in central Wellington, and makes recommendations for future strategic design and provision of urban green spaces in relation to current and projected future population levels. It was commissioned by Wellington City Council to complement a context of recent and current planning work relevant to the central city, including the Central City Framework Plan, "Our City Tomorrow", "Let's Get Wellington Moving", "Planning for Growth" and revision of the District Plan. The study was undertaken by urban researchers at University of Otago, Wellington, and Victoria University of Wellington, who are members of the New Zealand Centre for Sustainable Cities.

A combination of desk-top review, desk-top analysis and field inspection methods were used for this study. We used a combination of approaches at the level of the New Zealand Census Area Unit (CAU), linking the distribution of urban green space within three central city CAUs (Thorndon-Tinakori Road, Lambton, and Willis Street-Cambridge Terrace) to census population data. We also provided measures of accessibility of available urban green spaces within a threshold distance from a "typical" CAU inhabitant's residence.

We were primarily interested in three questions:

- Can urban councils and housing providers, especially Wellington City Council, with its vision of a 'compact, liveable city', ensure the provision of enough of the right types of green space to support intensification, without eroding residents' wellbeing and quality of life?
- Are all residents of all parts of central Wellington able to access and enjoy green space at a level that adequately provides for their health and wellbeing?
- Could the resilience of the central city be increased by increasing the quantity or quality of green spaces?

Our analysis was undertaken within a framework of *ecosystem services (*also known as *'nature's services'* and *'ecosystem benefits'),* which are the benefits that people derive either directly or indirectly from ecosystems that support human physical, psychological, social and economic wellbeing. Urban green spaces are some of the most important locations and providers of ecosystem services in urban areas. There is clear evidence that losses of urban biodiversity and urban ecosystem services can have significant impacts on the wellbeing of urban populations.

There is a wide range of different urban green and associated open space types, with varying degrees of "greenness". Correspondingly, there is no universally accepted definition of urban green space, and these spaces vary with regard to their health and well-being impacts. In this study, the emphasis is on *publicly accessible* green space which has a significant degree of vegetation cover. Given that some significant green spaces are on or very close to the waterfront of Te Whanganui a Tara (Wellington Harbour), the provision of green spaces cannot be entirely divorced from that of "blue spaces" (figure 2). There is also a significant amount of *private* green space within residential lots in the central city, but this was not quantified in this study.

Figure 2. Waterfront and Frank Kitts Park, Wellington (photographer: P. Blaschke)

Green space planning and provision should embrace a systems view of cities. This means thinking about the linkages between the central city and surrounding areas when considering green space needs and ecosystem services, as well as considering connected and interdependent urban processes.

Current state of green space in central Wellington

For this study *public green and open spaces* (henceforth 'green space') were classified into three broad *land use categories* related to tenure, and five *land cover categories*. The three land use categories are:

- "City parks and gardens" are areas that are owned by Wellington City Council and *zoned and managed as parks and gardens*;
- "Road reserves" are the green or associated open areas within the *legal boundaries of the designated road corridor*, other than the actual road and footpath;
- "Other non-council areas" are *other categories of publicly-owned and accessible green or associated open space*, not necessarily owned by Wellington City Council.

Central Wellington (as defined by the three CAUs mentioned) has a total of 41.25 ha of public green space. A significant proportion of the central city's public green space is located not in City parks and gardens (which are 43% of public green space), but in road reserves (24%) or in other non-council areas (33%) (figure 3).

Figure 3. Road reserve vegetation in Victoria Street, Wellington
(photographer: P. Blaschke)

A significant area categorised as green space within all land use categories, consists of impervious and largely non-green surfaces such as paved areas and single trees within paved areas. Such areas (26% of green space overall), while important given the small areas of green space, cannot fulfil all the ecosystem service benefits expected from green space.

The population of these three CAUs was 17,076 in 2013 and estimated at approximately 24,000 in 2018. Under the Council's high and medium growth scenarios, there will be a significant population increase in the central city by 2043, particularly in the Lambton and Willis St-Cambridge Terrace CAUs. Current average amount of public green space per person in the central city is 20m^2 (based on the 2013 population and excluding impervious surfaces). The per capita amount of green space in each CAU is highest at 41m^2 in Thorndon-Tinakori Road, close to average at 23m^2 in Lambton, and lowest at 6m^2 in Willis St-Cambridge Terrace. Thorndon-Tinakori Road CAU has a lower socio-economic deprivation index than the other two CAUs. There is and will continue to be a significant additional demand for green-space-based recreation and wellbeing benefits from non-resident city workers and visitors to Wellington City (a total of nearly 80,000 people working in the three CAUs).

The amount of green space within 300 metres of the population-weighted centroid in the central city and in each CAU accentuates the differences in available green space between the CAUs. There is a significant lack of green space within 300m of the population-weighted centre of the Willis St–Cambridge Terrace CAU; the per capita amount of any green space in this CAU is relatively very low, and what green space is available is dominated by impervious (hard) surfaces.

Future of central Wellington green space

Green space amount per capita in central Wellington City declines substantially - by half on average - when projected population growth to 2043 for the three CAUs is considered. The average amount of green space per capita in the central city in 2043 would decrease to 10m^2. The per capita amount of green space in each CAU would decrease to 27m^2 in Thorndon-Tinakori Road, 11m^2 in Lambton and only 3m^2 in Willis St - Cambridge Terrace.

There are likely to be more older adults and dependent children living in the central city in future. The prevalence of mobility impairments and other types of disability will increase as the population ages. Accessibility of green space (amount qualified by the ability to access it) will become more difficult for most people in these less mobile groups.

Figure 4. Children and elderly visitors at the Botanic Gardens, Wellington (photographer: 'Wanderer')

Environmental constraints such as sea-level rise, and more intense storms, floods and dry periods are likely to further limit green space amount or accessibility, especially on the harbour edge and in low-lying areas such as along Kent/Cambridge Terraces. This would be especially important given the importance of central city green space for resilience and disaster recovery.

A higher amount of green space in peri-central areas (including the Town Belt, educational institutions, and Wellington Botanical Garden) partly compensates for a lower amount in the centre, but not necessarily for persons with disabilities.

Green space and other land uses

Like other cities facing intensification, Wellington City is challenged to find creative ways to provide green amenity and ecosystem services to avoid loss of residents' wellbeing and quality of life. Cities must find an acceptable balance between urban green space benefits and costs, taking both the quantity and quality of green space into account. Competing uses of central city land for current or additional green space include motor vehicle traffic, car parking, residences (single and multiple unit), some commercial use, and non-green recreation and infrastructure. Some of these uses, especially extensive on-street parking for private cars, are increasingly a poor use of land as the city intensifies.

Much of Wellington's current green space provision is of high aesthetic quality, but sometimes this quality appears to be at the detriment of the provision of ecosystem services from green space, especially through excessive areas of hard impervious non-green surfaces (figure 5). There are also technical constraints to green space provision, including water availability and climate limitations, susceptibility of tree and other species to natural disasters, soil limitations, negative plant or animal characteristics for urban residents' living, and cost constraints.

Figure 5. Victoria Street, Wellington. Large areas of imperviousness and on-street parking (photographer: P. Blaschke)

There is scope to make better use of available space and better optimise the mix of land uses so that residents and visitors to central Wellington are satisfied with the quantity and quality of green space, and that it is not eroded to levels which may be adverse for their health and wellbeing, and the longer-term resilience of the central city. This requires the maximum possible protection of current green space in all land use categories, augmented by purchase of additional land for green spaces where this can be justified by likely population growth, particularly in the Willis Street-Cambridge Terrace CAU.

Recommendations summary

Recommendations are aimed at increasing the total amount, accessibility and quality of green space in the central city and fulfilling a vision where:

"Central city green spaces enhance community and ecosystem health".

The overarching recommendation is to plan for and adequately resource an increased amount, accessibility, and quality of green space in the central city, in order to provide for the health, wellbeing, amenity, and ecosystem benefits required by the likely significantly larger future population of the central city.

A supporting recommendation addresses the need for active collaboration on green space provision and accessibility between public agencies, private developers and a wide range of stakeholders and NGOs including vulnerable groups and those working with them.

A group of 12 further specific recommendations deal with:

- maximising accessibility and quality of the few relatively large public areas, together with maximum use of opportunities for 'pocket parks' and small green areas;
- use of universal accessibility design principles, ensuring that all spaces meet international/national guidelines for accessibility, and that all green spaces are of sufficient quality to ensure they are usable by diverse groups within the population;
- making maximum practicable and creative use of opportunities for non-traditional green space, and green spaces that provide multiple ecosystem services;
- maximising the number of trees in all central city development plans and broadening the range of trees and other vegetation used in street and greenspace planting;
- maximising the amount of pervious surfaces in all green spaces;
- making maximum practicable use of opportunities for complementarity between green space and other land uses, especially transport corridors, housing and commercial provision and flood control; and
- maximising accessibility links between central city green space and peripheral central city green space, especially through both active and motorised transport corridors.

Acknowledgements

Among the many people who have generously assisted with information and comments, we especially thank Myfanwy Emeny and Bec Ramsay from the Parks, Sport and Recreation team, Wellington City Council, for their constant support during the project, from commissioning to completion. We also received very helpful support from Jasmine Jamieson at the University of Otago, Wellington, and from Ben Fountain and Mohamed Hassan at Wellington Water.

1.0 Introduction

Central city areas the world over are characterised by higher population density, and the per capita amount of land for all purposes is much usually lower (Blaschke et al., 2017). However, residents, visitors and workers in the central city still have need of green space for their health and wellbeing. Wellington is no exception to this pattern. Over the last two decades the population of central Wellington has grown rapidly and is expected to continue to do so in future. The central city is strongly structured by topography, its relation to the harbour edge, and climatic limitations to plant growth. These factors all constrain available space so that provision of green spaces had to compete strongly with other uses. The colonial city, planned from London before European settlement (figure 6), had to be significantly changed to accommodate these factors. From the start, the central city was planned to include a Town Belt to delineate the city from its then rural hinterland (Schrader, 2015; Boffa Miskell, 2001). However, apart from the roading network there has been little consistent planning of inner-city open space, with very few parks within the area enclosed by the Town Belt, even after Wellington City Council started to add some new parks such as Midland Park (1983). Already in 1998 it was noted that there were notable gaps in the distribution of city parks in key central areas of high pedestrian numbers (Wellington City Council, 1998).

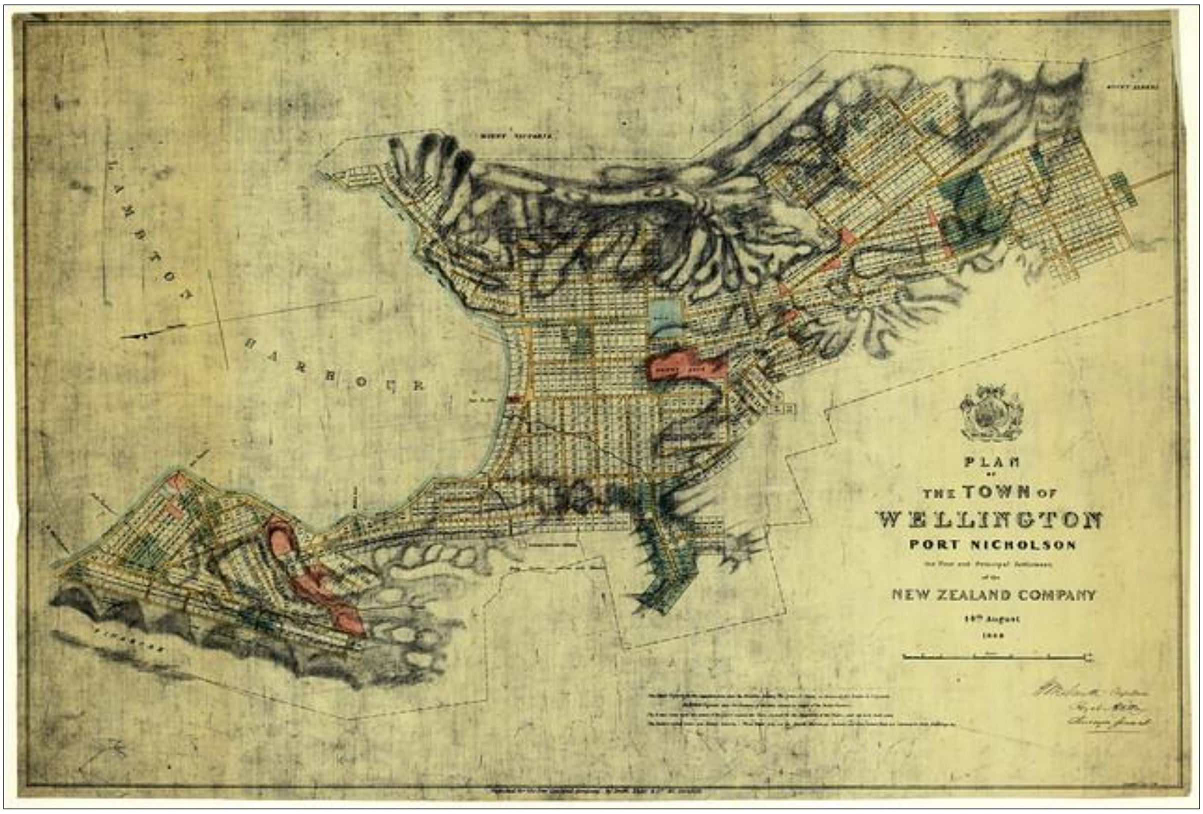


Figure 6. New Zealand Company plan of the Town of Wellington, Port Nicholson, 1840
(source: Archives New Zealand)

Central Wellington faces specific environmental and resilience challenges. Its situation on the Wellington Fault; one of New Zealand's most active faultlines (GNS, 2019), has been long known and to some extent planned for, but significant earthquakes in 2013 and 2015 graphically illustrated the vulnerability of much of the city to this natural hazard. Rainfall-induced slips can be active even in the heavily-reinforced central city (Capacity Infrastructure Services, 2013). Climate changes are almost certain to result in sea level rise that will cause major impacts in the central city as well as increased vulnerability to flood and storm damage from increased storm magnitude and/or frequency.

Most New Zealand urban areas have relatively low population and household density, but Wellington and Auckland central cities are the arguable exceptions. Looking across Australasia and using population-weighted density data, Wellington City is the densest, then follows Sydney and Melbourne. Auckland City and the Wellington urban area as a whole are denser than Brisbane, Perth, Adelaide and Christchurch (ordered by weighted density) (Nunns, 2014). Despite their increasing densities, Auckland and Wellington remain, like other New Zealand urban areas, well-endowed with urban green space at the city scale (Mathieu et al., 2007; Nutsford et al., 2013; Richardson, et al., 2013; Blaschke et al., 2017). There is debate about the effects that increased urban density could have on the available amount and use of urban green spaces, an issue that has current resonance in New Zealand. This report principally examines the following questions:

- Can urban councils and housing providers, especially Wellington City Council, with its vision of a 'compact, liveable city', ensure the provision of enough appropriate green amenities to support intensification without damage to residents' wellbeing and quality of life?
- At the local (central city) scale, are residents of some parts of central Wellington experiencing a decrease in green space to levels which are adverse for their health and wellbeing?
- Could the resilience and sustainability of the central city be increased by increasing the quantity or quality of green spaces?

In this study we have used a combination of approaches at the level of the New Zealand Census Area Unit (CAU), linking the distribution of urban green space within three central city CAUs to census population data including socio-economic and health status, as well as providing measures of accessibility in respect of available urban green spaces within a threshold distance from a "typical" CAU's inhabitant's residence.

1.1 Benefits of urban green space

International research indicates that urban green spaces confer a wide range of important benefits (de Vries et al., 2003; Lee & Maheswaran, 2011; Maas et al., 2006; Tzoulas et al., 2007; WHO Regional Office for Europe, 2016). Roberts et al. (2015), Meurk et al. (2013) and Blaschke (2013) review benefits of natural areas and green spaces generally for New Zealand. Residing in neighbourhoods that are more walkable and with better access to greenspace and local transport infrastructure has been associated with increased overall physical activity, while in a recent USA study, park quantity (measured as the percentage of city area covered by public parks) has been identified as among the strongest predictors of overall subjective wellbeing at a whole city level (Larson et al., 2016). Urban green space is also crucial for ecological health and resilience.

1.1.1 Health and wellbeing

There is now an extensive scientific literature documenting the health and wellbeing benefits for people of contact with nature or green space. Evidence of health benefits of green spaces point to improved mental health and cognitive function, reduced cardiovascular morbidity, reduced prevalence of type 2 diabetes, improved pregnancy outcomes, and reduced mortality. In general, studies have demonstrated stronger evidence for mental health benefits, and for stress reduction, compared with other potential pathways to health (de Vries, 2010; Gascon et al., 2015). The mechanisms underlying links between green space access and health are likely to be complex, interacting, and sometimes synergistic. Hartig et al. (2014) suggest four principal and interacting pathways through which nature or green space may contribute to health: improved air quality; enhanced physical activity; stress reduction; and greater social cohesion.[1]

There is strong evidence to show that physical inactivity is a global health problem which is associated with non-communicable diseases (e.g. diabetes and some cancers) (World Health Organization, 2018). Estimates suggest that the international economic burden of physical inactivity was (INT$) 53.8 billion in 2013 (Ding et al., 2016), including a cost to New Zealand's healthcare system of over $NZ200 million (Market Economics Ltd, 2013; Ding et al., 2016). In a bid to reduce the individual and societal burden of physical inactivity the World Health Organisation recently released a Global Action Plan on Physical Activity 2018-2030 (World Health Organization, 2018). This plan recommends a systems-based approach for increasing physical activity via four key objectives, one of which is creating active and inclusive environments. The provision of good-quality green space for recreation is specifically mentioned (World Health Organization, 2018). Indeed, the parks sector is specifically discussed, alongside urban planning and transportation, as pertinent for reducing the health burden of the global physical inactivity (Sallis et al., 2016).

Green spaces are important for community well-being and public health (Cohen et al., 2007), and provision of green spaces provides one solution for increasing whole population and individual health and well-being (Han et al., 2013). Greenspace enables opportunities for physical and leisure activities (Han et al., 2013) and human social connection needs (Bedimo-Rung, 2005). People in New Zealand who access greenspace are more likely to meet recommended physical activity guidelines (Fleming, 2016). However, these bio-psycho-social benefits are contingent on parks providing a safe environment (Fleming et al., 2016), which all generations and people of all abilities, including persons with disabilities, should be able to access (Bedimo-Rung et al., 2005; Springgate, 2008; World Health Organization, 2018).

The extent to which the available amount of green space facilitates high quality urban intensification is unclear, as the literature is not focused on this issue. But there appears to be a positive connection. A review by Haaland et al., (2015) noted that studies of Chinese cities found that per capita GDP was important in explaining green space cover, with a positive correlation; i.e. higher income cities retained more green space as cities developed. Byrne et al., (2010) in Australia note the challenges of quality green space planning, including in some Brisbane consolidation areas where even a low green space standard (1 ha public green space per 1000 residents) had not been achieved. However, they also note that urban green spaces are 'not an expensive luxury; rather they are a vital necessity for the wellbeing of residents…. most apparent in denser urban environments.' (p.164).

Provision of urban green spaces is, of course, not without cost for cities, mainly the opportunity value of the land, but also the potential impact of providing urban green space in enlarging the city and thus increasing travel distances and costs, and associated carbon emissions. There is concern that a trend towards compact urban settings may result in less area available for any type of green space or the provision of trees (Lin et al., 2015; McPherson et al., 2011). The challenge for cities is to find an optimal or at least acceptable balance between urban green space benefits and their costs.

[1] There is also some evidence of adverse effects of urban green space or neighbourhood greenery on health although this evidence is scarcer. Potential adverse effects include: increased local exposure to air pollutants, risk of allergies and asthma, exposure to pesticides and herbicides, exposure to disease vectors and zoonotic infections, accidental injuries, excessive exposure to UV radiation, and vulnerability to crime.

1.2 Ecosystem services framework

Designing and evolving urban green/blue spaces from the perspective of how ecosystems function (i.e. what they do) could work towards the creation of cities where positive integration with, and restoration of local ecosystems could be realised (Pedersen Zari, 2018), while at the same time making the city more liveable and attractive while providing wellbeing benefits (Taylor and Hochuli, 2015). The ecosystem services framework is one way to understand the complexity of ecosystem processes and human interactions with them in terms of need and use.

1.2.1 Ecosystem services

Ecosystem services (sometimes called 'nature's services or 'ecosystem benefits') are the benefits that people derive, either directly or indirectly from ecosystems that support human physical, psychological and economic wellbeing. In this context, ecosystem services are used as a way to understand what it is that ecosystems actually do that is crucial to human life, so that these services may then be supported, integrated with, or emulated in cities. Urban green and blue space is often a crucial component of this. If cities are able to design green and blue spaces, infrastructure and possibly even buildings so that they start to produce ecosystem services, some pressure that the city exerts on urban and nearby ecosystem services will be lessened (Pedersen Zari, 2018). A focus on ecosystem services has been widely adopted among ecology and policy professionals (Martín-López et al., 2014, Potschin et al., 2016), and was formalised by the United Nations' Millennium Ecosystem Assessment (2005b). Ecosystem services are usually classified as belonging to regulating, supporting, provisioning, or life-fulfilling (cultural) groups (table 1). Brief explanations and examples of what each ecosystem service is in the context of cities is given in Pedersen Zari (2018) and is further exemplified for a Wellington City context in table 2. Benefits and disadvantages to an ecosystem services approach to urban green/blue space are further discussed in Appendix 2.

Table 1. Ecosystem services

Regulation functions: • Climate regulation • Disturbance prevention • Decomposition • Purification • Pollination • Biological control	***Supporting functions:*** • Soil • Fixation of solar energy • Nutrient cycling • Habitat provision • Species maintenance
Provisioning Functions: • Food • Raw materials • Genetic resources • Medicinal resources • Fuel • Fresh water • Ornamental resources	***Life fulfilling functions:*** • Artistic inspiration • Aesthetic value • Education, innovation and knowledge • Cultural diversity and history • Recreation and tourism • Spiritual and religious inspiration • Creation of a sense of place • Relaxation and psychological wellbeing

1.2.2 Ecosystem services and human wellbeing

Ecosystem services are fundamental to basic human survival and human well-being, and the desire for enhanced well-being is the main driver of our demand for ecosystem services (Roberts et al., 2015). Human use of ecosystem services is expanding; however, due to human population increases as well as significant rises in per capita rates of consumption (Turner, 2008). The global condition of most ecosystem services except for the provisioning of food and raw materials has declined over the past fifty years. In fact, ecosystems have changed more in the last fifty years than in any other period of human history (Millennium Ecosystem Assessment, 2005a). Roberts et al. (2015) describe in detail how nature's ecosystem services contribute to the wellbeing of New Zealand and New Zealanders.

Table 2. Ecosystem services in a central Wellington City context

Ecosystem Service			Design objectives/ strategies / methods / programmes that can enhance provision
Supporting Services		**Habitat provision**	Increased urban vegetation: green roofs, living walls, wildlife corridors, pollinator pathways, wildlife sanctuaries, urban forests; regeneration of streams; built habitat analogues; avoidance of habitat loss and fragmentation; ecological engineering; Biophilic City policies. Important in Wellington because of proximity of large areas of habitat.
		Nutrient cycling	Avoidance of non-recyclable/reusable/biodegradable wastes; separation of waste streams; avoidance of landfilling; landfill mining; increased use of local materials; industrial ecology; Cradle-to-Cradle; design for deconstruction; composting/biodegradation.
Regulation Services		**Purification**	Avoidance of pollution; remediation of waterways / harbours / aquifers/air/soil; treatment of storm water/leachates/ greywater/blackwater; urban forest regeneration; phyto / bio-remediation; Living Machines; green roofs / facades / infrastructure; constructed wetlands; pollution remediating/ absorbing construction materials; water sensitive urban design; increased porosity of surfaces and reduction of stormwater velocity.
		Climate regulation	Carbon sequestration/storage materials/technologies; regeneration of protected forest; increased urban vegetation; planting for increased evapotranspiration /shading / sound absorption/wind buffering; ecosystem-based adaptation strategies; reduction of fossil fuel use; and car travel; renewable energy generation; non high-mass landscaping.
		Disturbance prevention and resilience	Ecosystem-based adaptation solutions; green / hybrid infrastructure for water/flood/wave/wind/erosion control; urban forest; urban wetlands; water-sensitive urban design.
Provisioning Services		**Provision of energy**	Reduction of energy use (behaviour & efficient technologies); renewable energy generation; increased local distributed energy generation.
		Provision of fresh water	Reduction of water demand; recycling & treating grey/black water on-site; returning clean waste water to original source; rainwater harvesting; rain water tanks; collection/production of 'alternative' water sources; water sensitive urban design; green infrastructure; forest & wetland capture/ storage/filtration.
		Provision of food	Urban agriculture & agroforestry; permaculture; edible landscaping; community/marae/school gardens/orchards/forage; plant-based diets; increased yield techniques (renewable/non-toxic/non-petrochemical); roof top/façade/interior/vertical food growth.

Cultural services		**Beauty**	Interventions to enhance city character and sense of place: landscape architecture; outdoor & environmental art; biophilic design; environmental psychology.
		Recreation	Design for natural environment recreation and play, physical and mental health and fitness: biophilic design; drainage provision, walking / cycling paths, exercise areas, outdoor recreation programmes.
		Culture	Interventions to connect environment and landscape of the city, enhance liveability and economic success as a place people want to live in and identify with: landscape architecture; biophilic design; environmental psychology; ecological history design; interpretation of historical/natural/cultural heritage.
		Health and wellbeing	Interventions for mental and physical health and wellbeing: landscape architecture; biophilic design; environmental psychology; recreation/relaxation/mindfulness programmes; contact with wildlife/vegetation/water/outdoor Green Prescription programmes; design for liveability, play, quality of life, social cohesion, sense of place, uniqueness based on interaction with local natural environment.
		Knowledge	Eco-revelatory design; biomimicry; outdoor science/matauranga programmes, zoos, botanical gardens; Enviroschools programmes; plant and animal pest management.

While the negative impacts of loss of ecosystems and biodiversity (and therefore the ecosystem services they provide) on people in urban areas are difficult to quantify, there is clear evidence that losses of urban biodiversity and therefore urban ecosystem services has significant adverse impacts on:

- Human physical health (Aerts, Honnay, and Van Nieuwenhuyse 2018, Kilpatrick et al., 2017),
- Human psychological health (Frumkin et al., 2017, Beatley 2011),
- Societal and cultural health (Vierikko et al., 2016, Botzat, Fischer, and Kowarik 2016), and
- Economic health and stability (Walsh, Carpenter, and Vander Zanden 2016, Elmqvist et al. 2015).

1.2.3 Ecosystem services and urban environments

The provision of ecosystem services is claimed to generally occur at low rates in cities except for cultural ecosystem services (Costanza et al., 2014). Despite this, important urban ecosystem services include air purification, water flow regulation, micro climate regulation, and carbon sequestration (Gómez-Baggethun and Barton 2013). Typically, these urban ecosystem services come from urban green areas such as forests and parks, or blue areas such as lakes and wetlands. They represent important opportunities for novel design interventions, particularly related to increasing adaptation to climate change options (Elmqvist, Gomez-Baggethun, and Langemeyer 2016).

One way to reduce or to reverse the negative impact urban environments have on ecosystems may be to create and re-design urban areas so that they more effectively provide, integrate with, or support ecosystem services, and therefore reduce pressure on both local and distant ecosystems. Healthier ecosystems more readily provide ecosystem services to humans that cannot be provided by the built environment itself or within urban environments (Pedersen Zari, 2010). This is critical as cities, including Wellington, continue to expand and as the climate continues to change (Wratt et al., 2008). Such a strategy supports and works towards several of the United Nation's Sustainable Development Goals for 2030 (UN General Assembly, 2015). Table 2 shows ecosystem services that are relevant to central Wellington City and suggests applicable design strategies, programmes or methods that could achieve or enhance the provision of those services. Enhancing cultural services is perhaps key to making ecosystem services relevant to human wellbeing in the central city. The liveability, quality of life, social cohesion, sense of place, and celebration of what is unique and special about Wellington, can all be enhanced through high quality interactions with the local natural environment.

1.3 Amount and accessibility[2] of green space for diverse populations

1.3.1 Provision of green space in urban areas

Urban residents prefer to live close to urban green space. Many surveys of urban park use indicate that the majority of users want to come by foot, and will only do so on a regular basis if the park is within 3 to 5 minutes' walk of their home or workplace (Thompson, 2002; WHO Regional Office for Europe, 2016).

Studies by Richardson et al. (2010, 2013) and Nutsford et al. (2013, 2016) have provided some information on urban green space distribution in relation to census area units in Auckland and Wellington, but this has been related to health outcomes and not to population measures. This was noted as a major information gap in New Zealand by Blaschke et al. (2017) who state that only when such gaps are filled can issues of accessibility and inequalities be addressed.

1.3.2 Green space accessibility and disability

Disability is a significant issue in Aotearoa New Zealand. Twenty four percent of the population, or 1.1 million people, identify as disabled and are limited by a physical, sensory, learning, mental health or other impairment (Statistics New Zealand, 2014). The rate of disability differs across age groups, with the prevalence of disability in children (i.e. <15 years of age) being 15% and in older adults (>65 years of age) being 60% (Statistics New Zealand, 2014). Furthermore, while prevalence rates look comparable across ethnic groups the age-adjusted rate of disability for Māori is 32% overall (Statistics New Zealand, 2014).

By 2038 the forecasted prevalence of disability in New Zealand is estimated to be close to 27% of the population. While this does not at first glance look excessive, the difference in projected increase is better illustrated by comparing the rise in general population. This is projected to increase by 31% between 2013 and 2038, but in the disabled population the projected rise is 45% (McIntosh, 2017). This large projected increase in disability between 2013 and 2038 is likely to occur predominantly in two main groups; young adults (18-39 years) and older adults (65+) (Petry, 2002). Indeed, adolescents and young adult rates of disability are projected to rise by 28% (McIntosh and Leah, 2017), and the number of older adults with disability will double by 2038 (McIntosh and Leah, 2017) because this is New Zealand's fastest growing demographic (Statistics New Zealand, 2014).

---

[2] In this report we use the term 'amount' or 'available amount' in the sense of existential capability of being used, i.e. a simple quantitative measure of area of urban green space per capita or per household in that urban area. By contrast, 'accessibility' is defined in the Concise Oxford Dictionary as the "ability to be reached or entered". Therefore 'accessibility' has an additional connotation (which may be expressed qualitatively or quantitatively) of *an ability (physically, socially, economically and culturally) to access urban green space*. In this sense, 'accessibility' can just be a synonym for 'nearby' and this is the sense in which the term is often used. However, the two terms appear to be used somewhat interchangeably and without clear distinction in much of the literature.

The World Health Organization (WHO) definition considers disability to be an overarching term covering impairments, activity limitations, and participation restrictions (World Health Organization, 2001). Importantly, this definition considers the interaction between an individual and the society within which they live, because this aspect (environment and social barriers) can be particularly disabling (World Health Organization, 2001). While 'persons with disabilities' is a large heterogenous group, physical activity is particularly important because this population has a higher risk of physical inactivity and associated long-term health conditions (Rimmer, 2012; Rimmer et al., 2007) compared to those without disability (Krahn et al, 2015). Given the health risks of physical inactivity in persons with disabilities, accessible and inclusive greenspace environments which promote physical activity and bio-psycho-social well-being are not only warranted (Rimmer, 2012), but also a human right.

Quality and usability of green space are as important as accessibility, especially for persons with disabilities for whom accessibility is more limited and who therefore must be able to make optimal use of whatever green space is accessible. This is particularly important in Wellington where there is generally thought to be a large amount of 'green open space' outside of the central city, but significant parts of this space are inaccessible because of topography and are not universally useable as public open space. Even for the general population, quality attributes of green spaces, such as safety, aesthetics, amenities, maintenance, and proximity to home, are important for supporting physical activity outdoors. Aspects such as concerns over safety, violence, vandalism, litter, noise, pollution, and dog fouling have negative associations with park use and physical activity (McCormack et al., 2010). Richardson et al. (2010) also comment that in New Zealand, green space quality may be a better predictor of health benefits than green space quantity. Further detail on the application of universal design to increase accessibility is available in Appendix 1.

1.3.3 Green space accessibility and socio-economic status

Some recent studies approached accessibility analysis by linking the distribution of urban green space to population data including socio-economic and health status (Astell-Burt et al., 2014; Bertram & Rehdanz, 2015; Nutsford et al., 2013; Shanahan et al., 2016). Several of these studies have shown inequalities in access opportunities to urban green space, particularly in areas of lower income or socio-economic status and higher population or household density (Astell-Burt et al., 2014; Mitchell and Popham, 2007 and 2008; Sister et al., 2010; Wolch et al., 2014; Iverson and Cook, 2000; Lin et al., 2015). Such higher density areas tend to have less amount per capita in any case, and Sister et al. (2010) showed in Los Angeles that Latinos, African-Americans, and other low-income groups were likely to live close to parks with higher actual or potential park congestion. Such findings are not, however, universal. Ståhle (2010) for example shows that citizens in some dense inner-city districts in Stockholm experienced higher green space accessibility than citizens in some low-density 'green' suburbs.

1.4 Critical types of green space

There is a wide range of different urban green space types, with varying degrees of 'greenness' (Byrne et al. 2010; Blaschke et al. 2017). Correspondingly, there is no universally accepted definition of urban green space, with regard to health and well-being impacts. In this study the emphasis is on publicly accessible green space which has a significant degree of vegetation cover (not necessarily 100%). Public parks and gardens typically have the highest and largest range of ecosystem services and other values (Meurk et al., 2013). We also include some other kinds of public open spaces outside public parks and gardens, which contain or could support some green elements such as planted trees or lawns. These types of urban green spaces include non-roadway portions of road reserves, non-council public land controlled by public organisations other than Wellington City Council, and school and university grounds (figure 7). In this study we do not include private green or open spaces.

Figure 7. Te Aro School grounds adjacent to Karo Drive (Photographer: P. Blaschke).

Green and Blue space: As well as green space, "blue spaces" adjacent to water have recently received considerable attention in the literature concerning health benefits of contact with nature in cities (Foley and Kistemann 2015). Given central Wellington's proximity to Wellington Harbour along much of its length, blue spaces undoubtedly come into the ambit of relationships between people and natural spaces in the city. Other blue spaces in the city include a lagoon directly adjacent to the harbour (figure 8), constructed wetlands (Waitangi Park) and other constructed features such as fountains. One study has examined the effects of visibility of blue spaces from locations in Wellington (not specifically in the central city) (Nutsford et al., 2016). The scope of our study was specifically centred on green not blue space. However, given that some significant green space areas are on or very close to the waterfront, the concept of green space or at least natural space cannot be entirely divorced from blue spaces.

Figure 8. Whairepo Lagoon (photographer: B. Taylor).

Public and private green space: This report concentrates on public rather than any kind of green space because it is the type of green space that is most amenable to council policies and programmes. Also, in the central city, the area of private green space (principally green space within private residential lots such as gardens) is quite low in comparison to that in public green space. In the Willis Street Cambridge Terrace Census Area Unit (CAU) within the central city (see: Chapter 3), the ratio of public to private green space is 1.8 whereas for two contrasting outer residential CAUs (Linden and Khandallah Park-Broadmeadows) the ratio is 0.57 and 0.27 respectively (Blaschke and Randal, unpublished data, 2017). Nevertheless, the supply of private green space is relevant and complementary to the overall supply of green space and we will return to this point in later chapters.

1.5 Background to this report

Wellington City Council (WCC) has a strong interest in green space provision including in the central city as is evident by a number of relevant frameworks and strategies. As well as sections of Wellington City's District Plan, WCC strategies and policies of particular relevance to central city green spaces include the Wellington Resilience Strategy (Wellington City Council, 2017a) and the Central City Framework Plan (Wellington City Council, 2017b) are of particular relevance to central city green spaces. Also of particular relevance to the central city, the Our City Tomorrow programme (Wellington City Council, 2019) carried out a series of public engagements in 2017 on aspirations for the future of Wellington. The goals that emerged were that central Wellington City should be: compact, inclusive and connected, greener, resilient, and vibrant and prosperous. Aspirations for a greener city included protecting existing green spaces, but also providing more urban green spaces including streams and wetlands, more trees, and for buildings to incorporate sustainable design features (Wellington City Council, 2017c).

Our City Tomorrow was followed by the Planning for Growth programme, a 'conversation about how we plan for the city's future growth' (Wellington City Council, 2019). Early 2019 consultation showed that about two-thirds of 1576 responses supported either keeping the city compact with higher density in the CBD and inner suburbs, or focussing development growth in and around existing suburban centres, supported by inner-city growth The Planning for Growth project is now building on these early stages, including various phases of further public engagement and consultation, that ultimately will lead to the creation of a Spatial Plan and a review of the current District Plan.

Other relevant city-wide strategies and projects include: The Town Belt Management Plan (Wellington City Council 2013a); The Wellington City Biodiversity Strategy 'Our Natural Capital' (Wellington City Council 2015); and Our Capital Spaces: An Open Spaces and Recreation Framework for Wellington 2013-23 (Wellington City Council, 2013b). WCC have also begun to recognise the relevance of green space to the multiple benefits associated with Water Sensitive Urban Design (WSUD) (Wellington City Council nd)[3]. Wellington is a partner city in the International Biophilic Cities Network[4].

Collectively, these plans and strategies aim for many desirable outcomes for central city parks and green spaces, and have a number of policies and objectives relevant to these areas. However, they have not necessarily been developed with reference to the specific characteristics of these areas in the central city, nor of the implications of expected population growth of the central city.

The Centre for Sustainable Cities (Centre) has had a memorandum of understanding with WCC for several decades to undertake research on land-use, housing, energy, and transport use, using a systems approach. It has recently completed the comprehensive Resilient Urban Futures Programme which had strands on land use, active travel, water use, Taone Tupu Ora and included extensive surveys on urban preferences[5]. Both the national programme and case study material on Wellington City (Russell et al., 2015) have important implications for the impacts of any future intensification in central Wellington on the environmental effects of intensification and the wellbeing of central city residents. The supply of readily available space is a significant element of the trade-off between preferences for housing types and stated wellbeing for residents[6].

In 2015-6 the Centre undertook a review of the international and New Zealand literature on amount of green and open spaces within cities, residents' satisfaction with and usage of these spaces, and to what extent these matters are associated with urban population density (Blaschke et al., 2017). That

[3] Relevant plans of other agencies include Wellington Water's draft Catchment Management Plan for the Lambton catchment (Global Research and WCC, 2017), and the Department of Conservation's Wellington Conservation Management Strategy (2019) which includes policies relevant to some central city places managed by the Department, and the National Policy Statement on Urban Development Capacity (Ministry for the Environment, 2016) which sets out the objectives and policies for providing development capacity under the Resource Management Act 1991. ***

[4] See https://www.biophiliccities.org/. Victoria University of Wellington School of Architecture staff and students have been involved in many central Wellington City design projects and have also collaborated with WCC to produce the Wellington Nature in the City map (see: https://wellington.govt.nz/recreation/enjoy-the-outdoors/wellington-nature-map). This map concentrates on natural sites within the central city.

[5] For more information see: http://sustainablecities.org.nz/resilient-urban-futures/

[6] Available research including theses is available on the following websites: www.sustainablecities.org.nz; http://sustainablecities.org.nz/resilient-urban-futures/; and http://www.healthyhousing.org.nz/.

review aimed to inform future empirical study of whether intensification ('smart' or compact urban growth) would increase or decrease New Zealanders' access to green and open urban spaces. As would be expected, the review showed that amount of urban green space per capita and per household varies widely, within and between cities, although specific quantitative data are scant. The review suggested that key to understanding the requirements for public urban green open space (UGOS) provision in the process of urban intensification is to know how to enable UGOS to be used more intensively in densely populated areas, without loss of amenity and satisfaction. Currently, the evidence to answer this question is difficult to find. It was clear, however, that different UGOS users have different needs which must be taken account of and satisfied in different ways in order to maintain and enhance equitable access to and use of UGOS.

The Centre also undertook a pilot study of green space distribution and amount in four Wellington City Census Area Units using population measures as well as green space analysis. The CAUs chosen included one within the central city and one in an inner suburb (Chan, 2017). The results indicated some disparities in green space amount between the four CAUs, both in absolute area and in amount per person. These disparities appeared to be especially marked in the inner city CAUs and were thought to have significant implications for growth and intensification strategies for central Wellington, with respect to increasing evidence of the benefits of accessible green and blue space for people's health and wellbeing.

WCC commissioned the current study from the Centre through a brief issued in August 2017. The study leader brought together a team of Centre-affiliated researchers from University of Otago (Wellington) and Victoria University of Wellington. The analysis and site inspection work were undertaken between January and July 2018.

1.6 Aims of study

The overall purpose of study was to assess the future need for green space in Wellington's central city and provide related recommendations to the Council. In order to do this there was a need to provide basic data on urban green space amount in relation to population and household density in central Wellington.

The following specific aims were slightly adapted from the project brief issued in August 2017.

1. To summarise green space options in central city environments, including benefits, expected sizes, roles, installation and maintenance costs.
2. To undertake a literature and policy review to understand the expected needs of varied demographic scenarios likely to occur in central Wellington and what the needs of likely demographic groups are.
3. To assess the current provision/supply of green space within the Wellington central city area.
4. To synthesise potential need for green space requirements and related open space requirements, given demographic trends, needs and current supply, and consideration of complementarity of green space with other central city needs such as transport, other infrastructure, and housing.
5. To assess existing and potential provision of green and open space within current and planned developments at central-city-wide level and by reference to specific location examples.
6. To review technical constraints to green space provision such as the potential for certain species of street tree to hold land against post-earthquake liquefaction and withstand climatic constraints including climate change.

7. To provide recommendations on green space provisions for central Wellington City, based on current provision, expected needs from demographic changes and the desirable provision of green space for full population amount, accessibility, usability, and quality.

1.7 Methods

A combination of desk-top review, desk-top analysis and field inspection methods were used for this study. Desk-top review was undertaken of previous research using University of Otago literature databases and Google Scholar searching for both international and New Zealand literature. Most literature for the supply-demand-density analysis drew on the literature search reported in Blaschke et al. (2017). Additional information relevant to Wellington City Council policy, strategy and projects was obtained from the website: www.wellington.govt.nz.

Methods for the desk-top analysis of green space supply and population breakdown and trends are described in Chapter 3. Study-specific field inspections ground-truthed and supplemented the desk-top analysis and team members' personal knowledge of the central city. Three of these inspections were carried out. The first was to field check preliminary green space classification and boundary delineation and covered parts of all three central city CAUs. The second inspection concentrated on selected areas in the Lambton and Willis St-Cambridge Terrace CAUs looking at opportunities to maximise ecosystem service values and accessibility for the general population. The third concentrated on selected areas in the same two CAUs, looking at opportunities to maximise accessibility to specific population groups.

Three team workshops were held. The first was an introduction to the project. The second and third workshop examined interim results and developed and discussed conclusions and recommendations.

2.0 Provision of Green Space

2.1 The Central City area

The central Wellington area does not have an official boundary set by the City Council. Accordingly, after discussion with WCC staff three 2013 census area units (CAUs) were chosen to represent the Central City area: Thorndon-Tinakori Road CAU, Lambton CAU, and Willis Street-Cambridge Terrace CAU (abbreviated to Thorndon, Lambton and Willis-Cambridge respectively). The CAUs were chosen because they provided the boundaries for the information on the demographics in central Wellington. To be consistent with the pilot study described in section 1.5 (Chan, 2017), any areas of the Wellington Town Belt were removed. This meant an area of Te Ahumairangi/Tinakori Hill was removed from the Thorndon CAU. Thorndon therefore, included the suburb of Thorndon on both sides of State Highway 1 (SH1) including Thorndon village and Tinakori Road, the Pipitea precinct, and the commercial wharf precinct. Lambton includes Lambton Quay, Terrace Gardens and Kelburn Park area, the area around SH1 south of the Terrace Tunnel, Civic Square and the Waterfront precinct as far south as Aotea Lagoon. The Willis-Cambridge Street CAU runs east from Willis Street to Kent Terrace, and south from Civic Square and the Waterfront to Webb Street, State Highway 1 and Buckle Street. Figure 9 shows the study area and its constituent CAUs. In 2013, there was a total of 17,076 people living in these three CAUs but the population has increased significantly since then. Detailed discussion of the Central City population and demographics can be found in Chapter 3.

2.1.1 Thorndon-Tinakori Road CAU

This CAU which has an area of 243 ha[7], includes four distinctive areas: the residential suburb of Thorndon, the Pipitea parliamentary and government precinct, the industrial area wharf area bordering Wellington Harbour (including the railway station and railyards), and Te Ahumairangi (Tinakori Hill). The last uninhabited section was excluded from the green space analysis as discussed in the preceding section. Thorndon is an inner suburb that sits between Te Ahumairangi and the industrial area. This suburb is bisected by the Te Aro Corridor, the State Highway 1 motorway entry to central Wellington city. Thorndon is a historical suburb and the houses along Tinakori Road are predominantly colonial villas. Premier House, the official residence of the New Zealand Prime Minister, and Katherine Mansfield House are two prominent features of Tinakori Road. Between the Motorway and the Harbour, the character of the CAU changes into that of a business district. This district features two High Schools, the New Zealand Parliament and government centre, and a large number of foreign embassies and consulates. From Thorndon Quay to the Harbour the area becomes more industrial, featuring the railway station, stadium, and port. These factors create an area with a mix of activities. Thorndon has the smallest population of the CAUs with only 4,125 living here. 40.9% of the population own their own home which is the highest rate in this study.

2.1.2 Lambton CAU

Lambton CAU, which has an area of 98.5 ha, sits between Thorndon and Willis-Cambridge CAUs. The business district between the Terrace and the Harbour includes many ministry offices, corporate offices, and retail shops. There are hotels in this area and it is an area that many tourists will visit, particularly the tourist who arrive via cruise ships, to go shopping and to ride the historic cable car up to the botanical gardens. Within this area there are also apartments, but unlike Willis-Cambridge there

[7] This area excludes the part of the Town Belt on Te Ahumairangi Hill which was excluded from our analysis. The total area of the CAU is 281 ha. Smaller green areas such as the Wellington Botanical Garden and Kelburn Park were not excluded from the analysis because they were smaller, fully contained within rather than marginal to the CAU and more easily accessed from all parts of the CAU.

Figure 9. Central City study area with CAUs

is less land available to build new apartments, so the population is predicted to grow less quickly. Near the SH1 Terrace tunnel, there is a residential fringe to this area. This residential area, predominantly of city workers and students, due to the proximately of Victoria University of Wellington. The number of students living in Lambton means that the median age (25.2) is lower than the other two areas. This could be a factor in Lambton's deprivation[8] index score of 8 and a median income of $21,400 which is well below the median Wellington income of $74,300 (2013 Census).

2.1.3 Willis Street-Cambridge Terrace CAU

Willis-Cambridge CAU, which has an area of 103 ha, is bounded by three streets, Willis Street, Kent Terrace and SH1-Karo Drive, together with the harbour edge, that together bound a square area predominantly in the suburb of Te Aro. This area includes prominent features such as Cuba Street, Courtenay Place, the Basin Reserve, Massey University and the New Zealand National War Memorial adjacent to Pukeahu National War Memorial Park, the newest large park in Wellington City. Te Aro has traditionally been a commercial and light industrial area, particularly towards Cambridge Terrace. More recently though Te Aro is where new or converted apartments are being built. These new apartments in formerly industrial areas, are a possible reason that this area is growing in population more rapidly than the other census area units. In this area there are a lot of restaurants, bars and cafes, bringing a strong hospitality culture. The median age is 26.8 and the average weekly rent is higher than the other census area units ($450 NZD), suggesting that professionals with higher disposable incomes might be more attracted to this area than the other two central city areas. Despite the higher weekly rent, Willis-Cambridge has a deprivation index score of 8 but a median income of $36,900 which is higher than Lambton but still below the Wellington median income.

2.2 Green space classification

As discussed earlier, green and associated open spaces are not homogenous and it is important to recognise the range of different ecosystem services and health and wellbeing benefits provided by different categories of land use and land cover. These differences are also very important in considering urban and spatial planning in the central city.

For this study green and associated open spaces were classified into three broad categories of land use related to tenure (called "zones" in this study), and five categories of land cover. The three land use categories, briefly described below, are Parks and Gardens, Road Reserves and Other Zoned Areas. The differences between these three zones are:

- 'Parks and Gardens' are areas that are owned by Wellington City Council and zoned and managed as parks and gardens;
- 'Road Reserves' are the green or open areas within the zoned boundaries of the designated road corridor, other than the actual road and footpath;
- 'Other Zoned Areas' are other categories of publicly owned and accessible open space, not necessarily owned by Wellington City Council.

The distinction between the three zones was determined using the Wellington City Council Parks and Reserves GIS file and the Primary Road Parcels GIS file from Land Information New Zealand. Figures 10-12 show the green and open space areas classified in this study for each CAU. This analysis was made using available Council imagery, which dated from 2013. Where the imagery was known to be

[8] Deprivation Index refers to NZDep (Salmond et al., 2006), a commonly used index of relative individual socioeconomic deprivation in New Zealand. Lower numbers on a 1-9 scale refer to lower levels of deprivation.

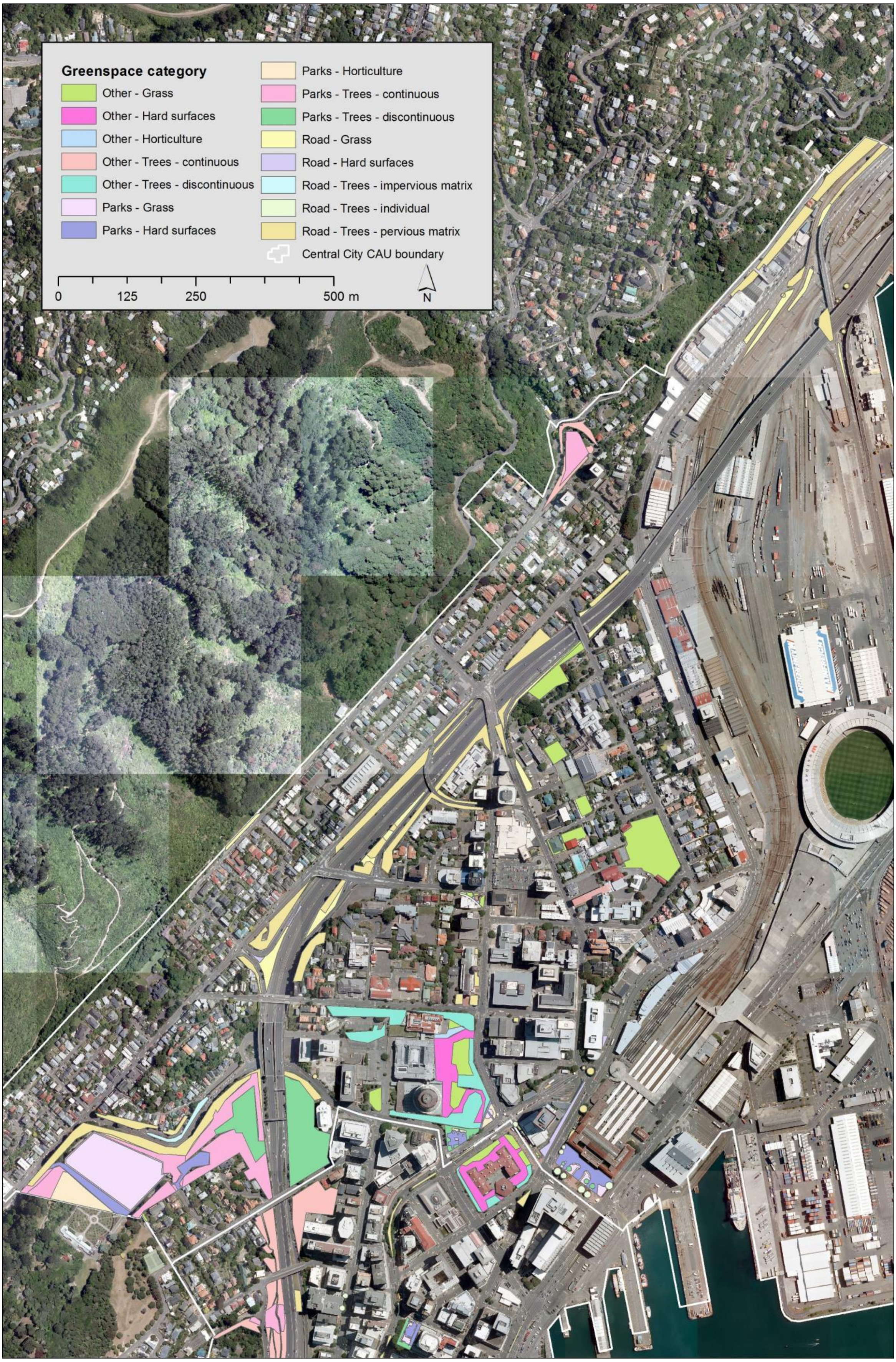


Figure 10. Classified greenspace in the Thorndon CAU

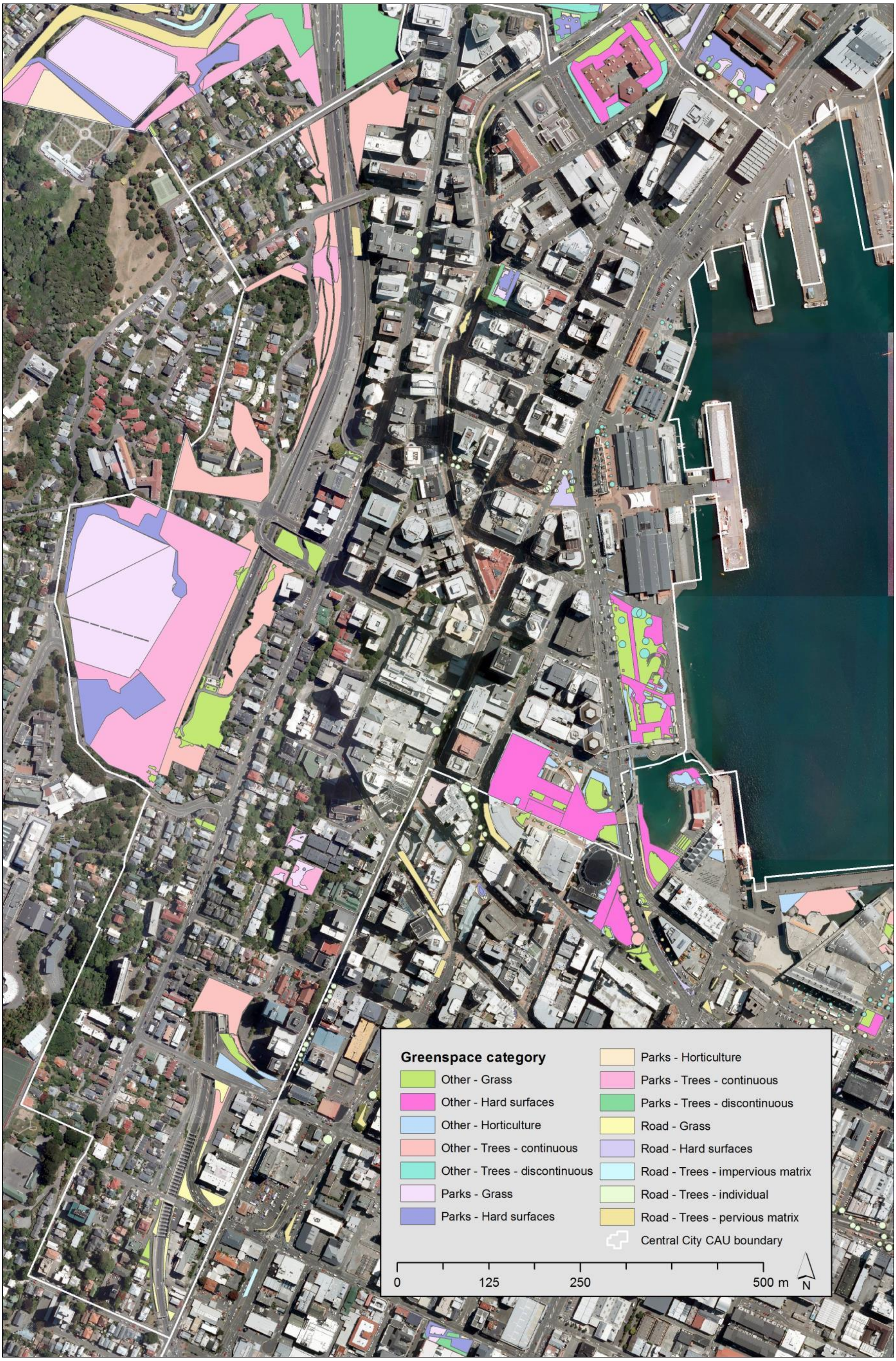


Figure 11. Classified greenspace in the Lambton CAU

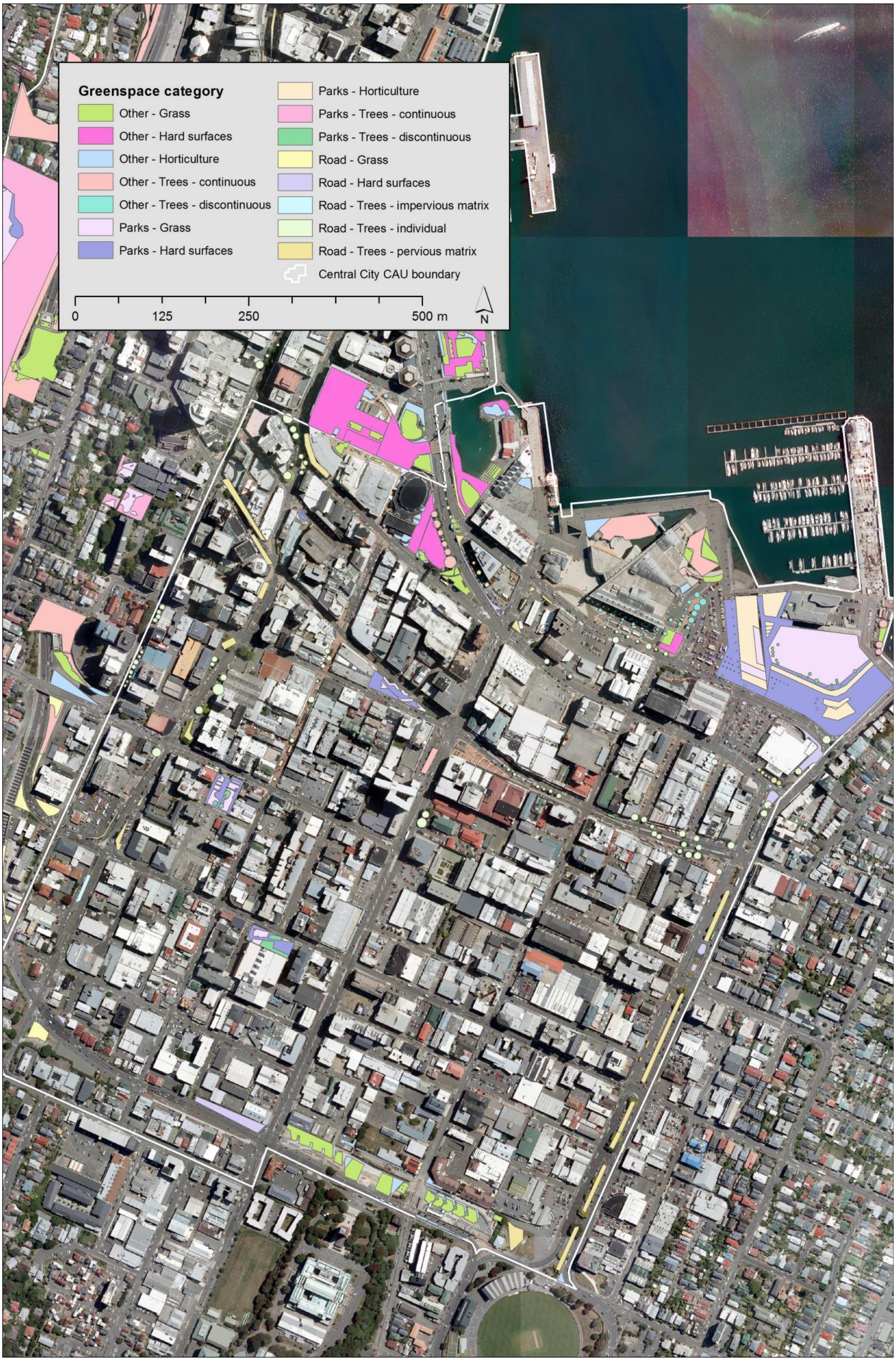


Figure 12. Classified greenspace in the Willis-Cambridge CAU

significantly out of date, mapping of land cover categories was made on the basis of site inspection and personal knowledge. The principal areas mapped in this way were sections of the Te Aro Transport Corridor, in particular Pukeahu Park, and redesigned sections of Victoria Street, within the Willis-Cambridge CAU.

2.2.1 Parks and Gardens Zone

Designated parks and gardens are superficially well spread across the central city area, with each CAU containing at least one significant public park or garden, not counting waterfront areas. The differences between the CAUs becomes apparent when the sizes of these parks and gardens are considered. Thorndon has 8.03 hectares (ha) total, Lambton has 6.92 ha, and Willis-Cambridge Street has 4.73 ha. Willis-Cambridge has the lowest total area of parks and gardens, and also has the highest amount of impervious surfaces within those parks and gardens (discussed further below). Of the 4.73 ha of Willis-Cambridge parks and gardens, 1.50 ha were hard surfaces (figure 13). This is in comparison to the 0.78 ha in Thorndon and 1.02 ha in Lambton.

Figure 13. Cobblestone Park, one of the few parks in the Willis - Cambridge CAU (source: Architecture Now; Photographer: Jeff Brass)

2.2.2 Road Reserve Zone

The Road Reserves Zone includes any green or open space that is within the Land Information New Zealand (LINZ) road parcel boundaries (land held legally for the purpose of road), not including the actual road and adjacent footpath surfaces. This land is currently not protected for open space or natural values. Within the three CAU boundaries there is 9.93 ha of green space in the road reserve. This is predominantly in Thorndon which has 7.66 ha of the 9.93 ha total. Willis-Cambridge has 1.51 ha and Lambton has 0.76 ha.

The reason for this difference is that in Thorndon there is a large section of the Te Aro Transport Corridor (the Urban Motorway) which is bordered by green space (figure 14). This motorway runs through the other two CAUs, but the size of the green space areas there is smaller, in part due to two sections of the motorway running through tunnels; the Terrace Tunnel and the Arras Tunnel. The areas above these tunnels, although green spaces, are not recognised as part of the road reserve but have been included in Other Zoned Areas. The New Zealand Transport Authority (NZTA) road corridor is not publicly accessible or managed for green space values. In terms of land cover, the greatest area is in the trees (pervious matrix) category. This is because there are large parts of this category along the motorway, while most street trees in central Wellington exist in a pervious matrix, with grasses or annual/perennial low vegetation at their bases. It is important to note that the total road reserve area excludes the road and pavement surface, which is in contrast with the Parks and Gardens zone where every type of surface including impervious surfaces were counted. Unlike Parks and Gardens, the road surface has a specific purpose of transporting goods and people, so it has been excluded in this assessment of green and open spaces.

Figure 14. Roading reserve adjacent to the urban motorway (Karo drive) (Photograph: P. Blaschke)

2.2.3 Other Zoned Areas

Other Zoned Areas are publicly owned and accessible open spaces that are not classified as Parks and Gardens or road reserve. There are a number of areas that the Council does not directly own or are not within designated road reserves but which are important green spaces. An example is Frank Kitts Park, which is in the Waterfront Precinct in Lambton. This park is managed by Wellington City Council but is not indicated within the Parks and Reserves information layer. Areas owned by the New Zealand Government are also included within this category, such as Parliament Lawn and Pukeahu War Memorial Park (figure 15). These areas contribute 19.60 hectares of green space to Central Wellington. This is predominantly 5.46 hectares of grassed areas and 5.43 hectares of continuous trees. This category does not follow the trend seen in the Parks and Gardens, and Road Reserves categories, with Thorndon containing less green space in this category than Lambton. Of the 19.60

hectares total, 10.45 hectares are in Lambton CAU with the result that Lambton has more Other Zoned Areas than the two other CAUs combined.

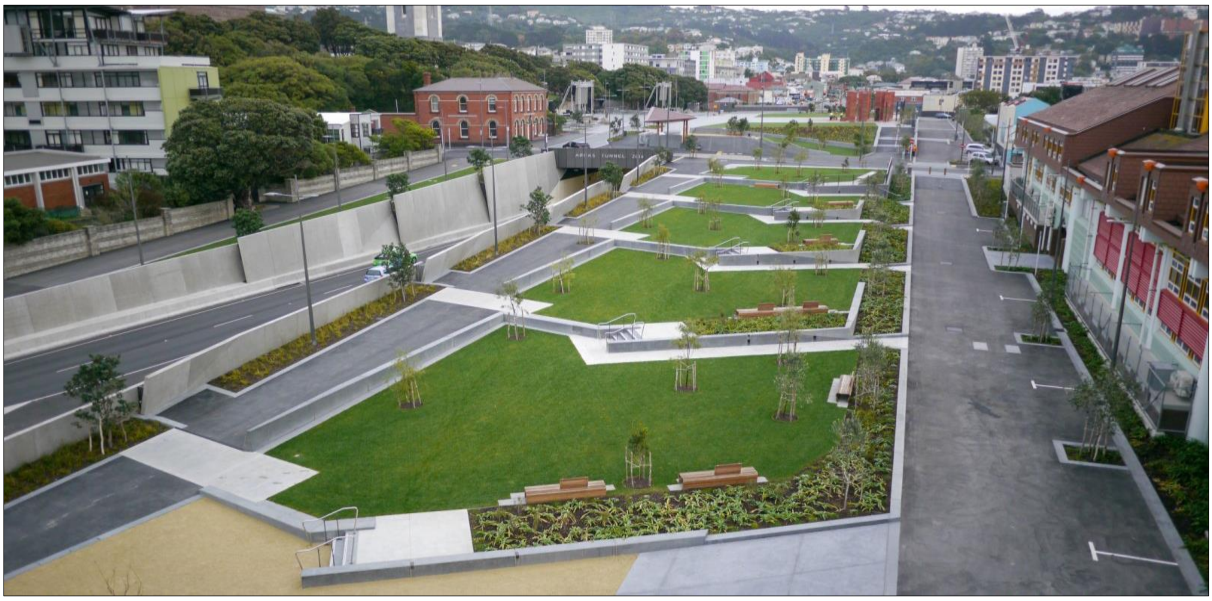


Figure 15. Pukeahu National War Memorial Park (source: Ministry for Culture and Heritage)

2.2.4 Land cover categories

Land cover categories are described in Table 3. The classification used is essentially similar for all three zones, with slight differences made to recognise the types of cover actually present in each. In particular, the Road Reserve zone contained virtually no continuous cover tree vegetation, but relatively large areas of discontinuous trees (treeland), so more detail was needed in this category to recognise the important differences in perviousness between treeland areas.

Table 3. Land cover categories

Parks and Reserves Zone (All areas in WCC Parks and Reserves GIS layer)		
Land cover category	**Definition**	**Notes**
Continuous canopy trees and forest	Forest and trees with >80% tree canopy cover	
Discontinuous canopy trees	Treeland with 10-80% tree canopy	Includes some individual large trees
Bushes, shrubs, horticulture areas	Areas of plantings within a park and reserve	Includes all planted vegetation smaller than individual canopy tree but excludes grassed areas
Grassed areas	Grassed area, with <10% tree canopy cover over the grass	Widely spaced large trees within grass matrix have been excluded from this class and included in the discontinuous trees category.
Impervious surfaces	Impervious surfaces such as roads, large paths, and sealed playgrounds and building surrounds	May include minor areas of mainly spontaneous vegetation (weeds etc.). Includes wider (>1.5m wide) paths or trails through vegetated classes

Road Reserves Zone (All areas in WCC Road Reserves GIS layer, excluding actual roadway and adjacent footpath)		
Land cover category	**Definition**	**Notes**
Treeland (pervious matrix)	Treeland (>10% canopy cover) in pervious matrix such as grass or herbaceous beds	Mainly discontinuous trees but includes small areas of continuous tree cover. Mapped polygon may be linear, rectangular or irregular
Treeland (impervious matrix)	Treeland in impervious matrix such as concrete	Mainly discontinuous trees but includes small areas of continuous tree cover. Matrix is usually designed open space with discontinuous trees. Mapped polygon is often linear or rectangular
Trees (individual)	Individual widely spaced single canopy trees in both pervious and impervious matrices	Marked on maps as small circles
Grassed areas	Grassed areas not covered by tree canopy	Includes small areas of herbaceous and low-growing vegetation
Impervious surfaces	Hard surface areas not within roadway, adjacent footpath or multi-space public carparks	May include minor areas of mainly spontaneous vegetation (weeds etc.)
Other area zone (All areas identified as publicly owned and accessible open and green space, but are not in the other two GIS layers e.g. Transit NZ motorway/expressway road reserve equivalent, Civic Square, accessible harbour waterfront area (Wellington Waterfront Ltd))		
Land cover category	**Definition**	**Notes**
Tree land and forest (continuous)	Treeland with >80% tree canopy,	Includes some individual large trees
Tree land (discontinuous)	Forest and treed area with 10-80% tree canopy cover	
Bushes, Shrubs, horticultural areas	Cultivated or planted areas not dominated by trees	Includes all planted vegetation (herbaceous or woody but smaller than canopy trees) and excluding grassed areas
Grassed areas	Grassed area, with <10% tree canopy covering it	Widely spaced large trees within grass matrix have been excluded from this class and included in the discontinuous trees category
Impervious surfaces	Impervious surfaces such as roads, large paths, and sealed playgrounds and building surrounds	May include minor areas of mainly spontaneous vegetation (weeds etc.). Includes wider (>1.5m wide) paths or trails through vegetated classes. Includes small areas of constructed quasi-green areas (artificial turf etc.)

2.2.5 Green space area totals

Tables 4-6 show the total areas of green space available in the three zones and vegetation categories discussed above. The total green space in all categories and zones is 41.19 ha. Examples of some land cover types are shown in figure 16.

Table 4. Total available green space in the Parks and Reserves Zone in Wellington Central City

Land cover	Area (ha)			
	Thorndon - Tinakori CAU	Lambton CAU	Willis St -Cambridge Tce CAU	Central City (total)
Discontinuous Trees	1.61	0.42	0.08	2.11
Continuous Trees	2.96	3.21	0.01	6.18
Impervious surfaces	0.76	0.95	1.5	3.21
Grassed areas	1.52	2.61	1.08	5.21
Bushes, Horticulture areas	0.42	0.02	0.69	1.13
Total	**7.27**	**7.21**	**3.36**	**17.84**

Table 5. Total available green space in the Road Reserves Zone in Wellington Central City

Land cover	Area (ha)			
	Thorndon - Tinakori CAU	Lambton CAU	Willis St -Cambridge Tce CAU	Central City (total)
Tree land (impervious matrix)	2.7	0.02	0.02	2.74
Tree land (pervious matrix)	3.79	0.26	0.69	4.74
Trees (individual)	0.08	0.13	0.41	0.62
Grassed areas	0.91	0.28	0.05	1.24
Impervious Surfaces	0.14	0.08	0.31	0.53
Total	**7.62**	**0.77**	**1.48**	**9.87**

Table 6. Total available green space in Other Zoned Areas in Wellington Central City

Land cover	Area (ha)			
	Thorndon-Tinakori CAU	Lambton CAU	Willis St - Cambridge Tce CAU	Central City (total)
Discontinuous Trees	1.08	0.24	0.06	1.38
Continuous Trees	0.23	3.58	0.51	4.32
Impervious surfaces	0.54	1.84	0.49	2.87
Grassed areas	1.75	1.63	0.75	4.13
Bushes, Horticulture areas	0.06	0.34	0.38	0.78
Total	**3.66**	**7.63**	**2.19**	**13.48**

Table 7 shows a summary of the three tables 4-6, in which the slight classification differences used for the three zones are merged to give a combined classification. This table shows that of the 41.19 ha total green space, 6.61 ha (16%) are hard (impervious) surfaces and are essentially not green space.

Table 7. Summary of total available green space in Wellington Central City

Land cover	Area (ha)			
	Thorndon-Tinakori CAU	Lambton CAU	Willis St -Cambridge Tce CAU	Central City (total)
Discontinuous Trees	9.26	1.07	1.26	11.59
Continuous Trees	3.19	6.79	0.52	10.50
Hard surfaces	1.44	2.87	2.30	6.61
Grassed areas	4.18	4.52	1.88	10.58
Bushes, Horticulture areas	0.48	0.36	1.07	1.91
Total	**18.55**	**15.61**	**7.03**	**41.19**
Total excluding hard surfaces	***17.11***	***12.74***	***4.73***	***34.58***

Figure 16. Landcover type examples in Wellington.
Top left: discontinuous trees (Featherstone Street). Top right: continuous trees (Flagstaff Hill).
Bottom left: Hard surfaces (Te Ngākau Civic Square). Bottom right: grassed areas (Jack Ilott Green)
(photographer: P. Blaschke)

3.0 Current demographic and needs analysis

3.1 Overall population

The population of the whole central city area in 2013 was 17,076, 9% of the whole Wellington City population. The highest population was concentrated in Willis-Cambridge and Lambton CAUs. In the central city, income is varied, with the median per capita income ranging between $48,300 in Thorndon and $21,400 in Lambton. These differences in income are reflected in the rates of home ownership. The lowest rates of home ownership are in Willis-Cambridge with less than 25%. In this CAU, there is also the highest median weekly rental price at $450.

In all CAUs in the central city, population is projected to grow significantly according to both the Statistics New Zealand (Stats NZ) high and medium measures and the forecast.id[9] measures. For the central city area between the years 2018-2043 the Stats NZ medium projection predicts that the population will grow by 10,060 people, while the high projection predicts that the population will grow by 12,330 people, reaching about 12% of the projected total city population. Once the 2018 census data are available it will be easier to determine which projection is more likely. In the forecast.id table, the population in non-private dwellings which includes students, rest homes, hotels, and hostels and the projected population growth is listed for each area in their measurements.

Table 8 shows in summary the population of the three census area units, the percentage of the total Wellington population that reside there and selected demographic information about the resident populations of each CAU. Home ownership rates and rent levels indicate that home ownership is significantly higher in Thorndon and that median weekly rentals were somewhat lower in Lambton than in Thorndon and Willis-Cambridge.

Table 8. Demographic information on the study areas (2013 Census)

CAU	Population	% Wellington City Pop.	Median Income (NZD)	% annual income over $50,000	% of home-ownership	Median weekly rent (NZD)	Median Age (years)	% of residents over 65	% of residents under 15 years	Deprivation Index
Thorndon-Tinakori Road	4,125	2.2	48,300	48.1	40.9	430	32.2	9.8	7.8	5
Lambton	5,622	2.9	21,400	28.5	27.9	400	25.2	4.9	3	8
Willis St-Cambridge Tce	7,329	3.8	36,900	36.9	24.8	450	26.8	3.3	3.2	8
Total Central City	**17,076**	**9%**	*These values are not available for the whole Central City area*							

The age distribution date shows that Thorndon has a somewhat more even age distribution that the other two CAUs, with more over-65 residents, but also more under 15-year olds, i.e. more older people

[9] Forecast.id is a commercial demographic information service providing demographic resources to a number of New Zealand local government agencies including Wellington City Council. See: https://forecast.idnz.co.nz/. Some information on projected population growth was used in our study to supplement Statistics New Zealand population forecasts.

and more families with dependent children. By contrast, Lambton and Willis-Cambridge populations were heavily concentrated in the 15-65 age groups.

3.2 Future population levels

Table 9 shows Stats NZ high and medium population growth projections for each census area unit and the central city total. These projections are based on 2013 census information, and once 2018 census data is available it will be possible to compare and evaluate which projection is more likely to occur[10]. Under both scenarios, there is significant population increase in the central city overall (nearly 90% in the high growth projection and nearly 75% in the medium growth projection) and in the Willis-Cambridge CAUs, although the rate of increase slows towards the end of the projection period. In the medium growth scenario there is also a relatively large population increase in Lambton. Under both population growth projections the increase in Thorndon is only half of that in the central city overall.

Table 9. Population projections (high and medium)

High population projection									
Year at 30 June	**2013**	**2018**	**2023**	**2028**	**2033**	**2038**	**2043**	**Pop. increase 2013-43**	**% Pop. increase 2013-43**
Thorndon-Tinakori Road	4260	4730	5070	5410	5760	6080	6400	2140	50.2
Lambton	5810	6840	7700	8570	9450	10300	11150	5340	61.9
Willis Street - Cambridge Tce	7560	9550	11000	12250	13500	14700	15900	8340	110.3
Total	**17630**	**21120**	**23770**	**26230**	**28710**	**31080**	**33450**	**15820**	**89.7**
Increase from previous year		***3490***	***2650***	***2460***	***2480***	***2370***	***2370***	**-**	**-**

Medium population projection									
Year at 30 June	**2013**	**2018**	**2023**	**2028**	**2033**	**2038**	**2043**	**Pop. increase 2013-43**	**% Pop. increase 2013-43**
Thorndon-Tinakori Road	4260	4640	4890	5140	5390	5630	5860	1600	37.6
Lambton	5810	6680	7370	8080	8790	9510	10250	4440	76.4
Willis Street - Cambridge Tce	7560	9230	10450	11450	12500	13500	14500	6940	91.8
Total	**17630**	**20550**	**22710**	**24670**	**26680**	**28640**	**30610**	**12980**	**73.6**
Increase from previous year		***2920***	***2160***	***1960***	***2010***	***1960***	***1970***	**-**	**-**

Tables 10-12 show other data on forecast population, households and dwellings for each part of the central area, with some additional information about households. These data (from forecast.id

[10] Current forecast.id estimates for 2013-2018 based on analysis of housing surveys, consents and public development plans suggest that the actual rate of population increase more closely conforms to the high projection for this period.

projections) are presented on different boundaries to the CAUs so cannot be directly compared, but the Thorndon-Pipitea, Wellington Central and Te Aro areas used by forecast.id approximately correspond to the Thorndon, Lambton and Willis-Cambridge CAUs respectively.

They show similar high population increases as in table 9 (from Stats NZ data), with a steady growth in household numbers. These data indicate that a large proportion of central city dwellers live in private dwellings and the proportion of residents in private dwellings over time increases in all CAUs. Some of these residents will have access to private green space as well as public green space.

Table 10. Forecast population, households and dwellings for Thorndon-Pipitea

Thorndon - Pipitea	**Forecast year**						
	2013	**2018**	**2023**	**2028**	**2033**	**2038**	**2043**
Population	4,469	4,775	5,043	5,209	5,393	5,633	5,967
Change in population (5yrs)		307	267	166	184	240	334
Average annual change		1.34%	1.10%	0.65%	0.70%	0.87%	1.16%
Households	2,036	2,193	2,307	2,400	2,515	2,650	2,809
Average household size	2.15	2.14	2.15	2.14	2.11	2.09	2.09
Population in non-private dwellings	84	84	84	84	84	84	84
Dwellings	2,235	2,322	2,442	2,542	2,666	2,811	2,982
Dwelling occupancy rate	91.10	94.44	94.47	94.41	94.34	94.27	94.20

Table 11. Forecast population, households and dwellings for Wellington Central

Wellington Central	**Forecast year**						
	2013	**2018**	**2023**	**2028**	**2033**	**2038**	**2043**
Population	3,277	3,970	5,115	6,221	6,812	7,413	8,037
Change in population (5yrs)		693	1,145	1,106	591	601	624
Average annual change		3.91%	5.20%	3.99%	1.83%	1.71%	1.63%
Households	1,112	1,260	1,715	2,184	2,444	2,739	3,042
Average household size	2.06	2.06	2.18	2.22	2.20	2.18	2.17
Population in non-private dwellings	988	1,378	1,378	1,378	1,438	1,438	1,438
Dwellings	1,325	1,421	1,917	2,437	2,719	3,038	3,363
Dwelling occupancy rate	83.92	88.67	89.46	89.62	89.89	90.16	90.45

Table 12. Forecast population, households and dwellings for Te Aro

Te Aro	**Forecast year**						
	2013	**2018**	**2023**	**2028**	**2033**	**2038**	**2043**
Population	10,028	12,456	15,221	16,536	17,643	18,371	19,416
Change in population (5yrs)		2,428	2,764	1,316	1,107	728	1,045
Average annual change		4.43%	4.09%	1.67%	1.30%	0.81%	1.11%
Households	4,089	5,004	6,077	6,697	7,306	7,814	8,373
Average household size	2.23	2.28	2.33	2.30	2.26	2.20	2.18
Population in non-private dwellings	896	1,046	1,046	1,128	1,128	1,169	1,169
Dwellings	4,658	5,315	6,355	7,053	7,710	8,255	8,855
Dwelling occupancy rate	87.78	94.15	95.63	94.95	94.76	94.66	94.56

3.3 The counting of students in student accommodation

Many tertiary student hostels and flats are situated in the central city (figure 17). There is significant student accommodation also in Kelburn, and the Basin Reserve to Newtown areas which are outside of our study area. It is highly likely that students in student hostels, have not registered their new address and are thus under-counted. Amore et al. (2013) report that "*many residents of student accommodation report that their usual address is overseas, despite tertiary students being instructed to report the student accommodation as their usual address.".* According to Statistics NZ (2013), non-private dwellings are considered to be *"dwellings that provide short- or long-term communal or transitory accommodation, and are available to the public, such as hotels, motels, boarding houses, hospitals, and residential care facilities."*

Figure 17. Inner city student accommodation: Boulcott Hall (on right of image) (Source: Booking)

Students in student halls are unlikely to have been included in these population statistics, given the timing of the census and the common practice of not listing a student hall as a primary residence. Where, however, non-student residents in hostels, some transit accommodation and other residential care facilities do not have any other usual place of residence, then they are likely to be included in the population figures for the central city.

3.4 Commuters into the Central City

Table 13 gives information about the number of people working in the central city and their residence and commuting patterns. There is a total of nearly 80,000 people working in the three CAUs, four and a half times as many as are resident in the areas. Over half of the commuters come into the Lambton CAU, so the *daytime* population density of this CAU is at least comparable to that of the Willis-Cambridge CAU.

Table 13. Number of residents and commuters Wellington Central City 2013

	Thorndon-Tinakori Road			**Lambton**			**Willis Street- Cambridge Terrace**		
Commuting Type	**Number**	**% of total**	**% of res pop**	**Number**	**% of total**	**% of res pop**	**Number**	**% of total**	**% of res pop**
Live and work in CAU	729	3.8	17.7	1,449	3.2	25.8	1,359	6.2	18.5
Commute out	1,884	9.8	45.7	1,410	3.2	25.1	3,174	14.2	43.3
Commute in	16,692	86.4	405	41,829	93.6	744	17,754	79.6	242
Total people working in area unit	**17,421**	**90.2**		**43,278**	**96.8**		**19,113**	**85.8**	
Total working population	***19,305***			***44,688***			***22,287***		
Total resident population	***4,125***			***5,622***			***7,329***		

The proportions of people living and working, and commuting in and out of the three CAUs shows some interesting comparisons although the current numbers of people living and working or commuting out of the CAUs are still small. All three CAUs have far more people commuting in to work than resident. Thorndon and Willis-Cambridge CAUs have a fairly similar pattern although the latter has a lower number of inwards commuters. Lambton CAU stands out, however in having a much higher number of inwards commuters, 7.5 times the number of residents. These differences have some implications for the type and timing of green space needs for commuters and residents and highlight the fact that, especially in the Lambton CAU, meeting green space requirements of commuters as well as residents is critical.

Figure 18. Wellington commuters (Source: Russellstreet, Wikimedia Commons)

4.0 Supply and demand synthesis

4.1 Current total and per capita amount of green space

Table 14 shows the *current* (2013) total green space and per capita amount of green space in the Central City and the three CAUs. These areas are shown separately for all areas classified (including hard surfaces) and excluding the hard (impervious) surfaces. Only the latter represent areas that supply the full range of green space ecosystem values. Table 15 shows the *current* (2013) green space and per capita amount of green space (excluding impervious surfaces) within parks and reserves in the Central City and the three CAUs.

Table 14. Per capita amount of all types of green space

	Population (2013)	Total green space (ha)		Green space per capita (m^2/person)	
		incl. hard surfaces	excl. hard surfaces	incl. hard surfaces	excl. hard surfaces
Thorndon-Tinakori Road	4,125	18.55	17.11	45	41
Lambton	5,622	15.61	12.74	28	23
Willis St-Cambridge Tce	7,329	7.03	4.73	10	6
Total Central City	17,076	41.19	34.58	24	20

Table 15. Per capita available green space (excluding impervious surfaces) in central city parks and reserves

CAU	Population (2013)	Green space in Parks and Reserves (ha)	Green space per capita (m^2/person)
Thorndon-Tinakori Road	4,125	6.51	15.8
Lambton	5,622	6.26	11.1
Willis St-Cambridge Tce	7,329	1.86	2.54
Total Central City	17,076	14.63	8.6

This analysis shows a relative lack of total and per capita green space in the Willis-Cambridge CAU. The reduction in pervious green spaces compared to impervious green spaces throughout the central city is also significant. The difference between pervious and impervious seems small in absolute terms – a reduction of 3-5 m^2 per capita. However, because of the absolute lack of green space in the Willis-Cambridge CAU, this is a reduction of 27% of total green space available, compared to 16% reduction for the central city and only 9% for the Thorndon CAU.

4.2 Future green space amount

Future green space amount (excluding hard surfaces) was assessed using Statistics New Zealand population projections to 2043 for the constituent CAUs of the Central City area. Assuming no change in total green space (excluding impervious hard surfaces) within each CAU, per capita green space was calculated for both the medium and high population projections. The results are presented in table 16 showing total green space in all three land use zones. Per capita amount of green space in parks and reserves becomes proportionately lower consistent with the totals shown in tables 14 and 15.

Table 16. Projected available total green space per person (excluding hard surfaces) for Stats NZ medium and high 2043 population projections

CAU	Population (2043)		Green space (excl. hard surfaces) (ha)	Green space per capita (m^2/person)	
	Medium	High		Medium	High
Thorndon-Tinakori Road	5860	6400	17.11	29.2	26.7
Lambton	10250	11150	12.7	12.4	11.4
Willis St-Cambridge Tce	14500	15900	4.73	3.3	3.0
Central City	30,610	33,450	34.58	11.3	10.3

Under the medium growth projection the results for total green space, compared with table 14, show per capita amount in Thorndon CAU decreasing by 12m^2, Lambton CAU decreasing by 11m^2 and Willis-Cambridge CAU decreasing by 3m^2 per capita. When considered proportionally however, while Willis-Cambridge decreases by less than Lambton or Thorndon, half of the per capita green space will be lost.

Under the high population projections for total green space for 2043 (furthest right column, table 16), Thorndon decreases by 14m^2 per capita, Lambton decreases by 12m^2, and Willis-Cambridge decreases by 3m^2. This means that under a high population growth scenario both Lambton and Willis-Cambridge will halve or more than halve their per capita green space amount by 2043. Thorndon in contrast will maintain more than half. It should also be noted that in 2043 the amount of per capita green space in Thorndon under the high population growth estimate will still be higher (27m^2) than the current per capita green space in either Lambton or Willis-Cambridge.

4.3 Green space amount and accessibility: buffer analysis

4.3.1 Overall Central City area

Whereas the previous section dealt with overall supply or *available amount* of green space within the central city and the three CAUs, it is also important to examine the actual *accessibility* of green space in relation to where people live or work. Green space amount was assessed using buffer analysis using the population-weighted centre as a point to represent the location of the average resident in the Central City area. The population-weighted centre was calculated using Census 2013 Mesh Block population data from Statistics New Zealand. Concentric buffers were drawn around this centre at intervals of 100m out to a distance of 500m (figure 19).

The population of each buffer was estimated by summing the population of each Mesh Block that has its geometric centre within that buffer. The greenspace within each buffer was then summed to give a measure of total available green space (m^2) within 500m of the population-weighted centre of the Central City zone at 100m intervals. Results summarised by land use zones and land cover category[11] are shown in tables 17 and 18, respectively. Full results can be found in appendix 4, table 31.

[11] Areas within land cover categories used in this section amalgamate the three zones as shown in Table 7.

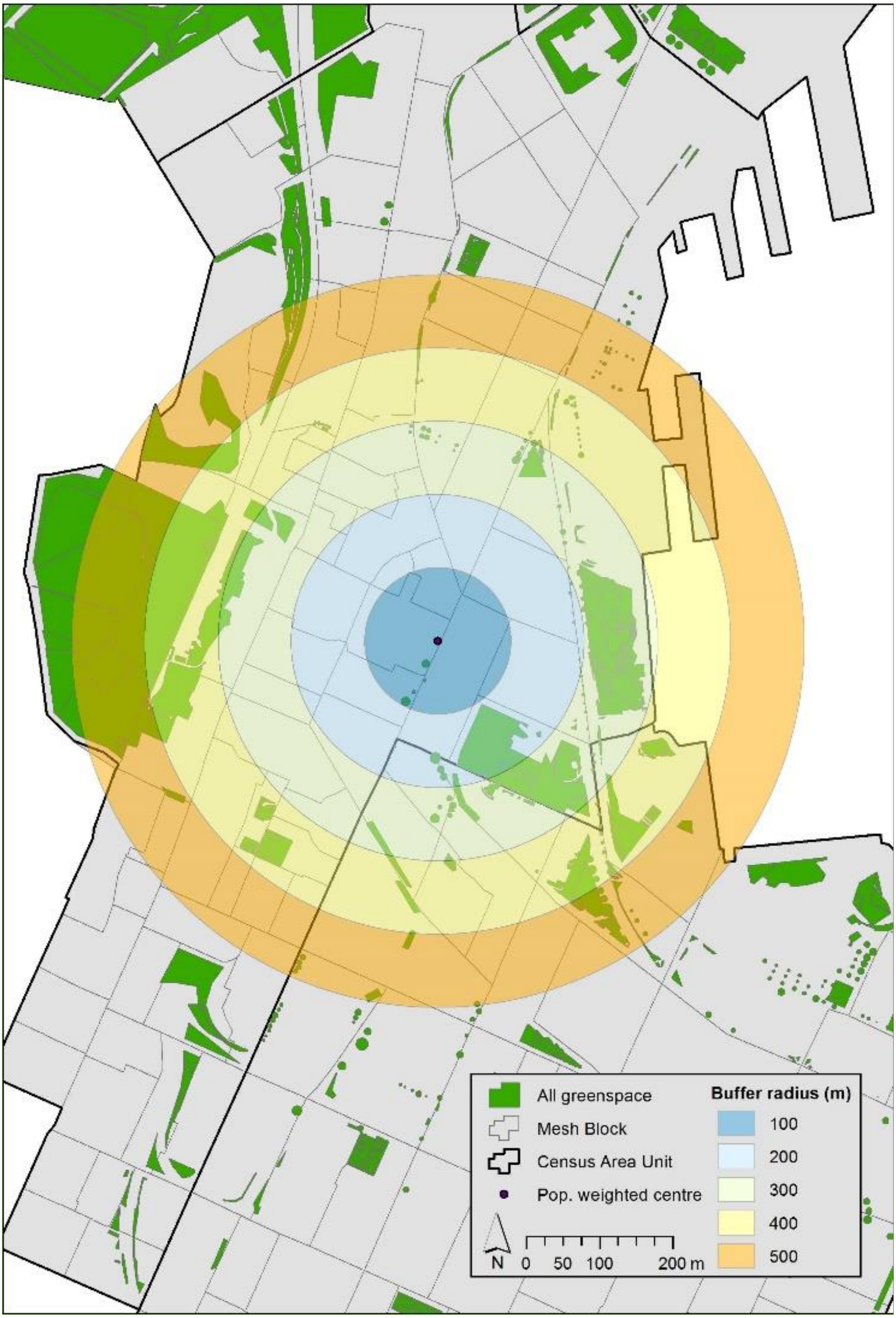


Figure 19. Map showing the location of the Central City population-weighted centre with buffers

Table 17. Total available public greenspace (m^2) within 500m of population-weighted centre of Central City zone (at 100m intervals) by land use zone

Radius (m)	Parks and reserves	Road reserves	Other	Total
100	0	226	0	226
200	0	701	5942	6643
300	98	3555	28572	32224
400	13518	4999	46649	65165
500	48118	6292	59229	113639

Table 18. Total available public greenspace (m^2) within 500m of population-weighted centre of the Central City (at 100m intervals) by land cover category

Radius (m)	Horticulture& bushes	Grass	Continuous trees*	Discontinuous trees#	Hard surfaces
100	0	0	0	226	0
200	327	135	125	576	5480
300	2322	8970	3180	2384	15368
400	3432	15897	23859	2872	19107
500	3793	31109	50771	3231	24736

* Includes trees within pervious and impervious matrices in the road reserve. # Includes individual trees in the road reserve.

Per capita greenspace amount for each buffer was then calculated by dividing the total available greenspace by the estimated population of the buffer. Results summarised by land use and land cover are shown in tables 19 and 20, respectively. Full results can be found in appendix 4, table 32.

Table 19. Per capita public greenspace amount (m2/person) within 500m of population-weighted centre of the Central City (at 100m intervals) by land use zone

Radius (m)	Est. pop.	Parks & reserves	Road reserves	Other	Total
100	162	0	1.40	0.0	**1.40**
200	876	0	0.80	6.78	**7.58**
300	1794	0.05	1.98	15.93	**17.96**
400	2805	4.82	1.78	16.63	**23.23**
500	4119	11.68	1.53	14.38	**27.59**

Table 20. Per capita public greenspace amount (m2/person) within 500m of population-weighted centre of the Central City (at 100m intervals) by land cover category

Radius (m)	Est. pop.	Horticulture & bushes	Grass	Continuous trees*	Discontin-uous trees#	Hard surfaces
100	162	0	0	0	1.40	0
200	876	0.37	0.15	0.14	0.66	6.26
300	1794	1.29	5.00	1.77	1.33	8.57
400	2805	1.22	5.67	8.51	1.02	6.81
500	4119	0.92	7.55	12.33	0.78	6.01

* Includes trees within pervious and impervious matrices in the road reserve. # Includes individual trees in the road reserve.

There is very little green space within 200m of the central city population-weighted centre, with a substantial increase in available greenspace at a distance of 300m from the population-weighted centre, beyond which green space amount is maintained at around the average for the Central City area (24m^2/person – see table 14). This coincides with a walking time of approximately 3-5 minutes from this centre.

The two main types of green space within 500m of the population-weighted centre are continuous trees (mostly within parks and reserves and other areas) and grassed areas. The third largest land cover within 500m, and the largest within 300m of the centre, comprises hard surfaces, i.e. non-green surfaces within green spaces (see discussion of Table 7). Small contributions are made from bush and horticulture areas and discontinuous trees.

4.3.2 Central City CAUs

Buffer analysis was also carried out for each CAU that makes up the Central City area (figure 20). This process was the same as described in the previous section, using Census 2013 Mesh Block population data to calculate population-weighted centres for each CAU. For clarity, only one buffer of 300m radius from each CAU centre was used for this analysis.

Population and available greenspace were summarised for the overall Central City area. Results summarised by land use and land cover are shown in tables 21 and 22, respectively. Full results can be found in appendix 4, table3 3.

Table 21. Total available public greenspace (m^2) within 300m of population-weighted centre of each CAU of the Central City by land use zone

CAU	Parks and reserves	Road reserves	Other	Total
Thorndon	0	28626	2628	31253
Lambton	52708	913	17098	70719
Willis-Cambridge	5028	898	349	6275

Table 22. Total available public greenspace (m^2) within 300m of population-weighted centre of each CAU of the Central City by land cover category

CAU	Horticulture & bushes	Grass	Continuous trees*	Discontinuous trees#	Hard surfaces
Thorndon	136	5245	25593	0	280
Lambton	117	23269	39901	534	6898
Willis-Cambridge	154	1489	410	1426	2795

* Includes trees within pervious and impervious matrices in the road reserve. # Includes individual trees in the road reserve.

Per capita greenspace amount for each CAU centre was then calculated by dividing the total available greenspace by the estimated population of the buffer. Results summarised by land use and land cover are shown in tables 23 and 24, respectively. Full results can be found in appendix 4, table 34. Total available green space per person was also analysed for each CAU and is presented in table 14.

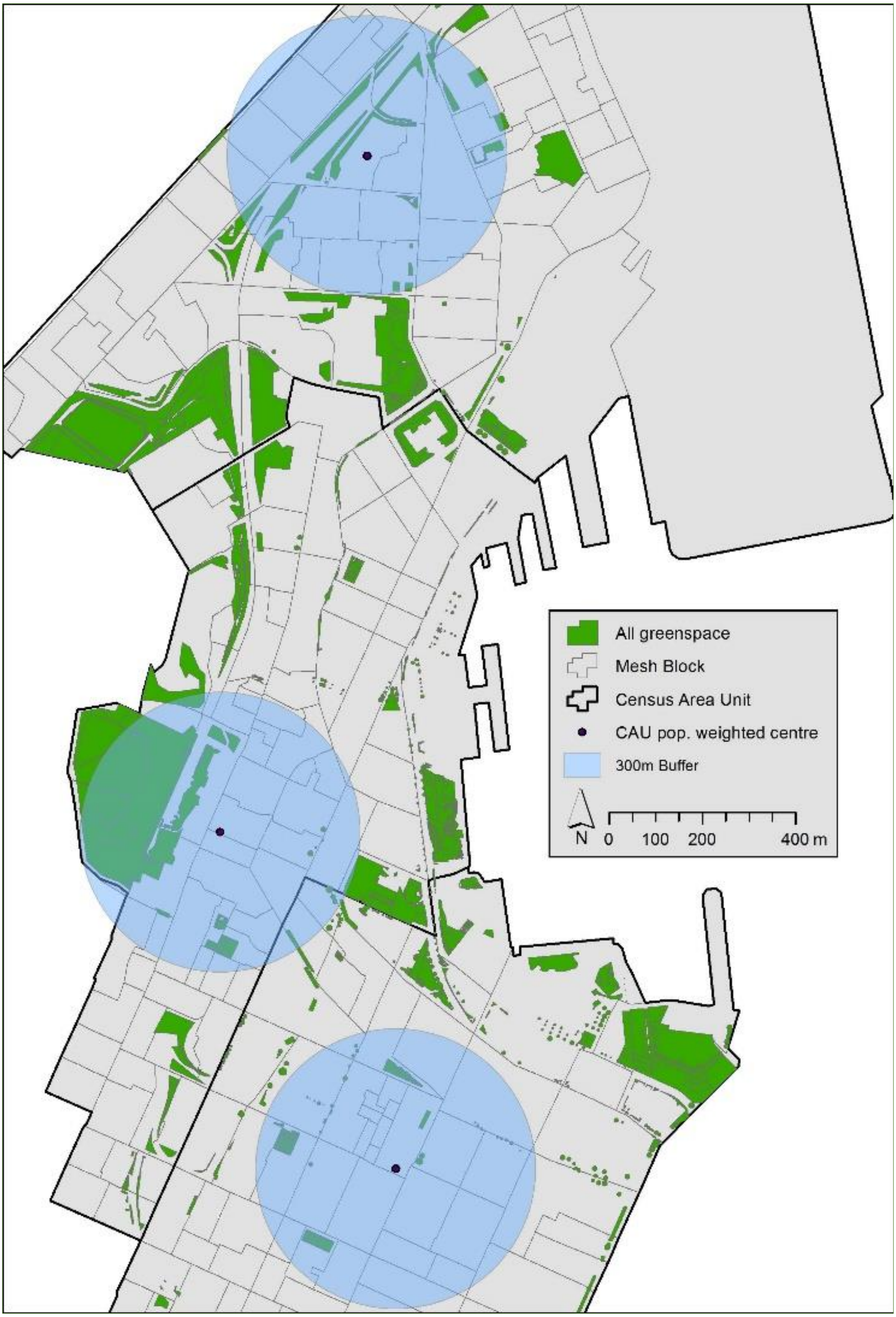


Figure 20. CAU population-weighted centres and 300m radius buffers

Table 23. Per capita public greenspace amount (m²/person) within 300m of population-weighted centre of each CAU of the Central City by land use zone

CAU	Est. pop.	Parks and reserves	Road reserves	Other	Total
Thorndon	789	0	36.28	3.33	39.61
Lambton	1242	42.44	0.74	13.77	56.94
Willis-Cambridge	2172	2.31	0.41	0.16	2.89

Table 24. Per capita public greenspace amount (m²/person) within 300m of population-weighted centre of each CAU of the Central City by land cover category

CAU	Est. pop.	Horticulture & bushes	Grass	Continuous trees*	Discontinuous trees#	Hard surfaces
Thorndon	789	0.17	6.65	32.44	0	0.35
Lambton	1242	0.09	18.74	32.13	0.43	5.55
Willis-Cambridge	2172	0.07	0.69	0.19	0.66	1.29

* Includes trees within pervious and impervious matrices in the road reserve. # Includes individual trees in the road reserve.

4.3.3 Discussion

There is a substantial lack of greenspace within 300m of the population-weighted centre of the Willis-Cambridge CAU (figure 20), in or adjacent to which area significant large apartment block building is currently focussed. The Thorndon CAU has no parks and reserves or discontinuous trees within 300m of the centre, but large amounts of greenspace can be found in the road reserve in this area. Lambton and Thorndon have 50-100 times more continuous trees than Willis-Cambridge within 300m of their centres, but the latter has more discontinuous trees (almost three times that of Lambton). Greenspaces within 3-5 minutes walking distance (300m) from the centre of Willis-Cambridge contain more hard surfaces than any other land cover (almost twice as much as the next highest land cover – grass).

On a per capita basis Lambton has substantial amounts of greenspace, especially parks and reserves, continuous trees and grass within 300m of the population-weighted centre. Thorndon still has substantial per capita amount of greenspace, but less than Lambton, with most of this found in the road reserve. The per capita amount of any greenspace in Willis-Cambridge is very low.

The per capita green space for the entire CAU areas shows Thorndon has large amounts of green space, with almost double the Central City area average, while Willis-Cambridge has very little greenspace (less than half the Central City area average). When hard surfaces are removed Thorndon total greenspace amount decreases by 9%, Lambton by 19% and Willis-Cambridge by 27%.

When the deprivation indices of the CAUs is considered, an interesting picture emerges. Thorndon has a deprivation index of 5 (Atkinson et al., 2014) while Lambton and Willis-Cambridge CAUs have higher deprivation indexes of 8. Lambton CAU also has the highest number of workers that commute into the CAU area each day. Willis Street-Cambridge Terrace has a mix of industrial and smaller businesses and relatively fewer commuters. The differences in greenspace amount in relation to the deprivation levels of the surrounding area, and the impact of commuter numbers on per capita greenspace amount should be explored further, although this is beyond the scope of the current study.

The importance of meeting the needs of large numbers of commuters was mentioned in Chapter 3. The needs of residents and commuters are highly complementary in terms of temporal patterns of use and therefore present opportunities to maximise the values and use of central city green spaces and can further justify the investment required to buy and/or manage areas for high quality open space. This is an opposite situation to suburban green spaces where there is often an issue of low weekday use and high peak periods in summer evenings and weekends.

Taking into account projected population growth to 2043, greenspace amount across the entire Central City area decreases substantially, by an average of 50%. The lack of greenspace in the Willis-Cambridge CAU becomes even more apparent with per capita greenspace projected to decrease to between 3 and 4 m^2/person. This conclusion does not differ greatly regardless of whether medium or high population growth estimates are used.

Currently, there is significant high-rise apartment construction occurring in the Willis Street-Ghuznee Street-Cuba Street precinct. When these apartments are complete and fully populated, the population-weighted centre of the Willis-Cambridge CAU will move to the north-west, towards the population weighted centre of the Lambton CAU (figure 20). This shift will not change the fundamental conclusions of this study about the lack of green space in the Willis-Cambridge CAU and of accessible green space close to where central city residents live. It is likely that within the next 25 years and the period of the next District Plan that there will be medium- and high-density residential development in many or most parts of the central city and in all three CAUs, but especially within Willis-Cambridge. This will require strategic provision of additional green space for the wellbeing of the increased central city population, as further discussed in Chapter 6.

It has already been noted that our analysis was conducted using somewhat dated census information and aerial imagery, both dating back to 2013. Aerial imagery was updated on an ad hoc basis using manual reclassification of land cover type based on the authors' knowledge. Census data were not adjusted but estimates of future population growth were carried out by Wellington City Council and forecast.id using estimated 2017 population levels. The quantitative data reported here must therefore be used with caution, but we believe that the distribution patterns and trends in green space amounts are accurate. It is recommended that the analysis reported here should be repeated when 2018 data and 2018 aerial imagery are available.

Furthermore, our analysis overstates the absolute amount of public green space by some measures, as it uses a relatively wide concept of 'green space' that is not restricted to public parks and gardens, but includes green space located on road reserves (not including the actual road and adjacent footpath surfaces) and in parts of other tenures such as transport corridors (owned by NZTA). Land in these tenures is not always publicly accessible and is often not green.

Measures of per capita green space in council-managed parks and gardens could be readily obtained from table 15. The reasons for including the other tenures (zones) was explained in section 2.2 above. Our analysis specifically identifies the hard and impervious surfaces which occupy significant portions of all types of green space including parks and gardens. Overall, we believe that showing all categories of public green space provides a defensible and full analysis of available amount. Although green space on road reserve and transport corridors is not legally protected as green space, and not universally accessible, it often is green, accessible and sometimes has significant green space values. We note also that although private green space analysis was beyond the scope of this project, it is still available to a significant number of residents in the central city, whose total access to green space is higher rather than lower than what is suggested by our data.

Overall, these results suggest that there is a significant lack of greenspace in the central city, particularly in the Willis-Cambridge CAU, and what greenspace is available is disproportionately dominated by impervious hard surfaces. The creation of greener areas and the planting of more continuous tree areas may be warranted here, especially given likely population growth in this CAU. Issues around the provision and quality of additional green spaces are discussed in the next two chapters.

5.0 Constraints to maintaining/increasing green space provision

5.1 Introduction

As stated in Chapter 1, central city areas are generally characterised by high population density, and the per capita available amount of land for all purposes is usually much lower than elsewhere in city regions (Blaschke et al., 2017). Put simply, central Wellington's comparatively high density provides a challenge for the council, as it supports intensification, to find creative ways to provide green amenity and ecosystem services to maintain and where possible enhance residents' wellbeing.

Provision of urban green space is generally costly for cities, mainly due to the opportunity value of the land, but also the potential impact of providing green space and thereby potentially enlarging the city and increasing travel distances and costs, and associated carbon emissions. Some have expressed a concern that a trend towards compact urban development may result in less area being available for any type of green space or trees (Lin et al., 2015; McPherson et al., 2011). The challenge for cities is to find an optimal or at least acceptable balance between urban green space benefits and their costs, taking both the quantity and quality of green space into account.

The first part of this chapter argues that there are powerful economic *and* ecological reasons for ensuring Wellington remains a compact city, and intensifies over time as more people shift to the city. If the council were to significantly expand the quantity (extent) of green space in central Wellington, the community could incur significant costs for only relatively small gains in terms of health, amenity and provision of ecosystem services. This implies that there are likely to be limits to the areal extent of green space expansion in the central city.

A way through this conundrum is to primarily focus on improving the *accessibility and quality* of green space in central Wellington, through actions such as street-tree planting, management to improve the delivery of ecosystem services from existing green spaces, and ensuring that green spaces are universally accessible. This does not preclude opportunities to purchase and restore land parcels to new green spaces. This has happened in the past (Midland Park for example) and may well be required in future in parts of the central city such as Willis-Cambridge where our analysis indicates that the existing low availability will be exacerbated by population increases. In general, however, additions of green spaces would be small in area. But they must be carefully targeted at the areas which are most lacking in green space, and cumulatively effective to achieve the outcome of a high-quality city environment. This could occur, for example, through provision of "pocket park" street corners or areas of road reserve for green space values, or the repurposing of low-value car parking spaces, impervious or vacant spaces as green spaces, sometimes temporarily. In other words, as the city centre intensifies, green space in Wellington can be optimised, rather than being increased significantly in quantity. This will require intensive creativity.

The second part of the chapter looks at a different set of constraints, being the environmental and technical constraints to establishment and maintenance of trees and habitats in the central city.

5.2 Optimising green space provision

A reasonable presumption is that the characteristics of green space which supply cultural ecosystem services (including social amenity, use value and 'option' value) will be a high priority for people in the central city (Swanwick et al., 2003). The provision of other ecosystem services from green space; such as regulation, provisioning, and supporting functions of ecosystems, is also important. However, provision of these other ecosystem services is usually able to be more cost-effectively provided in outer parts of the city (suburban parks and gardens, etc) or at the city edge, rather than in the central city, where population and employment density is highest. An example is extensive production forest: this is generally much more easily provided at the city's periphery rather than in the centre[12].

There is also scope for highly-developed and dense central areas to provide small areas for the provision of some regulating and provisioning ecosystem services: mini-habitats and biodiversity corridor elements, for example, can and should be fitted in. Trees and green areas in the central city can provide food and nesting places for birds and many other animals, together with air purification and noise absorption, at the same time as they provide high visual and cultural amenity. Many dense cities, in all parts of the world, have abundant street trees often growing to four or five storeys high. Larger and older trees, which have multiple ecosystem and amenity values, are a particularly important component of public green space as their supply becomes ever scarcer on private land. Green walls and roofs can also be accommodated and, although potentially costly from an initial construction cost perspective, are becoming more common because of high amenity and ecosystem service contributions.

Significant public green space benefits can also accrue from private land in some circumstances, particularly publicly available green spaces owned by Not-For-Profit groups. In central Wellington City these are often church-related properties, for example the St Mary's of All Angels side garden, the Old St Pauls grounds, and the Compassion Soup Kitchen garden (figure 21). Community gardens are another type of these green spaces, some located close to the central city, e.g. Innermost Garden on the lower slopes of Mt Victoria. Support for the maintenance of such places may be an efficient way of enhancing existing green spaces where large scale expansion of public green space is not possible.

Figure 21. Compassion Soup Kitchen (source: NZ Catholic)

[12] The introduced trees such as pines and eucalypts that dominated much of Wellington's Town Belt for more than a century were planted for shelter, recreation and visual amenity rather than with timber production in mind (Boffa Miskell 2001).

5.2.1 Density and the costs of green space

As stated above, Wellington and Auckland remain, like other New Zealand urban areas, well endowed with green space, even as they increase in density. Despite this density, Wellington's green space is not only significant in quantity, as argued below, but provides valuable amenity and ecosystem services in special ways. The Town Belt and harbour are visible and accessible from much of the city centre's densest areas, in a similar way to the accessibility and visibility of the Domain, Grafton Gully and the harbour in Auckland.

Economic factors are an essential part of the consideration of how much green space to provide in the central city. There are two principal costs of providing green space: firstly, the opportunity cost of the land; and secondly, as mentioned earlier, the cost of green space in terms of reducing density and indirectly enlarging the city, increasing travel distances and costs, and associated carbon emissions.

The *opportunity cost of land* used for green space is its value in alternative uses, for example housing or offices; this can be approximated by the land's market value. Councils have to take into consideration forgone rates revenue in holding green space. For this reason alone, council-owned centrally located green spaces tend to be small. However, the opportunity cost of green space should not be overstated, as unique features of urban green space can offset its value in alternative uses. Some particular green spaces will have unique value in current use, e.g. they will host old trees or have historical or cultural values. This is in contrast to space used by housing, offices, and car parking, which is generally flexible in terms of location. Because of this uniqueness, green spaces are difficult to value economically. For this reason, and also because of the interests of adjacent property owners, sacrifice of established green space for increased 'development' is likely to be strongly resisted politically: the Council cannot usually substitute one green place for another, or sell off part of an urban green space. To summarise, there are clear benefits for cities in limiting the *extent* of green space in their centres, if they wish to do what cities do best, i.e. foster and support agglomeration and the meeting of people and trading of goods and services. As economist Ed Glaeser (2011) has stated, cities can be seen as the absence of space between people and firms; helping people to come together readily is the quintessential function of cities. On the other hand, few city residents and users would be happy with a complete absence of green space. The amenity of green space is also critical to the aesthetic character of a city, its perceived attractiveness, and the health and well-being of urban residents.

The challenge for Wellington City Council in this regard, given its vision of a 'compact, liveable city', is to ensure the provision of the right amount and types of green amenities to align with further central city intensification, to avert damage to residents' wellbeing and quality of life. And in particular, taking into account competing land use values, the task is to better optimise the mix of land uses so that residents and users of central Wellington are comfortable with the quantity and quality of green space, and do not fear it being eroded to levels which may be adverse for their health and wellbeing, and the longer-term resilience of the central city. One aspect of this resolution is creative exploration of opportunities at the margin, such as land that is relatively poorly used at present. Within the central city though, a key implication of our findings is the need for multi-functional, high-quality green spaces, or "the right type of spaces in the right places".

5.2.3 Transport and parking

Some opportunities arise in relation to the provision of transport services and parking. A long-term trend in Wellington city is for its resident population to increase, with a concomitant rise in apartments and townhouses, together with increased walking as the primary mobility mode in the city centre. In fact, of those surveyed by the Council, 32% envisaged a city in which people lived in higher density housing in existing suburbs while 31% envisaged more apartments in the central city. Walking and cycling can be accorded higher priority in central Wellington streets, with more associated public spaces for all people to enjoy. The *Our City Tomorrow* conversations reflected a desire for a quality, accessible transport system that prioritised sustainable, active modes of transport (Wellington City Council 2017c). This suggests reduced space for the car in the city. Wellington's compactness was one of the things people were most proud of about the city, because it made walking and cycling easy options. WCC expressed its intention, in this document, to move towards making active transport modes and mass transit opportunities a priority. Additionally, 'the improvement of our public spaces will also continue through our laneways redevelopment programme.' However, maintaining existing space for car parking on streets is not compatible with these goals.

Close consideration of how space is used and sometimes poorly used in the city centre is critical. In our view, it is not so much cars *per se* that compromise other uses (such as parks) of the valuable land in the central city, but stationary i.e. parked cars, and the considerable space devoted to them. Cars and freight moving through arterial roads will continue to be necessary, and it is also necessary to allow for vehicles making deliveries, taxis, shared cars, and so on. They are part of a vibrant central city. But parked private cars are increasingly a poor use of land, as the city intensifies (figure 22).

Figure 22. Glover Street car park (Photographer: P. Blaschke)

The WCC's ongoing car-parking review should aim to reduce the provision of those carparks which are not occupied to very high levels, e.g. it might remove those where there is a vacancy rate above a nominated level. Another option is to remove car parking entirely down the side of certain key inner city streets, such as Tory Street, and instead install a cycle lane separated from the road by trees or shrubs. A complementary option might be to raise parking charges for use of public carparks (and possibly also charges for private carparks), rather than charging for vehicle movements as such, and use the revenue to help fund active transport and public space improvements including green spaces. In some cases such green spaces could be situated on top of underground car parks, as in some cities in Europe. Such a change of thinking on car parking would be a step in taking seriously the Council's themes from *Our City Tomorrow*, namely that Wellington city should be compact, inclusive and connected, greener and resilient, as well as vibrant and prosperous.

5.3 Technical constraints[13]

5.3.1 Vegetation maintenance

The main tree species used in central city planting are the following: pōhutukawa (*Metrosideros excelsa,* non-local native), tī kōuka (native, cabbage tree, *Cordyline australis*), kōwhai (native, *Sophora* species), Chinese elm (introduced, *Ulnus parviflora*) and Italian alder (introduced, *Ulnus cordata*). These species comprise a mixture of local and non-local natives and introduced species, and evergreen and deciduous species. They are all regarded as hardy species which are able to grow successfully in Wellington's relatively difficult growing conditions, and with little maintenance in many different settings. Deciduous trees, which include the two elm species and to some extent the native kowhai species, are generally favoured for street trees in the central city because they provide shade in summer while allowing light through to the street level in winter. Although gathering and taking away the shed leaves require more maintenance effort, this is regarded as manageable in the central city as part of the regular street maintenance work.

5.3.2 Water availability and climate limitations

The main species used in the central city are regarded as hardy and are regarded as resilient to the likely climate change considerations of sea level rise, increased frequency of flooding, drought and storms. Under climate change predictions at the higher range of severity, however, some trees planted on the waterfront and in areas of greater flood frequency and severity could be coming to the limits of their waterlogging tolerance within 30-40 years. Larger trees moderate summer temperatures and provide shade not only to people outside but also to people inside buildings; but this ability appears to be under-appreciated. WCC horticultural staff point this out to building owners and occupiers when requested to trim trees that are shading buildings.

5.3.3 Resilience to natural disasters

The response of central city trees to potential liquefaction is not seen as a problem on the evidence of previous earthquakes. The November 2016 Kaikoura Earthquake caused liquefaction in parts of the city but did not significantly damage trees in these areas. The susceptibility of species of the Myrtaceae family to the myrtle rust disease is potentially a much more widespread resilience issue. Myrtle rust disease has only been recorded in mainland New Zealand since May 2017 but has already spread widely including in the Wellington region (Lower Hutt). Myrtle rust appear to have the potential to attack all native and introduced species of the family, which include the native species: pōhutukawa; mānuka; northern rātā; kānuka; swamp maire; and ramarama. Commercially-grown species such as eucalyptus, guava, feijoa, and bottlebrush and eucalyptus amenity and forestry species are also affected[14]. This is of concern to planted trees throughout Wellington City including the central city, as

---

[13] Much of the information in this section is based on discussions with William Melville, WCC Arboriculture Team Manager.
[14] See https://www.doc.govt.nz/nature/pests-and-threats/diseases/myrtle-rust/ and https://www.mpi.govt.nz/protection-and-response/responding/alerts/myrtle-rust

a very significant proportion of planted trees (well over 50%) in the city belong to the above-named species in the family (figure 23). Pōhutukawa, although a much-loved tree, also has a well-known propensity for vigorous root growth that damages roads and footpaths as well as sewage and stormwater drains. This makes it not a physically suitable species for some sensitive commercial and residential neighbourhoods, while the susceptibility of the entire family makes the species used in street and other plantings a significant risk to the amenity of the central city in the unfortunate event of a serious outbreak of myrtle rust disease in the city. Restoration agencies including Project Crimson have recently restricted their planting of Myrtaceae species for this reason.

Figure 23. Pōhutukawa trees in bloom, Wellington (Photographer: Masa Osada)

Severe damage to endemic Australian Myrtaceae in native forests has been recorded in eastern Australia after only four years' exposure to the rust disease, as well as in New Caledonia and the Kermadec Islands, and the potential for it to negatively affect Australia's and New Zealand's native biodiversity has been noted (Carnegie et al. 2016; Beresford et al, 2018).

The above argument reinforces the need for a reasonable diversity of tree and other plant species to be available for public green space planting. Although it is reasonable that council concentrates on a relatively small number of well-proven species for cost-effectiveness and reliability, both these performance factors can change as a result of natural disaster or resilience challenge. For longer-term resilience, a wider range of species should be available for use when needed.

5.3.4 Plant growth form (roots, soil requirements)

Central Wellington soils have been considerably altered by the last 200 years of settlement, and include "new" soils (brought from elsewhere and further developed in situ through plant growth and additions of fertiliser, mulch etc) on significant areas of land that have been reclaimed from Wellington Harbour. Nevertheless, the quality, fertility or hydrological status of central city soils are not generally regarded as limiting for tree and plant growth. Topsoil of good fertility and water-holding capacity is generally brought in to the space in which the tree is established. Rather, the dominant limiting factor is felt to be the soil volume available for trees' root growth, which, especially in the paved street environment, is generally dictated by the size of the "tree pit" dug in which root growth can develop and is separated from other infrastructure. This has evolved from a small hole dug or punched by hand into the soil or substrate, to a concrete drainpipe inserted vertically into the ground in which the tree roots are confined, to modern larger square tree pits inserted into a hole dug by a digger. The necessary size differs between species, but council horticulturalists prefer as large a tree pit as possible, and feel this gives the tree the best chance of long-term survival, growth and resilience to disturbance. The tree pits dug recently for the Victoria Street redevelopment project are currently the best practice for the size of tree pits for mature trees. Best practice in new urban developments in water-short urban environments, especially Australian cities, includes the underground linking of tree pits which allow considerably more water storage (Ely, 2010)[15]. This could be considered for part of central Wellington which are most flood-prone.

The covering material for the tree pits or smaller beds in which trees were planted, was seen in our street inspections to vary considerably, including bare soil, gravel, mulch, lime granules of varying size, herbaceous planting and grass. These materials vary considerably in their appearance, durability, water-holding capacity and other ecosystem service provision, and cost. Coarse mulch is seen as a good material environmentally and is relatively cheap but can present a tripping hazard. Nevertheless mulch or planted low vegetation would be the best alternatives from an environmental perspective. In some situations it could be used with a fence surround where there is a high tripping or security (vandalism) hazard.

5.3.5 Plant or animal characteristics

Some of the tree species commonly occurring in central Wellington, in particular silver birch, are sometimes thought to be associated with the incidence of asthma, but the status of urban trees as allergenic is complex and not well proven (WHO Regional Office for Europe, 2016). WCC receives a few complaints about trees causing alleged asthma / hayfever problems, and currently silver birch is not a major species for street planting.

5.4 Cost and policy constraints

Other than the points noted above, detailed cost and cost-benefit information was not collated as part of this study. However, it is obviously of great significance in making public investment decisions. Many trees planted in the central city are not particularly long-lived because of the likelihood of disturbance and damage. This is of concern as it was noted that budgets for central city street trees are very limited. No new trees have been planted since 2007 except as replacements for dead or removed trees, or as part of new development projects with their own capital expenditure budgets. Given the benefits of green spaces and urban vegetation discussed throughout this report, it would

---

[15] Also refer to http://citygreen.com/case-studies/stratacell-praised-in-bankstown-cbd-upgrade/ and https://treenet.org/wp-content/uploads/2017/06/best-practice-design-and-implementation-of-urban-tree-planting-robert-smart.pdf for two Sydney case studies.

seem essential to provide adequately for the maintenance and replacement of vegetation, especially trees, in whatever green areas and street plantings do exist.

Although partly outside the scope of this project, we also encountered an issue about the cumulative impacts of large tree removal associated with infrastructure upgrade work and private developments, i.e. affecting both public and private land. Wellington experiences competing demands for road reserve land and services that are already there (both over- and underground). There is an enormous cost to move those services, which means it can be difficult to make a sufficiently strong case to plant new large trees, i.e. to prioritise trees over many other needs. There is little policy to guide prioritisation. In order to safeguard the benefits of urban green space, broadly the same provisions for protection of private land vegetation should be available for public land, including situations where infrastructure is being developed or upgraded.

6.0 Potential to increase green space provision

6.1 Current situation

Our analysis in previous chapters indicates a relatively low and declining amount and accessibility of green space in central Wellington City. We have also discussed the constraints to increasing the supply of green space in the central city. This is not to imply that the current situation is intolerable. Wellington City as a whole is relatively well endowed with green space. Even in the central city, the area analysed in our survey is surrounded by significant areas of green space: portions of the Town Belt, the Wellington Botanical Garden, and wooded areas within Victoria University of Wellington campus. However, many of these areas are steep and not readily accessible to many residents or visitors. Further work is required to consider how places like the Wellington Town Belt can complement green spaces in the central city to best meet the needs of the growing city for high quality urban park space.

Within the CBD, the bold construction of Midland Park in 1983 on the site of a demolished hotel (Gordon 2011), showed the popularity of a well-designed open/green space for a large number of workers and visitors in the central city. Midland Park was followed by other small CBD parks such as Glover Park, Cobblestone Park and Te Aro Park (figure 24). On the waterfront, Frank Kitts Park was constructed from 1974 on newly reclaimed land. That was followed by the development of Bush City as part of the Te Papa site, and Waitangi and Chaffers Parks. Both areas have successfully established a range of New Zealand habitats on constricted and exposed areas within only 20 years old and are very popular with visitors and city residents. Most recently, the successful development of Pukeahu on the southern boundary of the central city has increased the amount and quality of green space within that area, but not significantly changed the low green space amount for the Willis-Cambridge CAU as a whole.

Figure 24. Left: Midland Park (source: Architecture Now). Right: Te Aro Park (photographer: V. Android)

The first part of this chapter describes our vision for Wellington's urban green spaces: "City spaces that enhance ecosystem and community wellbeing". From an ecosystem services perspective, it lays out an indicative agenda for a design process for urban green spaces in Wellington. In this process there is a close integration between the central city and other parts of Wellington City, both spatially and in terms of the organisational effort of establishing and maintaining green spaces. One of the key conclusions to come out of this work is that green space planning and provision should embrace cities as dynamic systems. This does not only mean thinking about the wider area of the city when considering green space needs and ecosystem services, but also considering connected and interdependent urban processes and disciplines. For example, green space decision making should be made in conjunction with transport, residential and commercial planning processes, with mechanisms set up to share funds across budgets and capture added value to fund green space where appropriate.

The second part of the chapter highlights three central city green spaces that were inspected during the project and presents some indicative ideas for realising the ecosystem services, health and wellbeing and accessibility values offered delivered by the spaces.

6.2 Ecosystem services design process for urban green spaces in Wellington

Emulating what ecosystems do enables design teams to know what the quantifiable ecological goals should be for a development in a specific given location and climate if it is to integrate with existing ecosystems and contribute to their health rather than deplete them. Emulating, rather than just measuring ecosystem services in urban areas, suggests a design strategy based on a systematic transfer of scientific ecological knowledge into a built environment context, rather than design based on simple analogies of ecosystems. The following is a suggested six-step process for implementing ecosystem services-based urban green space design in Wellington based on the work of Pedersen Zari (2018). In so doing, the process provides a means to ensure green space contributes to what humans need to live in cities; i.e. the provision of ecosystem services and wildlife habitat, as well as conditions conducive to increased human wellbeing.

1. Conduct a city or region wide spatial ecosystem services analysis

Analyse Wellington (city and/or region) in terms of past and existing ecosystem services to set benchmarks and to determine appropriate spatial locations for future ecosystem services provision. This should be a spatial analysis. Pedersen Zari (2018) provides an in-depth case study of Wellington's past and current ecosystem services provision based on an ecological history and ecosystem services analysis (ESA) methodology and suggests quantifiable goals for the regeneration of these in the future[16].

2. Determine strategic locations for new/redesigned urban green spaces

Locations for new urban green spaces or those that should be redesigned can be determined by a combination of the city-wide ecosystem services analysis (step 1), combined with an analysis of existing green space, future demographics and zoning data, maps of sites of known risks and future changes (e.g. flooding/erosion/storm/wave vulnerable sites, air/soil/water polluted areas, fragmented or degraded habitats, areas of likely climate change impacts etc.).

3. Determine strategic sites for specific ecosystem services provision

Using data from steps 1 and 2, this step determines which sites are most strategically important in terms of ecosystem services provision and which ecosystem services each site should aim to provide. Each urban green space cannot produce all ecosystem services but should aim to produce at least one cultural ecosystem service and at least one regulating or supporting ecosystem service *at the same time.* If it were mandated for example that all new Wellington green spaces had to be designed to

[16] It is beyond the scope of this report to provide an in-depth summary of the findings of this work. However, results are available via the citation given or by contacting Dr Pedersen Zari: maibritt.pedersen@vuw.ac.nz.

provide or support at least three ecosystem services from at least two categories (see: table 1) it could start to shift the performance (ecologically) of the network of urban green spaces as well as managerial, designer, and public perceptions of the value and necessity of urban green space.

4. *Plan for ecosystem services synergies / trade-offs*

It is important not to design each urban green space in isolation, but rather to consider these as nodes in a network of spaces connected through space, people, fauna (specifically, native birds), and water. Relationships between the spaces must be designed. If designers and policy makers are to effectively use the ecosystem services model in urban setting they must understand how these ecosystem services are related. This is so potential synergies between ecosystem services can be utilised, but also so potential conflict or trade-off relationships (in terms of actual land area) between certain ecosystem services can be avoided or addressed. These relationships are illustrated in figure 25[17].

Provisioning services are dependent on both regulating and supporting services but supporting or regulating services tend not to be dependent on provisioning services. Because of this, it is important that urban green spaces do not ignore the provision of regulating or supporting ecosystem services as illustrated in table 1.

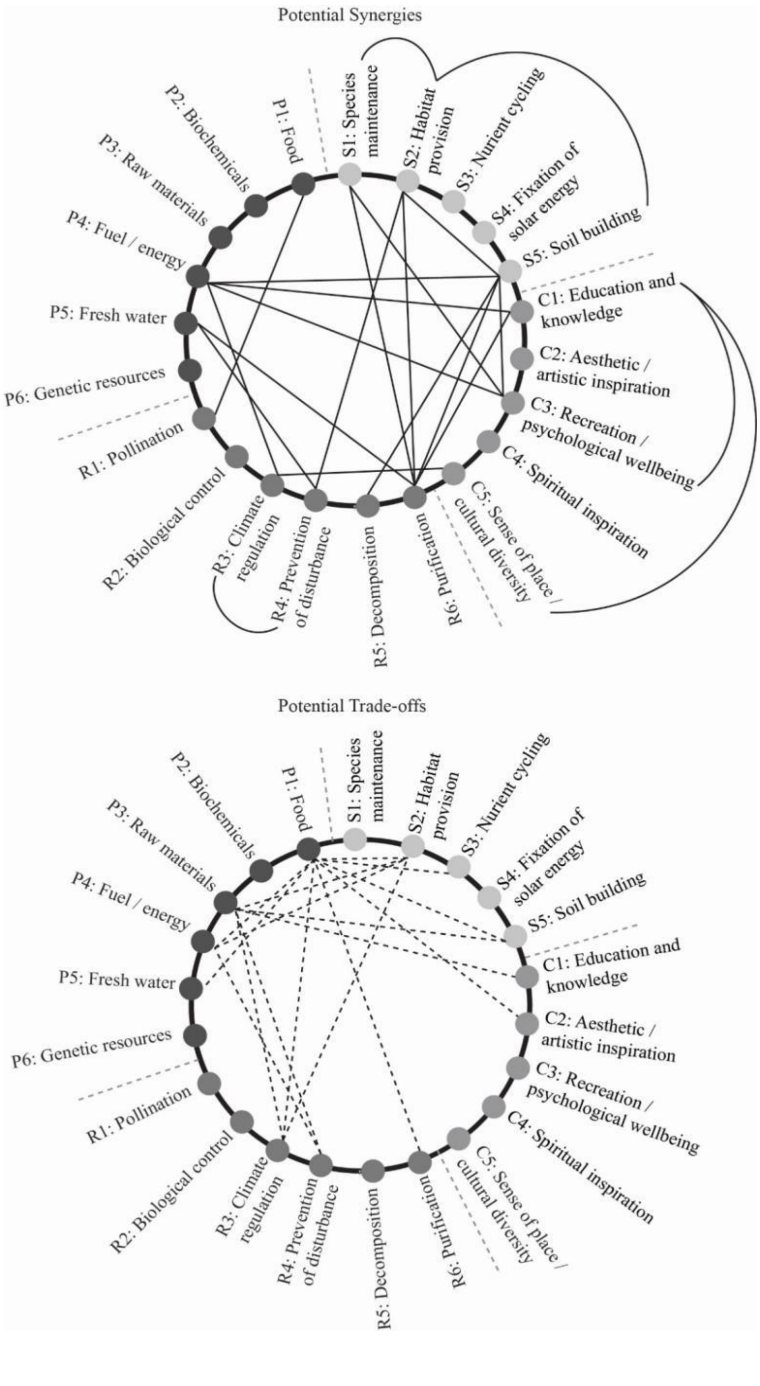


Figure 25. Relationships between ecosystem services
(source: Pedersen Zari 2018)

[17] The data used to create figure 25 is based on the research of Lee and Lautenbach, (2016), Mouchet et al., (2014) and Howe et al., (2014). Where associations are still undecided in the literature, have no known effect, or where there is not enough scientific evidence, associations are not shown.

5. Design the spaces to evolve

Ecosystem services change over time, so urban green spaces designed to produce ecosystem services must take this into account. Consideration of how the spaces change over the short term (day/night and through the seasons for example) and over the medium to long term (due to demographic and climate changes for example) should be planned for. Larger spaces may provide more flexibility to provide for such changes.

6. Evaluate designs of urban green spaces and the results after they are built

All interventions must be gauged for success using a complex set of ecological, social, and economic criteria appropriate for Wellington over the life-time of the spaces created and of the components and materials that are used to construct them. Evaluating and measuring how spaces work after they have been constructed is important so that feedback contributes to making future spaces more effective.

Cities must become key players in global efforts to conserve and restore ecosystem services, and also to produce them. If the goal of urban design is to create or retrofit cities so that they support the wellbeing of people, the support and regeneration of urban ecosystem services must be integrated into design decision making and interventions. This may help to reframe the essential human-nature relationship and may be of use to designers or policy makers working to create highly sustainable or even regenerative urban areas. In order to progress this agenda, urban design concepts and methods that enable cites to produce ecosystem services in greater volume is needed (Pedersen Zari and Hecht, 2019). The concept of ecosystem services is increasingly being applied to many fields of human endeavour, and if extended to architectural and urban design, the potential for profound change in how built environments, including Wellington, are designed, valued, built and used is apparent.

6.3 Central Wellington green space regeneration: potential places to start

The scope of this study did not include a detailed design process for specific green spaces in central Wellington. Rather, in the following pages we have chosen three green spaces that were inspected by the project team, and present some ideas for enhancing the ecosystem services and health and wellbeing benefits delivered by the spaces. A description of the spaces follows, along with a suggested set of ecosystem services to focus on (tables 25-27), simple conceptual visualisations, notes on accessibility considerations, and case studies of how similar spaces have been transformed in other cities. In the absence of a city-wide spatial and temporal ecosystem services analysis, and a resourced multidisciplinary design team process discussed above, these descriptions and visualisations should be taken as indicative / conceptual rather than as prescriptive design solutions.

Also, elements of these ideas would be costly to construct, but they could be cost-neutral in terms of public or overall costs and benefits over time. This would especially be the case if green space development accompanies medium- or high-density residential development; in which case development contributions and increased rates revenues could finance the green space development that would provide the wellbeing, ecosystem services, and liveability benefits that these additional residents would require if Wellington's desired high quality of life is to be maintained.

6.3.1 Cuba Quarter Green Nexus

Bute and Garrett streets are small streets that connect Vivian and Cuba Streets. Currently, they have almost no living infrastructure, but Glover Park borders Garrett St. Waimapihi Stream flows underneath the area. This is represented by an art installation and floor markings on the forecourt of the nearby service station (figure 26). The Bute-Garrett streetscape is dominated by small connecting roads, paths, two privately owned carparks, and low-rise commercial buildings (these become higher on Cuba and Vivian Streets). There are several apartment buildings in and around the area. Directly opposite Garrett Street is a third large carpark that connects Cuba and Marion Streets though Swan Lane.

Figure 26. Waterway marker (photographer: P. Blaschke)

Existing green elements are confined to a few trees and flax bushes in the Bute/Vivian Streets service station forecourt and some larger trees on the edge of the Cuba Street carpark. Glover Park, which connects Garrett and Ghuznee Streets, consists of pathways, impervious surfaces, grassed areas and several large trees (figure 27). Opened in 1971 it is a well-used resting spot and lunch break area for locals. It was upgraded in 2005 and features a sculpture by artist Shane McGrath. Aside from this park, the only other open spaces in the area are a series of low-quality, unattractive, impervious large carparks (figures 28, 29). This network of spaces is characterised as being left over, untidy, under-utilised space that could, if developed, become an important green space in the heart of the Cuba Quarter with important ecological and social functions.

Figure 30 shows a conceptual alternative nexus shown in bright green. Light green indicates adjacent spaces that could be incorporated into a developed green space over time. The irregular form of the space could lend itself to a series of connected green spaces, while referencing Waimapihi Stream beneath the surface. This could create an attractive large park for people and small businesses that is also a valuable habitat and ecosystem services feature. An additional benefit of a developed series of connected green spaces (figure 31) would be to enable cyclists and pedestrians to avoid high traffic volume areas of Vivian, Ghuznee and Victoria Streets, while reinforcing the vibrant pedestrian nature of Cuba Street.

Figure 37. Cuba Street carpark (left); Glover Park view from Garrett Street (right) *(photographer: P. Blaschke)*

Figure 28. Bute / Garrett Street car parks *(photographer: P. Blaschke)*

Figure 29. Carparks (red), earthquake damaged car parking building (orange), petrol station (yellow)

Figure 30. Conceptual Cuba Quarter Green Nexus. Stage 1 (bright green), stage 2 (light green)

Value of this investment for supporting central city population increase: Increasing the quantity of green space in this part of the Willis-Cambridge CAU which is already the most poorly served CAU for green spaces (Fig 20) would materially support current and likely future higher density living and quality of life for residents (especially) and workers.

Accessibility notes: This mostly flat space has enormous potential to enable people with disabilities, especially those working and living in the central city (Cuba quarter) to access green space. Careful consideration of pathways, seating, amenities (e.g. toilets and water fountains) is required to enable full use by the community. The connected green spaces could allow for a rich and diverse experience stimulating all the senses.

6.3.1.1 Cuba Quarter Green Nexus design concepts

Table 25. Ecosystem services for inclusion in the Cuba Quarter Green Nexus

Ecosystem Service			Design methods / concepts
Supporting Services		**Habitat provision** (including: provision of genetic information; biological control; pollination and seed dispersal; fixation of solar energy; and species maintenance)	Living elements, including trees, shrubs, and grasses could be introduced either in narrow beds within or bordering the carparking areas, or more extensively within car parks if these are rezoned[18]. References to native riparian streamside habitat, wetland, or regenerating forest could determine plant selection for increased habitat for wildlife. Pollinator pathway concepts could be investigated. Planting could also be selected based on air purification potential given that the green nexus falls between the north and south bound parts of SH1 (Vivian and Ghuznee Streets) and is known as an air pollution hotspot. Living walls could be introduced to surrounding building walls.
Regulation Services		**Purification**	Permeability should be increased through living or non-living matrices between trees. Rainwater gardens or swales and possible daylighting of a section of Waimapihi stream or a constructed wetland could be investigated. This would increase flooding control and storm water purification. Plant selection could be determined by phytoremediation potential for soil and/or water.
		Disturbance prevention	
Cultural services		**Beauty** (aesthetic value; artistic inspiration; spiritual and religious inspiration)	A vibrant walkable and/or cyclable series of pathways interwoven with habitat and possible water focused interventions that incorporates places to sit, rest, and meet could be suitable. Landscape architecture and biophilic design (Beatley, 2011) that is based on an understanding of environmental psychology could be used to guide the project. The presence of Waimapihi Stream and its relationship to tangata whenua past and present is an important aspect of the site that could be celebrated.
		Culture (provision for or celebration of cultural diversity; history; city character and sense of place)	

[18] Such a strategy is similar to various European city policies that discourage or prohibit car parks on vacant high-value inner-city sites.

6.3.1.2 Cuba Quarter Green Nexus transformation visualisations

Figure 31. Top: Garrett St car park from Glover Park (existing). Bottom: Conceptual image of the Garret Street part of Cuba Street Green Nexus from the same view (image: M. Pedersen Zari)

6.3.1.3 Next steps

- Identify tenure constraints, service provision and zoning options.
- Value land and investigate ecosystem services in the area, and determine benefits of alternative uses of the spaces including conversion to green / blue space.
- Determine citizen and business attitudes to large car parks and alternatives.
- Complete an economic feasibility study / benefits analysis of removing these carparks.
- Conduct an ecological history study, a heritage assessment, and community consultation.
- Investigate technical restraints, particularly concerning Waimapihi Stream and earthquake prone buildings on Cuba Street.
- Develop an in-depth planting guide for the area. Consider limitations to plant growth.
- Review existing and ongoing VUW School of Architecture urban design and Landscape Architecture work on this area.
- Analyse values of the areas that surround the Cuba Quarter with regards to greater opportunities for densification that would be supported by this green space development.

6.3.2 Kent and Cambridge Terraces Linear Park

Kent and Cambridge Terraces are a large and busy part of SH1 and are the main route to the Wellington Airport and Wellington Hospital from the inner city (figures 32 and 33). They are 3 to 4 lane roads in each direction connecting the Wellington Harbour waterfront at Waitangi Park to the Basin Reserve. Kent and Cambridge Terraces are a critical part of the recent *Let's Get Wellington Moving* planning work[19]. Various transport options are being considered and proposed which will have significant implications for the precinct.

The large width of the terraces means parking lanes exist on each side and a wide green strip separates the two directions of traffic between the two terraces. Commercial buildings frame the road, dominated by motor trade, hostels, and retail businesses. There are some apartment buildings on and immediately behind the route. There is one small building (the Taj Mahal) on the green strip and 2 heritage structures (the Greek memorial, and the Queen Victoria statue). Moderate foot traffic exists on either far side but walking on the central green islands is rare due to

CASE STUDY OF SIMLAR URBAN TRANSFORMATIONS

Tongva Park & Ken Genser Square

Tongva Park and Ken Genser Square in Santa Monica is an iconic 7.4 acre public park that was transformed in 2015 from a flat concrete derelict car park into an urban green space featuring rolling hills, swales, meadow gardens, and various places for people to walk, sit, meet, play, and view the ocean and parts of the city. It was designed by James Corner to be a 'gathering place of great social, ecological, and symbolic value' and has won numerous urban design awards. It was inspired by the arroyo landscape that once existed on site, and is defined by a series of braided pathways, water and architectural elements, and plantings in different themes and zones. Storm water is processed on site using bioswales and retention areas (City of Santa Monica 2018, Peters 2017).

[19] See: http://getwellymoving.co.nz/about/documents/

difficult and dangerous access. This is combined with a general lack of development of the islands' recreational or heritage educational potential. Both Waitangi Park and the Basin Reserve are important historical sites in Wellington in terms of both tangata whenua and tauiwi communities. The basin reserve was for example originally intended to be a harbour. It is a site that demonstrates extreme natural forces of change (particularly in terms of how earthquakes change landscapes).

Figure 32. Kent and Cambridge Terraces view from Courtenay Place (left). View from Basin Reserve (right)

Green elements are confined to the central island between the terraces, which consists of relatively well-established mature trees, herbaceous shrubs and grass borders. These are arranged in long islands interspersed by paved areas and vehicle turning bays. Waitangi stream flows beneath the roads. Part of the stream emerges at Waitangi Park which acts as a partial filter (approximately 10%) for local storm water discharges. The area is one where population is growing rapidly and where few other greenspace options exist.

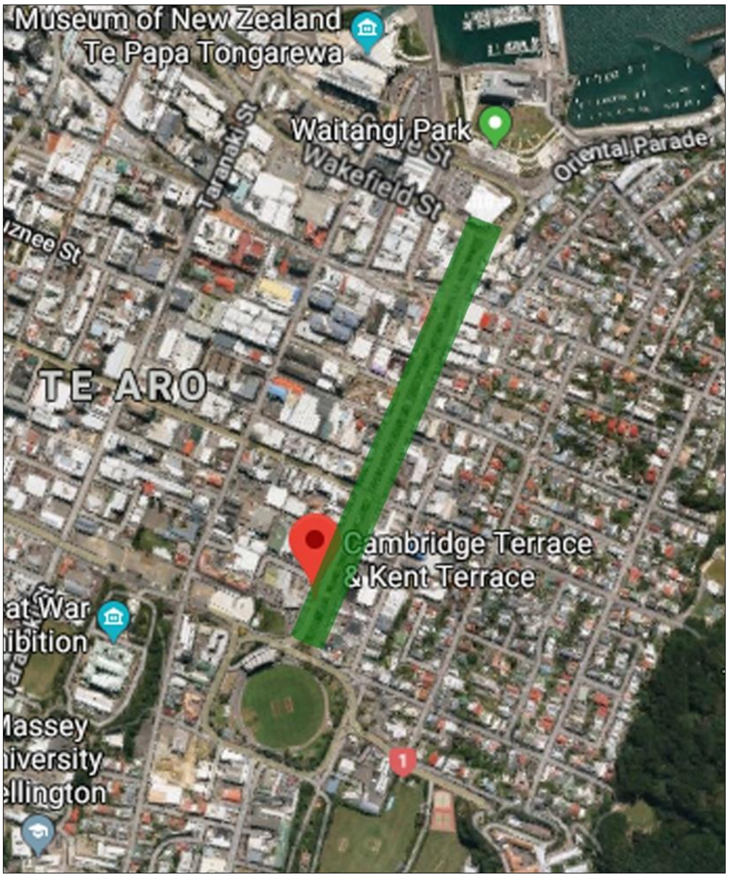


Figure 33. Kent and Cambridge Terraces (green)

Both of the terraces, the Basin Reserve, and the surrounding precinct have been identified as being at significant flood risk with estimates of damage to property and infrastructure even from 10-year events (flooding events experienced in 2013 and 2015) being high. Currently the area has very low permeability although this does not significantly affect flood volumes. Flooding is primarily caused by water flows from the large Waitangi catchment which takes in all of Newtown and surrounding areas south of the Basin Reserve (Wellington Water 2018). There is currently insufficient pipe volume to carry flood flows from this catchment, and significant constraints exist due to urban expansion. This affords an opportunity for Kent and Cambridge Terraces to be redeveloped as a linear urban park (Maddox 2016, Kullmann 2011) to address flood risk while considering other green space enhancements, particularly better accessibility and usability for active and passive recreation.

Value of this investment for supporting central city population increase: Increasing the quantity of green space in this part of the Willis-Cambridge CAU which is already the most poorly served CAU for green spaces (Fig. 20) would materially support likely future higher density living and quality of life for residents (especially) and workers, especially those less mobile who cannot access the adjacent Town Belt area. It would also increase the resilience of the area by increasing permeability and helping reduce flooding risks.

Accessibility notes: This space could provide a more pleasant route for entering and exiting the city, from southern and eastern suburbs, minimising road crossings and providing places for rest and restoration. However, its current close proximity to roads which carry high volumes of traffic would pose a significant safety risk to many individuals. Safer means to access this central strip of greenspace without having to negotiate several lanes of traffic (or expanding it and moving it to one side) should be considered. Furthermore, effective ways of highlighting and delineating green space edges and road beginnings will be important. Universal design principles regarding pathing, seating, and accessible signage should be used to enhance the design. This long green strip could also provide a means of accessing the nearby Waitangi Park (figure 34).

Waitangi Park represents a premiere large multipurpose space which all people should be able to access and use, especially given its proximity to the waterfront and Te Papa. The presence of the playground, the wetlands, the flat green space and the skateboard park provides a place which multiple generations and people of varying abilities, can enjoy alongside each other (adding to a sense of social cohesion). However, the playground and toilets require re-consideration because accessibility by people with a disability is limited. Additional seating and accessible seating design should be considered in any future redevelopment.

Figure 34. Waitangi Park (source: Landszine)

6.3.2.1 Kent and Cambridge Linear Park design concepts

Table 26. Ecosystem services for inclusion in the Kent and Cambridge Linear Park

Ecosystem Service		Design methods / concepts
Supporting Services	**Habitat provision** (including: provision of genetic information; biological control; pollination; fixation of solar energy; species maintenance)	Living elements, including trees, shrubs, and grasses could be introduced to this area in the green strip itself and possibly on the far edges of the roads. Planting could be guided by native riparian streamside habitat and wetland species. Pollinator pathway concepts could be investigated. Planting could also be selected based on air purification potential given the high volume of traffic along the roads. Because of the site's location it could become an important ecological connector between the larger parks of the Town Belt and also as part of a city-to-sea corridor for birds and other wildlife. Planting to form a canopy and provide food and habitat for native birds and other fauna would also be important.
	Climate regulation	Because the area is lacking in green space, the Kent and Cambridge Linear Park could be strategically designed to reduce local heat island effect and the wind tunnel phenomena through carefully placed increased vegetation. Because it is a transport route, effort to reduce car travel through effective public transport and cycling infrastructure is important.
	Disturbance prevention	A key focus should be on flooding control meaning this could be a combined green and blue space. Permeability should be increased. Rainwater gardens/swales could be investigated along with linear water storage wetlands etc. Plant selection could be determined by water phytoremediation potential.
Provisioning	**Provision of fresh water**	If the site was to become an important flood mitigation and water storage area, the possibility exists (if safe and appropriate), some of this water could be filtered and cycled for irrigation or local non-potable commercial/domestic water uses.
Cultural services	**Beauty** (aesthetic value; artistic inspiration; spiritual and religious inspiration)	Making the area attractive, accessible and safe for pedestrians and cyclists should be a priority. A walkable and cyclable series of connected pathways interwoven with habitat, or pollination supporting plants, or even edible landscaping alongside green/blue infrastructure designed to hold water and/or safely flood periodically could be suitable. The site is primarily a transport corridor, but incorporation of places to sit along pathways in sheltered niches, particularly near areas of water might be suitable. The presence of Waitangi stream beneath and its relationship to the health of the harbour is an important aspect of the site that could be visually celebrated.
	Culture (celebration of cultural diversity; history; sense of place)	
	Wellbeing (relaxation; reflection; & psychological benefit)	

6.3.2.2 Kent and Cambridge Terraces Linear Park transformation visualisation

Figure 35. Existing Kent and Cambridge Terraces looking towards harbour (top). Transformation concept (bottom) (image: M. Pedersen Zari).

6.3.2.3 Next Steps

- Clarify *Let's Get Wellington Moving* and Wellington Water transportation and flood protection preferred options.
- Value land and investigate ecosystem services in the area, and analyse co-benefits of combined green and blue spaces.
- Collate and review previous design suggestions including work from VUW School of Architecture along with international examples.
- Determine physical constraints (water table, water quality, soils, current infrastructure, Waitangi stream flows and heights, connection with Waitangi Park etc.).
- Analyse values of the areas that surround Kent and Cambridge Terraces and opportunities for higher density development supported by an integrated transport/green space development.
- Investigate tenure constraints and zoning options.

CASE STUDY OF SIMLAR URBAN TRANSFORMATIONS

Chulalongkorn University Centennial Park

Chulalongkorn University Centennial Park in Bangkok designed in 2017 by Kotchakorn Voraakhom is an 11 acre urban green space (see image top left). It features meetings spaces, an amphitheatre, recreation and playground spaces, and a series of wetlands and water features. In flood-prone Bangkok it contributes to vital ecological hydrological functions. It collects and cleans water, reduces the urban heat island and can hold approximately 3.5 million litres of water of during flood events. Green pathways and bike lanes were added along the park's heavily trafficked bordering road (D'Arcy 2018). See also linear urban parks such as: The Highline in New York, the Emerald Necklace in Los Angeles, Cheonggyechoen in Seoul, and Madrid Rio in Madrid (Maddox 2016).

6.3.3 Terrace Gardens Flagstaff Hill

Terrace Gardens-Flagstaff Hill is a small existing greenspace that connects other green areas between O'Reilly Terrace (Boulcott St) and Percival St with pedestrian linkages to The Terrace. It is surrounded by residential houses. Some houses are also within the green space itself and have only pedestrian access. There is one large adjoining multi-unit block (Dixon St Flats) to the south and commercial premises and St Marys Cathedral to the North East (figures 36, 37).

Figure 36. Stage 1: Terrace Gardens-Flagstaff Hill (bright green). Stage 2: Potential adjoining green spaces for development. Red dot is Terrace Gardens, Orange dot is Flagstaff Hill

Terrace Gardens-Flagstaff Hill is mainly vegetated with some large trees, shrubs and grass, and a lower landscaped area with seats and a stage. It is made up of older reserve (Terrace Gardens) and newly acquired land (Flagstaff Hill). The latter has important historical associations with the early European settlement period. There is high pedestrian use at one corner (Terrace Gardens-Allenby Terrace steps) but the green space itself is not well known to the public, and hence is under-utilised considering its high-density inner-city suburb location. Some habitat regeneration work has occurred in the area, but the space has a reputation as being a management challenge by Wellington City Council staff. This is because it is difficult to access (pedestrian only), is a public space with private houses within it, has known security and litter problems, and is steep. Maintenance is difficult and developing the reserve as a visitor/recreation destination could be risky and/or expensive. Despite this, it offers several potentials for development over time as a key Wellington urban green space that connects several important inner-city streets. It also has high vegetation values and high potential to become an important habitat for birds, insects, lizards etc. It contains some of the biggest trees in the central city.

Figure 37. Clockwise from top left: Percival Street entrance; walkway to Flagstaff Hill; Flagstaff Hill; Terrace Gardens seating area; Terrace Gardens boundary condition; Terrace Gardens walkway (photographer: P. Blaschke)

In the short to medium term emphasis should be put on regulatory and supporting ecosystem services rather than cultural ones (except historic heritage) in the site. There are typically lower management costs associated with these services compared to recreational ones. The main short-term cultural benefits might relate to a community ecological restoration programme for the reserve, possibly combined with a community garden, orchard, or food forest designed to bring people into the space (Kowalski and Conway 2018, Clark and Nicholas 2013). More emphasis could be placed on recreation and access issues in later design stages, once habitat and ecological values are higher and the reserve becomes a destination for experiencing these.

Value of this investment for supporting central city population increase: The quantity of investment required for the suggested design concept is lower than for the preceding two case studies. The main benefits for residents and workers in the short term relate to higher quality of life from increased habitat quality and provision of produce. Later investment for greater accessibility could be justified at a later stage.

Figure 38. Terrace Gardens existing access and signage (photographer: P. Blaschke)

Accessibility notes: This space could provide considerable richness of experience due to its peaceful nature, well-established trees, and presence of bird song. The council and stakeholders need to carefully consider the intended purpose(s) of this space, as discussed above. Its isolation, perceived lack of safety and amenities and steep topography mean that only a small section of the population are currently able to use this space. If the council decide to develop this area as an open space for city dwellers, workers, and university students to congregate in then developing an accessible route off Percival Street might be possible. Consideration of path specifications (width, gradient, presence of handrails, tactile path markings), stairs, (edging, standard widths and heights), and seating (of varying heights, with and without handrails) which enable different grouping configurations (and inclusion of mobility devices) will be necessary. Use of signage to advertise the presence of this space is also required.

6.3.3.1 Terrace Gardens-Flagstaff Hill design concepts

Table 27. Ecosystem services for inclusion in Terrace Gardens-Flagstaff Hill

Ecosystem Service			**Existing design strategies / methods**
Supporting		**Habitat provision** (including: provision of genetic information; biological control; pollination; etc.)	The primary focus for this site should be on habitat provision. Planting could be guided by native forest habitat species. Pollinator pathway concepts could be investigated. Planting, particularly that forms a canopy that provides food and habitat for native birds could also be important.
Regulating		**Purification**	Plant selection could also be determined by air purification potential.
Provisioning		**Provision of food** (including: medicinal resources)	The existing open area on Flagstaff Hill could be suitable for a community garden/orchard/food forest within the wider habitat focused green space if there is public interest. Student or community groups might be interested in such an initiative.
Cultural		**Culture** (celebration of cultural diversity; history; sense of place)	Making the area attractive, accessible, and safe for pedestrians is important. A walkable series of connected pathways with incorporation of places to sit or picnic along pathways in sheltered niches might be suitable. Terrace Gardens has some recreation infrastructure in place. A more visible and accessible entrance is likely to make the space more frequently visited.

6.3.3.2 Flagstaff Hill Terrace Gardens transformation visualisation

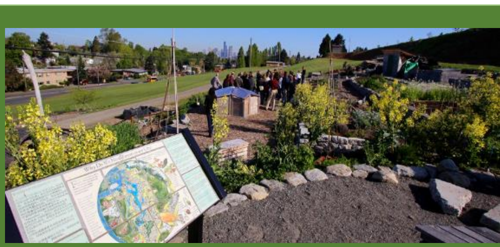
Figure 39. Existing Flagstaff Hill (top). Transformation concept (bottom) (image: M. Pedersen Zari)

6.3.3.4 Next steps

- Develop an effective management plan for the area. Work with residents, adjacent private land owners, and stakeholders for community restoration/gardening possibilities and common understanding.
- Develop better access portals, pathways, and signage where possible.

CASE STUDY OF SIMLAR URBAN TRANSFORMATIONS

Beacon Hill Food Forest



Beacon Hill Food Forest in Seattle began in 2009. It is a 7 acre community-initiated food systems project that combines native habitat rehabilitation with edible forest gardening based on permaculture principles. It features an edible arboretum with heritage and exotic fruit trees, a berry patch, a nut grove, garden plots, bee hives, a gathering space, and a children's play and education area. Community volunteers are responsible for ongoing maintenance. Locals gather food following rules of taking only what is needed. An emphasis is placed on community building in the project.

See also regeneration projects such as: the Maungataniwha Pine to Native Forest project and numerous other Wellington and nationwide forest regeneration project. Urban food growing projects for reference include: The Sumner Food Forest in Christchurch and others listed by Clark and Nicholas (2013).

7.0 Conclusions and recommendations

7.1 Conclusions

7.1.1 General

1. Green spaces are a critical part of central Wellington's "green infrastructure", delivering a wide range of vital ecosystem benefits to humans. Particularly important are the cultural ecosystem services that include health and wellbeing benefits provided to central city residents, non-resident city workers and visitors.
2. Green space planning and provision should embrace cities as systems, thinking about the whole city when considering green space needs and ecosystem services, as well as considering connected and interdependent urban processes and disciplines.
3. Deliberate consultation and collaborative planning with a wide range of stakeholders is necessary to ensure appropriate equitable access to green space.

7.1.2 State of green space in central Wellington

4. Central Wellington (defined here as the Thorndon-Tinakori, Lambton and Willis St-Cambridge Terrace Census Area Units), has a total of 41.25 ha of *public* green space.
5. A significant proportion of the central city's total public green space is located not in city parks and reserves (43% of green space), but in road reserves (24% of green space) or in non-council-owned public lots (33% of green space). Significant non-council owners include Transit New Zealand and Council-controlled organisations such as the City Shaper Business Unit.
6. There is also a significant amount of *private* green space within residential lots in the central city, but this was not quantified in this study.
7. A significant amount of total green space area (26% overall) within all green space categories consists of impervious and largely non-green surfaces such as paved areas and single trees within paved areas. This significantly reduces the ability of green spaces to deliver multiple ecosystem services.
8. Average total amount of green space per person in the central city is 20m^2 (excluding impervious surfaces). The per capita amount of green space in each CAU is highest at 41m^2 in Thorndon-Tinakori Road, 23m^2 in Lambton and 6m^2 in Willis St- Cambridge Terrace. Thorndon-Tinakori Road CAU has a lower socio-economic deprivation index than the other two CAUs.
9. The amount of greenspace within 300 metres of the population-weighted centroid in central city and in each CAU emphasises the differences in available green space between the CAUS.
10. There is a substantial lack of greenspace within 300m of the population-weighted centre of the Willis St – Cambridge Terrace CAU; the per capita amount of any green space in this CAU is very low and what greenspace is available is dominated by hard surfaces

11. Taking projected population growth to 2043 into account, greenspace amount across the entire Central City area will decrease substantially by an average of 50%.
12. There is a significant additional demand for greenspace-based recreation and wellbeing benefits from non-resident city workers and visitors to Wellington City.

7.1.3 Future of central Wellington green space

13. Without augmentation, the amount available per capita of green space will decrease significantly over the next 30 years, as central Wellington continues to intensify with a steadily expanding residential population (up to 33,450 in 2043 - nearly double the 2013 population - under a high increase scenario).
14. The average total amount of green space per person in the central city in 2043 with this level of increase would then decrease to $10m^2$ (excluding impervious surfaces). The per capita amount of green space (excluding impervious surfaces) in each CAU would decrease to $27m^2$ in Thorndon-Tinakori Road, $11m^2$ in Lambton and $3m^2$ in Willis St-Cambridge Terrace.
15. There are likely to be more older adults and dependent children living in the central city in future. The prevalence of mobility impairments and other types of disability will increase as the population ages. The accessibility of green space (amount qualified by the ability to access it) will become more difficult for some of these less mobile groups.
16. Environmental constraints such as sea-level rise, and more intense storms, floods and dry periods could further limit green space amount or accessibility, especially on the harbour edge and in low-lying areas such as along Kent/Cambridge Terraces. This could be especially important given the importance of central city green space for resilience and disaster recovery.
17. A higher amount of green space in peri-central areas (including the Town Belt, educational institutions, and Wellington Botanical Garden) partly compensates for the lower amount in the central city, but not necessarily for persons with disabilities.

7.1.4 Green space and other land uses

18. Competing uses of central city land for current or additional green space include motor vehicle traffic, car parking, residences (single and multiple unit), some commercial use, and non-green recreation and infrastructure. Some of these uses, especially car parking, are not always of high social value.
19. There is scope to better optimise the mix of land uses so that residents and visitors to central Wellington are satisfied with the quantity and quality of green space, and that it is not eroded to levels which may be adverse for their health and wellbeing, and the longer-term resilience of the central city.
20. Much of the current green space provision is of high aesthetic quality, but sometimes this appears to be at the detriment of the provision of ecosystem services from green space.

7.2 Recommendations

1. Plan for and adequately resource an increased amount, accessibility and quality of green space in the central city, in order to provide for the health, wellbeing, amenity and ecosystem benefits required by the significantly larger likely future population of the central city.
2. Actively collaborate with council-owned, Māori and public agencies and community stakeholders to ensure green space provision and accessibility is provided for. Key agencies and stakeholders include Wellington Water, New Zealand Transport Agency, a wide range of stakeholders in *Let's Get Wellington Moving*, *Planning for Growth* and the District Plan review, private developers, and NGOs including those working with vulnerable groups.
3. Increase investment to make maximum use of the few relatively large public areas (including in the Town Belt and areas peripheral to the central city) potentially available for the widest range of green space benefits. These areas include Flagstaff-Terrace Gardens, Wellington Botanic Garden, Central Park, Te Ahu Mairangi, and Transit NZ- and council-managed road reserves.
4. Purchase additional land for high quality green spaces where this is justified by likely population growth, particularly in the Willis Street-Cambridge Terrace CAU, where green spaces are already less per person.
5. Use more creatively and increase investment in the significant number of opportunities for utilising small areas for 'pocket parks' and additional local green space, especially within Lambton and Willis Street - Cambridge Terrace CAUs, including support for the maintenance of existing publicly available green spaces owned by Not-For-Profit organisations.
6. Ensure that all spaces meet international/national guidelines for accessibility (especially universal accessibility design principles) and that all green spaces are of sufficient quality to ensure the space is usable by diverse groups within the population.
7. Increase investment to make maximum and creative use of opportunities for non-traditional green space, e.g. planter boxes, green walls and roofs, painted and virtual green space, temporary green spaces on unused sites.
8. Design green spaces to provide at least two ecosystem services from different ecosystem services categories (provisioning, regulating, supporting, cultural), in order to enhance their versatility as multi-purpose areas.
9. Incorporate the maximum practicable number of trees (including native, evergreen, and deciduous species) into all central city development plans, including provision for adequate maintenance and replacement funding.
10. Broaden the range of trees and other vegetation used in street and green space planting to maximise ecosystem service values and strengthen resilience; in particular, restrict the

planting of pōhutukawa (at least in the short term) in order to reduce the risk of catastrophic loss to myrtle rust disease.

11. Maximise the amount of pervious vegetated surfaces in all green spaces, and make more use of durable pervious surfaces in areas of high foot traffic and parking areas that will allow easier integration of vegetation elements, while increasing resilience to flooding.
12. Make maximum practicable use of opportunities for co-benefits and synergies between green space and other land uses, especially transport corridors (shaded footpaths, cycleways and roads), housing and commercial provision and flood control. Decision-making for green space provision should be made in conjunction with planning processes in the above sectors, with mechanisms set up to share funding across budgets and capture added value to fund green space where appropriate.
13. Maximise accessible links between central city green spaces and those on the periphery of the central city green space, especially through active and motorised transport corridors.
14. Further investigate the following topics:
    a. Update the results of the present study using 2018 Census information, very recent imagery and topographic information
    b. Provision of green space benefits from private green space
    c. Costs and cost-effectiveness of additional green space, including economic benefits of and constraints to increasing city centre green space
    d. More unified tenure and/or management of public green space including road reserves
    e. Development of specific amount, accessibility and quality guidelines/standards for green space areas
    f. City-wide mapping of existing and potential future ecosystem services provision
    g. Optimal sizes for tree pits and the potential to provide linked tree pits to increase water storage in flood-prone areas.

Appendix One: Disability and accessibility

Accessibility, usability and universal design

Accessibility: Accessibility is a term which refers to the possibility to take part in something desirable. At an individual level, this possibility may depend upon physical mobility and the geographic proximity to the demanded phenomenon as well as opening hours and regulations (Iwarsson & Ståhl, 2003). The ecological model predominantly considers the transaction between individual competence including biological health, sensory-motor functioning, cognitive skills and desire/determination, and environmental pressure with individual competence. Environmental press (i.e. demand) increases as individual frailty increases (Iwarsson & Ståhl, 1999; Steinfeld & Danford 1999). While the term accessibility has predominantly been used in an environmental context, simultaneous access to information and other services (at potentially both a meso and macro level) is essential for environmental accessibility. Accessibility is essentially an objective measure of whether a specific standard (perhaps related to legislation or guidelines) is met (Iwarsson & Ståhl, 2003).

Usability: Distinct from accessibility is the term usability, which relates more to individual preferences (Steinfeld & Danford 1999) and "the ability to be in, and use, an environment on equal terms with others" (Iwarsson & Ståhl 2003) and is contingent on an individual's psychosocial perspective, such as self-image, motivation, social pressure and expectations (Steinfeld & Danford 1999). Accessibility is the necessary precursor to usability, however, usability is not only based on standards and social values, it is also a measure of effectiveness, efficiency and satisfaction related to how well the design enables functioning and well-being, from an individual's perspective (Iwarsson & Ståhl 2003; Steinfeld & Danford 1999; Lawton 2001).

Universal design: Universal design is based upon the principle that populations represent a diverse group of individuals with varying physical and psychological characteristics and abilities i.e. 'design for all' (Iwarsson & Ståhl, 2003). It shifts design from a perhaps more segregated perspective of ensuring that two different populations are considered ('normal' and a 'special' consideration for those with disabilities), to a perspective of democracy and equity among individuals regardless of age, gender, ethnicity, and ability. (Iwarsson & Ståhl, 2003; Mace, 1985). Application of the seven principles of universal design (see Table 31 in Appendix 1) highlights that universal design requires integration of accessibility and usability features from the onset.

Work published by the Centre for Universal Design, North Carolina State University, NC, USA outlines the seven core principles of Universal design (Follette-Story, 2001) (see Table 28). Subsequently, Steinfeld and Maisel (2012) have modified and modernised these principles Application of these principles demonstrates requires the integration of accessibility and usability features into universal design from the onset of any given project (Iwarsson & Ståhl, 2003; Steinfeld & Danford 1999). A positive, interactive and iterative model of designing green-space across the life span is reported by Douglas et al., (2017) and in the design of Verslius Park (Scott 2008). Acceptance of the importance of ensuring use for all individual with 'no exceptions" is also evident in the universal design policy outlined by Auckland Council (nd).

To ensure that person-environment design is efficient, theoretical and practical knowledge of concepts such as accessibility, usability and universal design is essential (Iwarsson & Ståhl 2003). The rationale for agreed upon terminology becomes clear when the diverse groups who should be involved in design e. g. architects, engineers, planners, user groups, health care professionals, politicians, and researchers representing different disciplines is recognised, as all of these groups may come with a different perspective and usage of the terminology resulting in mismatched expectation and lost opportunities.

Table 28. Universal design principles

Principle	Definition
1. Equitable use	Usable and marketable to people with diverse abilities
2. Flexibility in use	Accommodates a wide range of individual preferences and abilities
3. Simple and intuitive use	Easy to understand, regardless of experience, knowledge, language skills or current concentration levels
4. Perceptible information	Communicates necessary information effectively, regardless of ambient conditions or sensory abilities
5. Tolerance for error	Minimizes hazards and adverse consequences of accident or unintended actions
6. Low physical effort	Can be used efficiently and comfortably, with a minimum of fatigue
7. Size and space for approach and use	Appropriate size and space for approach, reach, manipulation, and use regardless of body size, posture or mobility

Table 29. Goals of universal design (Steinfeld and Maisel, 2012)

Goal	Definition
1. Body Fit	Accommodating a wide a range of body sizes and abilities
2. Comfort	Keeping demands within desirable limits of body function
3. Awareness	Ensuring critical information for use is easily perceived
4. Understanding	Making methods of operation and use intuitive, clear and unambiguous
5. Wellness	Contributing to health promotion, avoidance of disease and prevention of injury
6. Social Integration	Treating all groups with dignity and respect
7. Personalisation	Incorporating opportunities for choice and the expression of individual preferences
8. Cultural Appropriateness	Respecting and reinforcing cultural and the social and environmental context of any design project

Accessibility for older people, children and people with disabilities

Researchers associated with the team (M. Perry and colleagues, unpublished) have recently conducted three studies exploring the accessibility of urban park based greenspaces in the greater Wellington Region: 1) an audit of park accessibility based off relevant standards (NZS 4121:2001 and NZS 5828:2004) and International standards; (Department of Justice, 2010); 2) perceptions of urban park accessibility by older adults with and without disability; and 3) perceptions of park accessibility by children with disability and their whanau.

Park accessibility

From 21 parks in the greater Wellington Region, seven were located in Wellington City and one of these (Waitangi Park) is situated in the CAU's of this report. None of the Wellington parks surveyed had tactile marks denoting changes in the directions of main paths, only 2 had main paths wider than 1.5m and only one park had regular and even surfaces along the main paths enabling access to all areas of the park. Accessible routes to ground level of play components were limited and routes to upper levels were typically non-existent or if present did not meet standards to enable safe transference. The standards recommend that all play components at ground level should be accessible and that at least 50% of upper levels play components should be accessible.

Of the 7 Wellington parks evaluated, 3 had accessible restroom facilities on site. All 3 restroom had an accessible route, however none provided powered assistance when opening the door (automatic doors, power assist, push button doors) and in one park the most direct entrance was inaccessible. While the space inside the stalls was accessible, provision of handles on both sides of the toilet basin was inconsistent and style of water faucets would have made usable of these facilities difficult for some people. For premiere sites such as the water front (e.g. Waitangi Park), which attracts large number of tourists, the council is urged to consider a higher standard of accessible toilets.

Two of the 7 play areas had a drinking fountain; only 1 of these could be operated without the use of a tight grasping/pinching/twisting action. Neither drinking fountain had spouts mounted at different heights to service both seated and standing users. None had bowl from which dogs could be watered. Only 1 had adequate clear floor space in front of the fountain to allow a person using a wheelchair or mobility scooter access. These findings are consistent with recent literature showing few drinking fountains in Wellington parks and playgrounds and when present with poor maintenance. (Wilson et al., 2018)

More consideration needs to be given to the richness and quality of the experience of being in Wellington greenspace. Within the urban parks we found issues with maintenance, such as rusty equipment and climbing frames, broken seating or uplifted tile mats under play surfaces and path degradation creating falls hazards. Richness of experience could be enhanced by intentional inclusion of natural and man-made components which stimulate the different senses (i.e. touch, sound, small, vision, taste, and vestibular).

We also found a trend that parks in geographical areas of high deprivation were less accessible and had fewer amenities. This is relevant as people with a disability are have lower incomes (44% earn less than $20,000 p.a.), have significantly lower rates of employment (45% vs 72%), and are significantly less likely to have any educational qualification (e.g. 34% vs 15% among disabled women) (Office for Disability Issues, 2018).

Older adults with and without disability

Our survey of 1,000 older adults (65+) living in the Greater Wellington Region demonstrated that use of urban greenspace (i.e. not the playgrounds) was related to the activity being considered a pleasant walking experience and an environment in which activities could be shared with friends. However, as perceived health declined perceived accessibility of parks also declined. The impact of health status on park use is exemplified by 36% of older adults surveyed reporting use of a park at least twice a week compared to only 15% of older adults with disability. Limited mobility in the park due to steep, uneven and unclear pathing negatively and significantly affected park access.

However older adults with disability perceived that park use was not only beneficial for the physical health but also for their psychological and social well-being. It reduced feelings of isolation and enhances community cohesion

> *In some ways it's a little bit contradictory, in one way going to a park gives you a little bit of solitude……at the same time, it's an opportunity to be social.*

Greenspace enabled time to be spent with friends and family

> *Spending that amount of time, together, interacting, enjoying looking at the same things, and enjoying everything, conversation, and just being there together in such a worthwhile environment. Parks are 'it' for that.*

When specifically asked about playgrounds and equipment, the older adults with disability that we spoke to suggested that they felt hesitant about using equipment they perceived to be for children only. They were unsure whether this was considered socially appropriate and unclear whether equipment would be designed for their body weight. Yet, the temptation to use play equipment was discussed:

> *I think a swing is always tempting, isn't it?...Just something about being a child again, I guess, I don't know. I always go and sit on a swing and have a go…The wind going past your face. Yes, And the flying fox as well.*

Yet as their health declined, limited knowledge about park facilities determined park use. As the effort of getting to the park increased, older adults needed to be sure there were places to rest, go to the toilet and to have refreshment.

Children with disability

Children with disabilities and their whanau also described the inherent physical, psychological and social benefits of visiting parks.

> *"Oh it's definitely developed his motor- gross motor skills and his strength, and obviously social, cause he can do it with friends and family, and stuff like that" Adult*
> *"Social, definitely…but being here is- you know, she's been exposed to little people, and it's helped me teach her to not do [hit]… so it's definitely helped with that, and she's learnt- and she's learning how to positively interact with people" Adult*

Similar to the older adults, the overall quality of the environment, not just the play equipment was important.

> *He likes to walk in the bush with the bush around him…Likes …The river. The water. Oh yeah. The sound of the water" Adult*

But play equipment was psychological damaging as it highlighted impairments and enabled social exclusion. One young boy described his use of play equipment:

> *Not often…. Because I don't normally like playing in the park… because of my condition. I can't play with a lot of the stuff" Child.*

The children's whanau carefully selected the play environment they went to. They were unlikely to frequent their local park due to topography and lack of amenities. They suggested they would be prepared to travel to ensure their child would have a good park experience:

> *"I'd definitely drive somewhere to go to a playground if it was well maintained, and had the better equipment, you know." Adult.*
>
> *"It's not the closest park, we live down the far end, but this is definitely the one that we use" Adult.*

In particular the lack of (and if present poor maintenance) of accessible toilets and drinking determined park use:

> *"There's no toilets and no water fountain…. I know they're big cost items, but it's just, you know,… it's nice to have [them] and a place to change in … That's just my two big things." Adult.*

Summary

This research demonstrates that at least two age groups, particularly when they have a disability, living in Wellington have difficulty accessing and using parks. This clearly contravenes both the United Nations Conventions of the Rights of Persons with Disabilities (United Nations, 2007) and ignores key recommendations by the World Health Organisation with respect to their Action Plan on Physical Activity (World Health Organization, 2018). Careful reflection as to whether the current 'minimum standards' are sufficiently aspirational for parks and playgrounds is required when considering the importance of including persons with disabilities accessing and using these environments. We recommend that universal design principles are embedded, front ended, into all park modifications and upgrades and that potential designs are fully discussed with relevant used groups. Consultation requires flexibility as formal written and oral submissions place an undue burden on people with disability.

Appendix Two: Ecosystem Services

Benefits and disadvantages to an ecosystem services approach to urban green/blue space

Benefits of incorporating an understanding of ecosystem services into urban design include increased human health, increased biodiversity, and increased resiliency to climate change in urban areas (TEEB 2011). Figure 30 illustrates that when urban green/blue spaces are strategically designed to create more ecosystem services, benefits in terms of increased human wellbeing are reinforced in several positive feedback loops. Aside from obvious general ecological benefits of increased ecosystem services provision in Wellington, there are significant social and economic benefits such as: more resilient communities as the climate changes; more equitable communities; potential new revenue streams from buildings; and increased financial value of buildings (further discussion can be found in Pedersen Zari and Jenkin 2009). Elaboration upon these will not be repeated here, but there are several important additional advantages when increasing ecosystem services provision in cities. Strategically designing urban green/blue space to increase the provision of ecosystem services enables the success or failures of developments to be gauged from a perspective of ecological reality, and if measured, can demonstrate tangible social, ecological and possibly economic benefits. It avoids anthropocentric goals and unhelpful design metaphors that are difficult to quantify, or that might ultimately amount to 'greenwashing'. Such an urban design strategy enables quantifiable ecological bench marks to be devised over different time periods and in different spatial locations, and lends itself to long term urban planning.

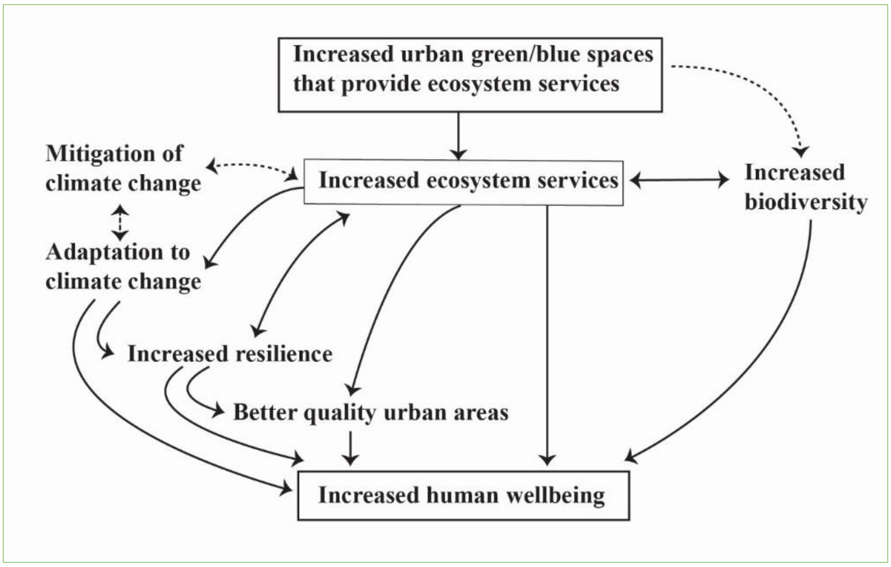


Figure 30. Benefits and interactions of increased urban green/blue space to provide ecosystem services (source: M. Pedersen Zari)

When the benefits derived from local ecosystems and/or urban green/blue spaces are understood or become apparent these are valued more and perhaps therefore preserved. For example, understanding that trees throughout Wellington can result in less damaging flood flows could mean it is easier to convince people of the need to conserve and plant trees for that purpose (and other ecosystem services) rather than to only value them aesthetically. This has the potential to contribute to prioritising or preventing certain urban development projects in particular areas, and therefore to long term effective spatial planning right down to the detail of materials selection (Pedersen Zari 2017). In addition, by considering impacts on ecosystem services the implications of decision making can be understood across various spatial boundaries, time scales, and multiple interconnected environmental issues, and can therefore be communicated to clients, city managers, residents, and other stakeholders. This means more accurate planning and budgeting.

The built environment varies greatly according to different climatic, economic, political and cultural contexts. Systemic approaches that are appropriate to specific places will therefore also vary. This means despite Wellington needing to evolve its own unique ecosystem services integration system, which will take time and research, knowledge of how to create or begin such systems can be transferred. Case studies from around the world are available to facilitate learning.

Using ecosystem services in a design context requires design teams to consider which ecosystem services are important or suitable for a particular site before any design of buildings or urban areas begins. Discussions with ecologists who have knowledge of local ecosystems may further define the hierarchy of importance of the ecosystem services for a specific site and identify an appropriate ecological focus. This means design teams must be multidisciplinary. Such a process may extra take time and resource initially. Working with the concept of ecosystem services requires a multi-scale approach and requires sometimes complex calculations and modelling. This is a challenge because ecologists still do not have absolutely certain or comprehensive knowledge about all ecosystem services and are still devising typologies and metrics associated with them (Zhang, Singh, and Bakshi 2010). The pay back implications over time of such a method could be investigated further.

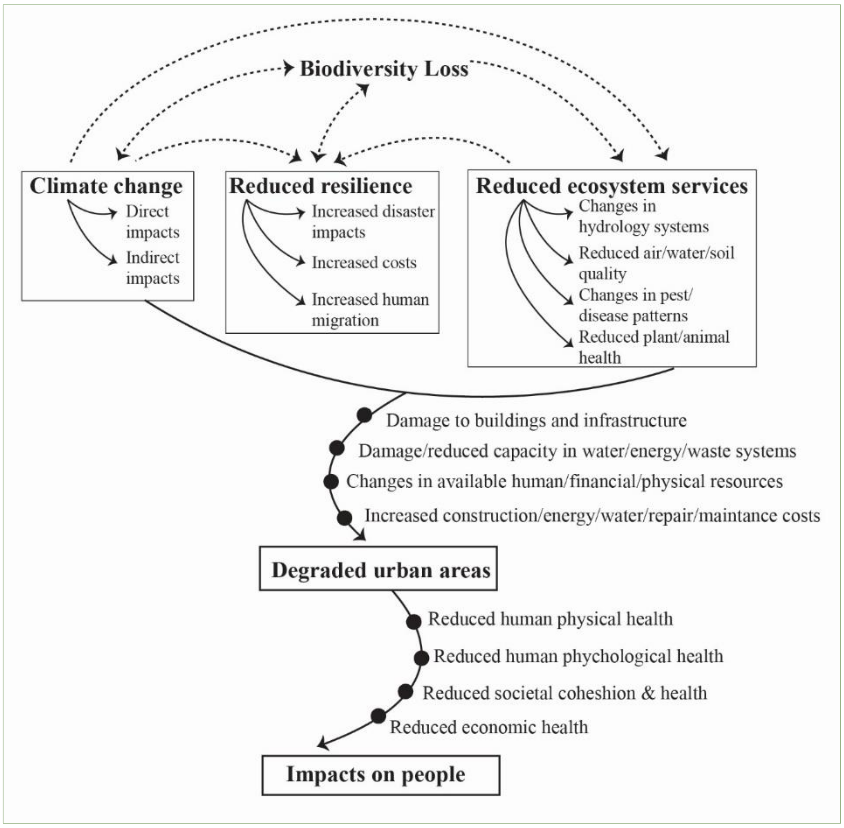


Figure 31. Biodiversity, ecosystem services, urban environments, and human wellbeing impacts and interactions (source: M. Pedersen Zari)

Biodiversity-ecosystem services-human interactions can be complex and indirect particularly in urban settings (Pedersen Zari 2014), and the ecosystem services-human impacts field of enquiry is still developing (Botzat, Fischer, and Kowarik 2016, Soulsbury and White 2016). Figure 31 illustrates some of these relationships in terms of adverse effects of climate change and biodiversity loss.

Appendix Four: Buffer analysis details

Table 31. Total amount of public greenspace (m^2) within 500m of population weighted centre of Wellington ventral city zone (at 100m intervals)

	Parks and reserves						Road reserves						Other						
Radius (m)	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Horticulture	Trees - impervious matrix	Trees - pervious matrix	Trees - individual	Hard surfaces	Subtotal	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Total
100	0	0	0	0	0	0	0	0	0	226	0	226	0	0	0	0	0	0	226
200	0	0	0	0	0	0	0	0	125	576	0	701	327	135	0	0	5480	5942	6643
300	31	10	0	0	56	98	0	0	1026	1654	874	3555	2291	8959	2154	730	14438	28572	32224
400	136	1072	12153	0	156	13518	0	0	2199	1925	874	4999	3296	14824	9506	946	18076	46649	65165
500	193	14974	28062	2	4887	48118	0	0	3176	2108	1008	6292	3600	16135	19532	1121	18842	59229	113639

Table 32. Per capita public greenspace amount (m^2/person) within 500m of population weighted centre of central city zone (at 100m intervals)

		Parks and reserves						Road reserves						Other						
Radius (m)	Est. pop.	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Horticulture	Trees - impervious matrix	Trees - pervious matrix	Trees - individual	Hard surfaces	Subtotal	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Total
100	162	0	0	0	0	0	0	0	0	0	1.40	0	1.40	0	0	0	0	0	0	1.40
200	876	0	0	0	0	0	0	0	0	0.14	0.66	0	0.80	0.37	0.15	0	0	6.26	6.78	7.58
300	1794	0.02	0.01	0	0	0.03	0.05	0	0	0.57	0.92	0.49	1.98	1.28	4.99	1.20	0.41	8.05	15.93	17.96
400	2805	0.05	0.38	4.33	0	0.06	4.82	0	0	0.78	0.69	0.31	1.78	1.18	5.28	3.39	0.34	6.44	16.63	23.23
500	4119	0.05	3.64	6.81	0	1.19	11.68	0	0	0.77	0.51	0.24	1.53	0.87	3.92	4.74	0.27	4.57	14.38	27.59

Table 33. Total amount of public greenspace (m2) within 300m of population weighted centre of each CAU of the central city zone

	Parks and reserves						Road reserves						Other						
CAU	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Grass	Trees - impervious matrix	Trees - pervious matrix	Trees - individual	Hard surfaces	Subtotal	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Total
Thorndon	0	0	0	0	0	0	2765	11919	13662	0	280	28626	136	2479	12	0	0	2628	31253
Lambton	117	17027	29137	0	6427	52708	0	0	379	534	0	913	0	6242	10385	0	471	17098	70719
Willis	148	1489	0	595	2795	5028	0	0	67	831	0	898	6	0	343	0	0	349	6275

Table 34. Per capita public greenspace amount (m2/person) within 300m of population weighted centre of each CAU of the central city zone

		Parks and reserves						Road reserves						Other						
CAU	Est. pop.	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Grass	Trees - impervious matrix	Trees - pervious matrix	Trees - individual	Hard surfaces	Subtotal	Horticulture	Grass	Continuous trees	Discontinuous trees	Hard surfaces	Subtotal	Total
Thorndon	789	0	0	0	0	0	0	3.504868	15.10646115	17.3155492	0	0.35427	36.28114882	0.172428565	3.1424	0.01544675	0	0	3.33032	39.61
Lambton	1242	0.094376058	13.70956	23.4593647	0	5.175094	42.438394	0	0	0.30517949	0.42997719	0	0.735156678	0	5.0255	8.36190047	0	0.378837	13.7663	56.94
Willis	2172	0.068255306	0.685756	0	0.27405581	1.286822	2.3148892	0	0	0.03107444	0.38240734	0	0.413481774	0.002598292	0	0.15791073	0	0	0.16051	2.889

Glossary

Biomimicry: the design and production of materials, structures, and systems that are modelled on biological entities and processes.

Biophilic design: a concept used within design with an aim to increase occupant connectivity to the natural environment, and therefore wellbeing, through the use of direct nature, indirect nature, and space and place conditions.

Black water: sewage

Carbon sequestration: a natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form. E.g. tree growth.

Ecosystem services: the benefits that people derive, either directly or indirectly from ecosystems that support human physical, psychological and economic wellbeing.

Enviroschools: a New Zealand environmental action-based programme where young people are empowered to design and lead sustainability projects in their schools, neighbourhoods and country.

Green Prescription (GRx): is a New Zealand health professional's written advice to a patient to be physically active, as part of the patient's health management.

Green roofs: a roof covered in vegetation.

Grey Water: the relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances.

Impervious: not allowing fluid to pass through.

Intensification: increase in the density of population and/or economic activity.

Living Machines: a patented form of ecological water treatment designed to mimic the cleansing functions of wetlands.

Pervious: allowing water to pass through; permeable.

Non high-mass landscaping: landscaping that avoids or reducing the use of high mass materials such as concrete, asphalt, and stone.

Water sensitive urban design (WSUD): an approach to water resource management in urban environments that addresses both water quantity and water quality issues. WSUD integrates natural water systems with built form and landscapes and promotes a more resourceful use of water.

References

Aerts, R., Honnay, O. and Van Nieuwenhuyse, A. 2018. Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. British Medical Bulletin: ldy021-ldy021. doi: 10.1093/bmb/ldy021.

Amore K., Viggers H., Baker, M.G., & Howden-Chapman, P. 2013. Severe housing deprivation: The problem and its measurement, Official Statistics Research Series, 6. Available online: www.statisphere.govt.nz.

Astell-Burt, T., Feng, X., Mavoa, S., Badland, H.M. and Giles-Corti, B., 2014. Do low-income neighbourhoods have the least green space? A cross-sectional study of Australia's most populous cities. BMC Public Health, 14 (1), 292.

Atkinson, J., Salmond, C. and Crampton, P., 2014. NZDep2013 index of deprivation. Wellington: Department of Public Health, University of Otago.

Auckland City Council. Nd. Auckland Design Manual. Available online: http://www.aucklanddesignmanual.co.nz/design-thinking/universal_design.

Beatley, T. 2011. Biophilic cities: integrating nature into urban design and planning: Island Press.

Bedimo-Rung A.L., Mowen A.J., Cohen D.A. 2005. The significance of parks to physical activity and public health: A conceptual model. American journal of preventive medicine. 28(2):159-168.

Beresford, R.M., Turner, R., Tait, A., Paul, V., Macara, G., Zhidong, D.Y., Lima, L. and Martin, R., 2018. Predicting the climatic risk of myrtle rust during its first year in New Zealand. New Zealand Plant Protection, 71: 332-347.

Bertram, C. and Rehdanz, K., 2015. The role of urban green space for human well-being. Ecological Economics, 120: 139-152.

Blaschke, P.M., 2013. Health and wellbeing benefits of conservation in New Zealand. Science for Conservation 231. Publishing Team, Department of Conservation.

Blaschke P., R. Chapman, E. Randal, N. Preval. 2017. Does population density affect access to and satisfaction with urban green and open spaces? A review for the Resilient Urban Futures programme strand on compact and dispersed development. NZCSC Policy Paper, New Zealand Centre for Sustainable Cities, Wellington.

Boffa Miskell Ltd. 2001. Green and Promised Land: the story of the Wellington Town Belt. Museum of Wellington City and Sea, Wellington.

Botzat, A., L.K. Fischer, and I. Kowarik. 2016. Unexploited opportunities in understanding liveable and biodiverse cities. A review on urban biodiversity perception and valuation. Global Environmental Change 39:220-233.

Byrne, J., N. Sipe, G. Searle (2010). "Green around the gills? The challenge of density for urban greenspace planning in SEQ." Australian Planner 47: 162-177

Capacity Infrastructure Services. 2013. Northern CBD: ICMP Stage 1: Catchment Characteristics and Issues (unpublished draft)

Carnegie, A.J., Kathuria, A., Pegg, G.S., Entwistle, P., Nagel, M. and Giblin, F.R., 2016. Impact of the invasive rust Puccinia psidii (myrtle rust) on native Myrtaceae in natural ecosystems in Australia. Biological Invasions 18: 127-144.

Chan, F. 2017. Exploratory census of green spaces in higher and lower density Wellington City suburbs. Report, 2016/17 Summer Studentship Programme, University of Otago Wellington. Available online: https://www.otago.ac.nz/wellington/otago659137.pdf

City of Santa Monica. 2018. Tongva Park + Ken Genser Square. City of Santa Monica, accessed July 2018. Available online: http://tongvapark.smgov.net/.

Clark, K.H., and K.A. Nicholas. 2013. Introducing urban food forestry: a multifunctional approach to increase food security and provide ecosystem services. Landscape Ecology. 28 (9):1649-1669.

Cohen D.A., McKenzie T.L., Sehgal A., Williamson S., Golinelli D., Lurie N. 2007. Contribution of public parks to physical activity. American Journal of Public Health. 97(3):509-514.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S.J. Anderson, I. Kubiszewski, S. Farber, and R.K. Turner. 2014. Changes in the global value of ecosystem services. Global environmental change. 26:152-158.

D'Arcy, P. 2018. When Bangkok floods (and it floods a lot), this park does something amazing. TED Conferences, accessed July 2018. Available online: https://ideas.ted.com/when-bangkok-floods-and-it-floods-a-lot-this-park-does-something-amazing/.

De Vries, S., Verheij, R.A., Groenewegen, P.P. and Spreeuwenberg, P., 2003. Natural environments—healthy environments? An exploratory analysis of the relationship between greenspace and health. Environment and planning A, 35: 1717-1731.

de Vries, S., 2010. Nearby nature and human health: looking at mechanisms and their implications. In: Innovative approaches to researching landscape and health 2: 77-96). Routledge.

Department of Justice (USA). 2010. Ada standards for accessible design. Date accessed August 2019. Available online: https://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards_prt.pdf.

Department of Conservation. 2019. Conservation Management Strategy Wellington. New Zealand Department of Conservation, Wellington. Date accessed August 2019. Available online: https://www.doc.govt.nz/about-us/our-policies-and-plans/statutory-plans/statutory-plan-publications/conservation-management-strategies/wellington/

Ding D., Lawson K.D., Kolbe-Alexander T.L., et al. 2016. The economic burden of physical inactivity: A global analysis of major non-communicable diseases. The Lancet. 388(10051):1311-1324.

Douglas O., Lennon M., Scott M. 2017. Green space benefits for health and well-being: A life-course approach for urban planning, design and management. Cities. 66:53-62.

Elmqvist, T., E. Gomez-Baggethun, and J. Langemeyer. 2016. Ecosystem services provided by urban green infrastructure. In: Routledge Handbook of Ecosystem Services. Routledge. 452-464.

Elmqvist, T., H. Setälä, S.N. Handel, S. van der Ploeg, J. Aronson, J.N. Blignaut, E. Gómez-Baggethun, D.J. Nowak, J. Kronenberg, and R. de Groot. 2015. Benefits of restoring ecosystem services in urban areas. Current Opinion in Environmental Sustainability. 14:101-108.

Ely, M.E., 2010. Integrating trees into the design of the city: expert opinions on developing more sustainable practices for planting street trees in Australian cities (Doctoral dissertation, University of Adelaide).

Fleming C.M., Manning M., Ambrey C.L. 2016. Crime, greenspace and life satisfaction: An evaluation of the New Zealand experience. Landscape and Urban Planning. 149:1-10.

Foley, R., and T. Kistemann. 2015. Blue space geographies: Enabling health in place. Health & place. 35, 157-165.

Follette Story M. 2001. Principles of universal design. In: Universal Design Handbook. W.F.E Preiser, E. Ostro (eds) New York: McGraw-Hill.

Frumkin, H., G.N. Bratman, SJj. Breslow, B. Cochran, P.H. Kahn Jr, J.J. Lawler, P.S. Levin, P.S. Tandon, U. Varanasi, K.L. Wolf, and S.A. Wood. 2017. Nature Contact and Human Health: A Research Agenda. Environmental Health Perspectives 125 (7):075001.

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència, A. and Nieuwenhuijsen, M.J., 2015. Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. International Journal of Environmental Research and Public Health, 12(4): 4354-4379.

Glaeser, E. 2011. Urban Public Finance. Cambridge, MA. Available online: https://eml.berkeley.edu/~burch/Glaeser-Handbook-2011.pdf

Global Research and Wellington City Council. 2017. Our City, Tomorrow: Online engagement: Survey analysis (Global Research for Wellington City Council). Wellington, Wellington City Council.

GNS. 2019. Wellington Fault. GNS. Accessed August 2019. Available online: https://www.gns.cri.nz/Home/Learning/Science-Topics/Earthquakes/Major-Faults-in-New-Zealand/Wellington-Fault

Gómez-Baggethun, E., and D.N. Barton. 2013. Classifying and valuing ecosystem services for urban planning. Ecological Economics 86:235-245.

Gordon C. 2011. Charles Gordon's Look for Wellington: Midland Park. In – Landscape Architecture New Zealand June 2011 (Issue 10) see http://architecturenow.co.nz/articles/miidland-park/

Haaland, C. and C. K. van den Bosch (2015). "Challenges and strategies for urban green-space planning in cities undergoing densification: A review." Urban forestry & urban greening 14: 760-771.

Han B., Cohen D., McKenzie T.L. 2013. Quantifying the contribution of neighbourhood parks to physical activity. Preventive medicine. 57(5):483-487.

Hartig, T., Mitchell, R., De Vries, S. and Frumkin, H., 2014. Nature and health. Annual Review of Public Health, 35: 207-228.

Howe, C., H. Suich, B. Vira, and G.M. Mace. 2014. Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. Global Environmental Change. 28 (Supplement C): 263-275.

Iverson, L.R. and Cook, E.A., 2000. Urban forest cover of the Chicago region and its relation to household density and income. Urban Ecosystems, 4(2): 105-124.

Iwarsson S., Ståhl A. 2003. Accessibility, usability and universal design—positioning and definition of concepts describing person-environment relationships. Disability and Rehabilitation. 25(2):57-66.

Iwarsson S., Ståhl A. 1999. Traffic engineering and occupational therapy: a collaborative approach for future directions. Scandinavian Journal of Occupational Therapy. 6: 21-28.

Kilpatrick, A. Marm, D.J. Salkeld, G. Titcomb, and M.B. Hahn. 2017. Conservation of biodiversity as a strategy for improving human health and well-being. Philosophical Transactions of the Royal Society B: Biological Sciences 372 (1722).

Kowalski, J.M., and T.M. Conway. 2018. Branching out: The inclusion of urban food trees in Canadian urban forest management plans. Urban Forestry & Urban Greening. doi: 10.1016/j.ufug.2018.05.012

Krahn G.L., Walker D.K., Correa-De-Araujo R. 2015. Persons with disabilities as an unrecognized health disparity population. American Journal of Public Health. 105(Suppl 2): S198-S206.

Kullmann, K. 2011. Thin parks/thick edges: towards a linear park typology for (post) infrastructural sites. Journal of Landscape Architecture. 6(2):70-81.

Lawton M.P. 2001. Designing by degree: Assessing and incorporating individual accessibility needs. In: Universal Design Handbook. W.F.E Preiser, E. Ostro (eds) New York: McGraw-Hill.

Lee, A.C. and Maheswaran, R., 2011. The health benefits of urban green spaces: a review of the evidence. Journal of Public Health 33(2): 212-222.

Lee, H., and S. Lautenbach. 2016. A quantitative review of relationships between ecosystem services. Ecological Indicators. 66 (Supplement C):340-351.

Lin, B., Meyers, J., & Barnett, G. 2015. Understanding the potential loss and inequities of green space distribution with urban densification. Urban Forestry & Urban Greening, 14(4), 952-958.

Maas, J., Verheij, R.A., Groenewegen, P.P., De Vries, S. and Spreeuwenberg, P., 2006. Green space, urbanity, and health: how strong is the relation?. Journal of Epidemiology & Community Health, 60(7), 587-592.

Mace R. 1985. Universal Design, Barrier-Free Environments for Everyone. Los Angeles: Designers West.

Maddox, D. 2016. Justice and Geometry in the Form of Linear Parks. The Nature of Cities. April 18.

Market Economics Ltd. 2013. The costs of physical inactivity: towards a regional full-cost accounting perspective. Auckland Council, Waikato Regional Council and Wellington Regional Strategy Committee. 105 p. Available online: www.waikatoregion.govt.nz/Costs-of-Physical-Inactivity

Martín-López, B., E. Gómez-Baggethun, M. García-Llorente, and C. Montes. 2014. Trade-offs across value-domains in ecosystem services assessment. Ecological Indicators. 37:220-228.

Mathieu, R., Freeman, C., & Aryal, J. 2007. Mapping private gardens in urban areas using object-oriented techniques and very high-resolution satellite imagery. Landscape and Urban Planning. 81(3), 179-192.

McCormack, G.R., Rock, M., Toohey, A.M. and Hignell, D., 2010. Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. Health & Place, 16(4):, 712-726.

McIntosh J., Leah A. 2017. Mapping housing for the disabled in New Zealand. The New Zealand Medical Journal (Online). 130(1457).

McPherson, E.G., Simpson, J.R., Xiao, Q., & Wu, C. 2011. Million trees Los Angeles canopy cover and benefit assessment. Landscape and Urban Planning. 99(1), 40-50.

Meurk, C.D., Blaschke, P.M., & Simcock, R. 2013. Ecosystem services in New Zealand cities. Ecosystem services in New Zealand: conditions and trends. Manaaki Whenua Press, Lincoln, 254-273.

Millennium Ecosystem Assessment. 2005a. Ecosystems and Human Well-being: Current State and Trends. 5 vols. Vol. 1. Washington, DC: Island Press.

Millennium Ecosystem Assessment. 2005b. Ecosystems and Human Well-Being: Synthesis. Washington DC: Island Press.

Ministry for the Environment. 2016. National Policy Statement on Urban Development Capacity. New Zealand Ministry for the Environment, Wellington. Available online: https://www.mfe.govt.nz/sites/default/files/media/Towns%20and%20cities/National_Policy_Statement_on_Urban_Development_Capacity_2016-final.pdf

Mitchell, R. and Popham, F., 2007. Greenspace, urbanity and health: relationships in England. Journal of Epidemiology & Community Health, 61(8): 681-683.

Mitchell, R. and Popham, F., 2008. Effect of exposure to natural environment on health inequalities: an observational population study. The Lancet, 372 (9650): 1655-1660.

Mouchet, M.A., P. Lamarque, B. Martín-López, E. Crouzat, P. Gos, C. Byczek, and S. Lavorel. 2014. An interdisciplinary methodological guide for quantifying associations between ecosystem services. Global Environmental Change. 28 (Supplement C):298-308.

Nunns, P. 2014. Population-weighted densities in New Zealand and Australian cities: A new comparative dataset. MRCagney Pty Ltd, Auckland.

Nutsford, D., Pearson, A.L., & Kingham, S. 2013. An ecological study investigating the association between access to urban green space and mental health. Public health. 127(11), 1005-1011.

Nutsford, D., Pearson, A.L., Kingham, S. and Reitsma, F., 2016. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. Health & Place, 39: 70-78.

Office for Disability Issues. 2018. Key facts about disability in New Zealand. Date accessed July 2018. Available online: http://www.odi.govt.nz/home/about-disability/key-facts-about-disability-in-new-zealand/.

Pedersen Zari, M. 2010. Biomimetic design for climate change adaptation and mitigation. Architectural Science Review, *53*(2): 172-183.

Pedersen Zari, M. 2014. Ecosystem Services Analysis in Response to Biodiversity Loss Caused by the Built Environment. S.A.P.I.E.N.S. 7(1).

Pedersen Zari, M. 2017. Utilizing relationships between ecosystem services, built environments, and building materials. In Materials for a Healthy, Ecological and Sustainable Built Environment: Principles for Evaluation, edited by E.K. Petrović, B. Vale and M. Pedersen Zari, 1-28. Duxford, UK: Woodhead.

Pedersen Zari, M. 2018. Regenerative Urban Design and Ecosystem Biomimicry. Oxon: Routledge.

Pedersen Zari, M. and K. Hecht. 2019. Biomimicry for regenerative built environments: mapping design strategies for producing ecosystem services. TensiNet Symposium - Softening the habitat. A. Zanelli, C. Monticelli, M. Mollaert and B. Stimpfle. Milan, Italy, Politecnico di Milano.

Pedersen Zari, M., and S Jenkin. 2009. Rethinking our built environments: Towards a sustainable future. Wellington: Ministry for the Environment, New Zealand Government.

Peters, A. 2017. These Cities Are Replacing The Worst Kind Of Infrastructure With The Best. Date accessed July 2018. Available online: https://www.fastcompany.com/90109925/these-cities-are-replacing-the-worst-kind-of-infrastructure-with-the-best.

Petry N.M. 2002. A comparison of young, middle-aged, and older adult treatment-seeking pathological gamblers. The Gerontologist. 42(1):92-99.

Potschin, M., R. Haines-Young, R. Fish, and K. Turner. 2016. Ecosystem services in the twenty-first century. In Routledge Handbook of Ecosystem Services. Potschin, M., Haines-Young, R., Fish, R., Turner, R.K. (Eds.), Routledge, London and New York: 1-9.

Richardson, E., Pearce, J., Mitchell, R., Day, P. and Kingham, S., 2010. The association between green space and cause-specific mortality in urban New Zealand: an ecological analysis of green space utility. BMC Public Health, 10(1): 240.

Richardson, E.A., Pearce, J., Mitchell, R., & Kingham, S. 2013. Role of physical activity in the relationship between urban green space and health. Public health, 127(4), 318-324.

Rimmer J.H., Marques A.C. 2012. Physical activity for people with disabilities. The Lancet. 380(9838):193-195.

Rimmer J.H., Rowland J.L., Yamaki K. 2007. Obesity and secondary conditions in adolescents with disabilities: Addressing the needs of an underserved population. Journal of Adolescent Health. 41(3):224-229.

Roberts, L., Brower, A., Kerr, G., Lambert, S., McWilliam, W., Moore, K., Quinn, J., Simmons, D., Thrush, S., Townsend, M., Blaschke, P., Costanza, R., Cullen, R., Hughey, K., & Wratten, S. 2015: The nature of wellbeing: how nature's ecosystem services contribute to the wellbeing of New Zealand and New Zealanders. Department of Conservation, Wellington. 145 p.

Russell M., Early, L., Hamer-Adams, A., & Ombler, J. 2015. Wellington. Chapter 4 in: Early L., Howden-Chapman P., Russell M., eds. Drivers of Urban Change. Steele Roberts, Wellington.

Sallis J.F., Cerin E., Conway T.L., et al. 2016. Physical activity in relation to urban environments in 14 cities worldwide: A cross-sectional study. The Lancet 387(10034):2207-17

Salmond, C., P. Crampton, P. King, and C. Waldegrave. 2006. NZiDep: a New Zealand index of socioeconomic deprivation for individuals. Social science & medicine. 62, no. 6 : 1474-1485.

Schrader, B., 2016. *The Big Smoke: New Zealand Cities, 1840–1920*. Bridget Williams Books.

Scott G. 2008. Success stories in design: The Versluis park. Topics in Stroke Rehabilitation. 15(2):118-124.

Shanahan, D.F., Bush, R., Gaston, K.J., Lin, B.B., Dean, J., Barber, E. and Fuller, R.A., 2016. Health benefits from nature experiences depend on dose. Scientific Reports 6, 28551.

Sister, C., Wolch, J. and Wilson, J., 2010. Got green? Addressing environmental justice in park provision. *GeoJournal*, *75*(3), pp.229-248.

Ståhle, A., 2010. More green space in a denser city: Critical relations between user experience and urban form. Urban Design International, 15(1): 47-67.

Soulsbury, C.D., and P.C.L. White. 2016. Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildlife Research 42 (7):541-553.

Springgate L. 2008. Defining parks and park systems. Planning Advisory Service Report. 551:1-14. .

Statistics New Zealand. 2014. Disability survey: 2013. In: Statistics New Zealand, ed. Wellington: Statistics New Zealand.

Steinfeld E., Danford G.S. 1999. Theory as a basis for research on enabling environments. In Enabling Environments. Measuring the Impact of Environment on Disability and Rehabilitation. E Steinfeld, GS Danford (eds). New York: Kluwer Academic/Plenum Publishers.

Steinfeld E., Maisel J. Universal design: Creating inclusive environments. John Wiley & Sons; 2012.

Swanwick, C., Dunnett, N. and Woolley, H., 2003. Nature, role and value of green space in towns and cities: An overview. Built Environment: 94-106.

Taylor, L., and D.F. Hochuli. 2015. Creating better cities: how biodiversity and ecosystem functioning enhance urban residents' wellbeing. Urban Ecosystems. 18 (3):747-762.

TEEB. 2011. TEEB Manual for Cities: Ecosystem Services in Urban Management. Online: TEEB.

Thompson, C.W., 2002. Urban open space in the 21st century. Landscape and Urban Planning, 60(2), 59-72.

Turner, G. 2008. A comparison of the limits to growth with thirty years of reality, Socio-Economics and the Environment in Discussion. CSIRO Working Paper Series 2008-09. Canberra: CSIRO.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J. and James, P., 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning, 81(3), 167-178.

UN General Assembly. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. New York: United Nations.

United Nations. 2007. Convention on the rights of persons with disabilities. Available online at: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

Vierikko, K., B. Elands, J. Niemelä, E. Andersson, A. Buijs, L.K. Fischer, D. Haase, N. Kabisch, I. Kowarik, A.C. Luz, A. Olafsson Stahl, L. Száraz, A. Van der Jagt, and C. Konijnendijk van den Bosch. 2016. Considering the ways biocultural diversity helps enforce the urban green infrastructure in times of urban transformation. Current Opinion in Environmental Sustainability. 22:7-12.

Walsh, J.R., S.R. Carpenter, and M.J. Vander Zanden. 2016. Invasive species triggers a massive loss of ecosystem services through a trophic cascade. Proceedings of the National Academy of Sciences. 113 (15):4081.

Wellington City Council 1998. Capital Spaces: the open space strategy for Wellington Te Whanganui-a-Tara.

Wellington City Council. 2013a. The Town Belt Management Plan. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/~/media/your-council/plans-policies-and-bylaws/plans-and-policies/ a-to-z/townbeltmgmt/files/10intro.pdf?la=en

Wellington City Council 2013b. Our Capital Spaces: An Open Spaces and Recreation Framework for Wellington 2013-2023. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/~/ media/your-council/projects/files/our-capital-spaces.pdf?la=en

Wellington City Council. 2015. Our Natural Capital Spaces: Wellington's biodiversity strategy and action plan. Wellington City Council, Wellington.

Wellington City Council. 2017a. Wellington Resilience Strategy. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/about-wellington/wellington-resilience-strategy

Wellington City Council. 2017b. Wellington Central City Framework: approach to Implementation. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/your-council/plans-policies-and-bylaws/policies/central-city-framework

Wellington City Council. 2017c. Our City Tomorrow: What's Next. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/~/media/your-council/projects/files/oct/oct-3final-doc12-04-2018. pdf?la=en

Wellington City Council. 2019. Our City Tomorrow: Planning for Growth. Wellington City Council, Wellington. Website: https://planningforgrowth.wellington.govt.nz/

Wellington City Council. nd. Water Sensitive Urban Design: A Guide for WSUD Stormwater Management in Wellington. Wellington City Council, Wellington. Available online: https://wellington.govt.nz/~/media/services/environment-and-waste/environment/files /wsud-guide.pdf

Wellington Water. 2018. CBD Flood Management Plan. Unpubl. presentation to Wellington City Council.

Wilson N., Signal L., Thomson G. 2018. Surveying all public drinking water fountains in a city: Outdoor field observations and google street view. Australian and New Zealand Journal of Public Health. 42(1):83-85.

World Health Organization (WHO). 2001. International classification of functioning, disability and health. World Health Organization.

World Health Organization (WHO) Regional Office for Europe. 2016. Urban green spaces and health. Copenhagen, WHO Regional Office for Europe.

World Health Organization (WHO). 2018. Global action plan on physical activity 2018–2030: More active people for a healthier world. Geneva, Switzerland.

Wratt, D., B. Mullan, J. Salinger, S. Allan, T. Morgan, and G. Kenny. 2008. Climate change effects and impacts assessment. A guidance manual for local government in New Zealand (2nd ed). Ministry for the Environment, Wellington. Available online: https://www.mfe.govt.nz/sites/default/files/climate-change-effect-impacts-assessment-may08.pdf

Zhang, Y., S. Singh, and B.R. Bakshi. 2010. Accounting for Ecosystem Services in Life Cycle Assessment, Part I: A Critical Review. Environmental Science and Technology. 44 (7):2232-2242.