

SUBMISSION ON PLAN CHANGE 29
Dr Alistair Kwan

1 Agreement with greater residential density

I agree with increasing residential density close to the commercial centres of Nelson and Stoke.

2 Inadequacy of motivations

The proposed change does not recognise much of the reasoning that could motivate increased residential density. There are many, including better economic function (notably for downtown retail), better functioning and provision of public transportation, improved public safety, reduced congestion, better access to rural space because it will remain close to residents rather than being pushed out by sprawl.

Saying that people need homes is true. Saying *only* that people need homes is lying by omission, guarantees a poor decision-making process, and cannot be expected to lead us to optimal outcomes.

REQUEST: Give motivations that explain the proposal, grounded in a comprehensive evaluation of desired outcomes, and driven by a comprehensive evaluation of Nelson's current constraints and problems.

3 General inadequacy of proposal

This proposed change is very difficult to respond to because it has been presented without the background research needed to understand what it is for and what it is meant to achieve. Specifically, it lacks rationale for any specific changes, and it lacks a clear strategic direction or purpose. It hence does not read as a plan change proposal, but merely as a new managerial ruleset that appears to be uninformed by even introductory-level urban planning concepts, principles and methods.

As the Resource Management Act is framed largely around the assessment of environmental effects, it comes across as ironic that this plan proposal provides no serious assessment of what environmental effects should be expected from its implementation.

Please remember that materials for public consultation need to be written for people who are not specialists in the field. This does not mean leaving out all of the specialist rationale, but it does mean conveying it in a way that informs and educates us who do not know.

Not having done this writing work, plus the general absence of rationale and vision, gives the impression that the proposal was written in bad faith. You must bear in mind that we who submit do not have a Council salary to support our submission work: it costs us time to submit, you benefit from perspective and expertise that submitters bring, and it is reasonable for submitters to receive consultation documents that were written expressly for consultation. As things stand, you will not be getting submissions from thousands who cannot spare the time and energy to do so: we have seen nothing to facilitate engagement from suppressed voices.

REQUEST: Write a new proposal that speaks explicitly to good urban planning. This must include basics such as modelling

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arranging a time by e-mail or SMS.

I do not request to speak at a public hearing.

I will gain no trade advantage through this submission.

I am an academic and technical writer and editor; my fields include heritage and history (specialising in sites and objects), urban planning, architecture, and heating, ventilation and air conditioning (HVAC).

1. circulation, transport, temperature, humidity, wind, water flows, noise levels
2. urban ecosystem services

to identify both

1. where increased population densities will achieve the best outcomes
2. where taller, closer building forms will achieve the best outcomes.

REQUEST: Contextualise the project within a vision for Nelson’s long-term future – a design strategy that we need our Councillors to strive towards, even if they have not studied urban planning.

REQUEST: If you do not have a technical writer and editor on staff, hire one for the project. If you do have them, please bring their abilities to the project. Technical writing and editing involve specialist writing, multidisciplinary learning, and information management skills that almost no one has in the appropriate combination.

REQUEST: Enable participation from people without enough time, enough money, enough safety, enough cultural capital.

4 Provision needed for urban improvement

The proposal makes no mention of actually improving anything.

REQUEST: I ask that some explicit evaluation of urban conditions be included both to justify the plan change, and also as a criterion for urban development.

The options include measuring urban ecosystem services, using e.g. *landsenses ecology*. *Landsenses ecology* has been developing for nearly a decade, as a more multidisciplinary approach to urban ecosystem services. *Landsenses ecology* integrates the human and natural worlds to examine the realities of occupants’ everyday experience such as our access to food and work and shelter, our safety and security, our peaceful enjoyment of a space, our being welcome in a space, our being able to enter and to leave a space at will. Engaging *landsenses ecology* will provide natural opportunity to speak to *ao Māori* considerations of the urban form, its future, and community wellbeing.

Any substantial change to a site should require justification by showing that urban ecosystem service measures are improved in at least some categories, and not worsened in any categories.

REQUEST: Read

- Gómez-Baggethun & al., “Urban ecosystem services” in Elmqvist & al. edd. *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities* (Springer, 2013, pp. 175–251 and
- Meurk & al., “Ecosystem services in New Zealand cities” in Dymond, ed. *Ecosystem services in New Zealand – conditions and trends* (Manaaki Whenua Press, Lincoln, New Zealand).

REQUEST: Provide maps showing the current state of ecosystem services. These are needed to identify and prioritise where bigger changes should happen, and what kinds of changes – if any – should happen, everywhere.

REQUEST: Require that applications for character-changing development include a demonstration – perhaps using *landsenses ecology*, or urban ecosystem services more generally – that quality of life will improve, or at least not decline, both close to the site (e.g. within 20 metres), and also in some broader neighbourhood area (e.g. within 100 street-metres) of the site.

5 Protections needed for neighbour's costs of living

Extensive mention has been already of people losing the usefulness of solar photovoltaic cells and direct-insolation water heaters due to shading by new, tall buildings being erected next-door. The loss of photovoltaic generation capacity is of significance not only to the occupant, but also on a national scale as it conflicts with government efforts to implement a distributed buffer against overshooting electrical demand peaks. This distributed buffer comprises residential batteries, for which immense government support has already been provided to Solar Zero.

There are also other losses to consider:

- Lost winter heat gain through insolation on the roof and walls. Such loss would reduce the effectiveness of humidity removal systems that rely on preheated air in the roof cavity, and would increase the need for heating the interior living spaces. The results, in both cases, are increased costs to the occupants.
- Lost food production through shading of gardens, resulting in increased food costs.
- Lost recreational gardening prospects through shading of gardens, resulting in reduced mental health through general cultural and leisure impoverishment.

The proposed plan does not explain how developers should recompense neighbours for the costs that casting more shade will cause. Given Nelson's established character as a large retirement community, and repeated exhortations to make it friendlier towards younger families, any plan change must provide for them.

REQUEST: Incorporate better protections for neighbour's sun – which may come in various forms, such as

- financial compensation for lost area-sun-hours (area of shade, integrated over time of shading) recognising that the imposed costs are, in effect, forever
- more conservative recession planes
- guaranteed area-sunlight-hours (square metres of direct sun, integrated over exposure time, at winter solstice) on open ground in at least some residential land-use zones
- compensatory garden space, e.g. through rooftop and courtyard gardens on new buildings or lifetime allotments on community garden sites nearby
- compensatory garden space along roadsides.

REQUEST: Adjust recession planes and setback lines to allow terraced housing across sections in the innermost land use zones so that immediately adjacent walls, and indeed party walls, can be a means of thermal control – they neither take in solar heat nor radiate it to space.

6 Inadequate provision for community

Much is said about the need to accommodate individuals and families. More must be said about the need to build communities. The problem context here is a city, not a warehouse: we do not put up apartments simply to store people in. Those people have lives. They need to come and go, they need to connect with others both through their windows and over their property boundaries, and also when they leave and return to their properties. Others need to be able to connect with them to form neighbourhood communities.

REQUEST: Provide for positive interaction: not merely setting aside space such as an occasional park, but by requiring spatial design of environmental cues to increase social connectivity and communal thriving (see ecosystem services above).

7 Inadequate provision for outlooks and viewshafts

Open views of natural space are important both out of a building, and also onto a building. Views provide not simply for simple niceness, but for mental health. Many houses along Locking Street, for example, get views only to the Grampians and, if you look directly up, into the sky. Inconsiderately erecting a tall building at the west end of Examiner Street may cut those residents off entirely.

Similarly, consider the fine specimen of aggressive, antisocial architecture that was erected behind 105 Grove Street. The home is delightful from the front, but the back yard has been made into a nasty hellhole by the deliberately imposition of horrible two-storey buildings on the site behind it. This literally an arse-end view: the neighbours are greeted with grubby el-cheapo stucco punctuated by toilet windows and plumbing vents. Considerable concern has been expressed that developers will do similarly elsewhere in the city.

REQUEST: Protect for *some* long-range view, e.g. guarantee some solid angle measure of view to and above the horizon from the main living spaces of existing buildings.

REQUEST: Protect against the imposition of antisocial wall views.

8 A more mature approach to heritage is needed

The city's current approach to urban heritage has centred mainly on retaining late 19th century and early 20th century houses, mainly the exteriors. This is not urban heritage, but only façadism. When property owners then cut their frontages off from public view by erecting tall fences or growing dense, tall hedges, these houses no longer contribute to heritage in any public sense.

The Council has accepted the *Taonga tuku iho* heritage strategy. As one of its contributors, I am aware that Council has committed to a more mature approach to urban and regional heritage that considers more than just looks, and more than just colonial additions.

Council has thus committed to the whakapapa of site and structures, which extends far beyond the beautiful timber houses that we so greatly treasure. It includes past uses of that land, and it includes the land itself, and the waterways that used to run through it. Council has committed to understanding that whakapapa is not just a list of things that were there before, but the chain of causes that make Nelson and Whakatū what they are today, and that continues on into the future.

These commitments align well with approaching urban planning through ecosystem services (see above).

REQUEST: Require development to extend the whakapapa of the site and of existing and previous structures and uses.

REQUEST: All Council support of urban heritage significance should contribute to *public* heritage service, not to private heritage possession. For example, require that the front boundaries, in areas conservatively preserved for their heritage, be 60% transparent up to two metres from the ground, to be achieved through a combination of fence/hedge height, fence/hedge opacity (e.g. gaps between slats or rails), and unoccluded gateways.

REQUEST: Encourage and favour developments that make good use of existing, on-site materials and structures†

REQUEST: Much as we protect airsheds from fireplace pollutants, protect other aspects of our natural heritage.

†See e.g. Page, *Why preservation matters* (Yale, 2017).

9 Inadequate provision for water management

The reduced requirement for permeable surface is understandable but, given alone, it comes across as half-baked (if not merely fabricated).

REQUEST: Increase the provisions for water absorption by adding e.g. green roofs, infiltration ponds, permeable pavement, green walls, etc.

10 Inadequate provision for urban microclimate, and for environmental changes more generally

The proposed plans say nothing at all about how taller, closer buildings will affect temperatures, airflow, and reflected light and heat. Cities are already designed to admit cooling and refreshing breezes, to provide shade. Models (e.g. implemented in ENVI-met software) are often a bit crude – mainly due to the computational costs of fine detail – but they at least give sufficient reliable ballpark indications to be widely used. There is nothing new here. It is hence hard to think of any good reasons why the modelling was not included in the proposal.

In addition, we have some remarkably dumb disasters such as the ‘creative’ architects who build concave mirrors into a London skyscraper, focussing the reflected sunlight tightly onto the road below – causing great discomfort to pedestrians and damaging the paint on parked cars. Such mirrors also reflect noise in the same way. The mathematics to handle this has been available for approximately two thousand years (consider e.g. Apollonius’s works); there is, again, nothing new.

REQUEST: Provide models that show the effects of building densification.

REQUEST: Require developers to show such models to demonstrate that their proposed buildings will cause no substantial harm.

REQUEST: Encourage green roofs, green walls.

Please consider Condominio 25 Verde, a five-storey apartment block on via Gabriele Chiabrera, Torino. It has been there since 2012, a very short walk from the Borgo Medievale. It contains over 60 apartments, interspersed and interpenetrated by living greenery. If this is possible to remediate a dying industrial hole in Italy, we should surely be able to achieve at least half of that in a building here! Or do we not aspire?‡

11 Regulation of vehicle noise and pollution misses the problem, passes the buck

There has not been enough attention to the noise and dust caused by vehicles. This noise is largely optional, and insulating against it does not reduce the effect that it has on pedestrians and cyclists: road noise simply makes the city inhospitable, and requiring insulation along highways is ignoring that problem.

REQUEST: Address noise and dust by not creating so much of it in the first place: prescribe low-noise, low-abrasion road surfaces.

The situation has become only more acute given (a) the recent observation that the vast majority of oceanic microplastics comes from car tyres, and (b) the expectation that, as temperatures increase, New Zealand roads will show ever more damage – notably potholes – because they are not designed for such conditions.

REQUEST: Prescribe pavement structures that will stand up to the new climatic conditions.

‡<https://maps.app.goo.gl/YwtBzoFwYNf1ufpw5>

12 Broader ideas for urban direction

This plan change gives us no sense of a positive future into which we are heading; as you have seen, it has rather inspired anger and dread. People are scared of all manner of ‘what if’ scenarios, of having their lives ruined. Much of this might have been avoided had an urban design strategy been provided.

I finish with a few notes on what I would like the Council to consider.

12.1 Connect with the Maitai

REQUEST: Treat the Maitai as one of the cities circulation arteries. Provide direct access to the water – e.g. by steps and beaches – so that we can interact with the river, versus merely seeing it at a distance. Such access provision will also contribute to safety: spots where people can get down to the water are also spots where, having fallen in accidentally, they will be able to get out.

12.2 Open buried rivers

High-tide flooding is not simply because the tide rises, but because the space that it rises into is too small.

REQUEST: Re-open the buried rivers, and develop them as intervention nuclei for the inner city’s leisure space and commercial reinvigoration. As a model, consider the Canal St-Martin in Paris, and the Cheonggyecheon in Seoul. This could be the lower end of St Vincent and Vanguard Streets. Please look also to the literature on shrinking cities for examples of how disused commercial and industrial space has been handled – this may offer some solutions to the egress of retail from central Nelson.

Re-opening the buried rivers could also contribute, via a shift of drainage needs, to the improvement of Bridge Street.

12.3 Increase the urban forest

Tree coverage will be lost through increases in building coverage, with consequences for water management, temperature, and greenness (see urban ecosystem services above), and also for the wildlife connectivity between the coast, the Brook Waimarama Sanctuary, and other nearby ecosystem areas.

There is extensive recent research on how cities benefit in many, many ways from urban forest coverage.

REQUEST: Plant more trees, and work towards substantial shade coverage, along streets and in carparks. Start with reasonably large trees, not tiny saplings. Let the trees grow large; large is important.

REQUEST: Include more open space, and more green space, throughout the city – pockets need to be everywhere, serving as both community foci and as relief for residents. Note that, if implemented as public courtyards, these spaces might also be considered reason to construct buildings closer to the site boundary. They would need to be protected as welcoming *public* space, however – not configured as pseudo-foyers for the buildings adjacent to them (for a model of a public space whose design gave control to private interest, consider City Square in Melbourne).

12.4 Address the city’s profile

Focus densification on the inner city: it should spike centrally, or very nearly centrally. Downtown Nelson does not have an area like the Italian centri storici that requires total preservation as-is, nor

a bombed-out circle of World War II horror into which we can pile a hundred cheap-and-ugly (but quick-to-build) apartment blocks; we can more appropriately add residential structures to the inner city while improving the downtown environment and adding population to support retail and hospitality. Doing so does not need to generate conflict with nightclubs.

Implementing equal densification further out would naturally increase transportation needs, reducing overall urban efficiency and putting more spending into fuel than into the goods and services that our local economy might otherwise thrive on.

An intermediate ring of medium-density, two- or three-storey townhouses (consider London terrace houses with small but substantial backyards) could be invaluable in achieving residential capacity without giving the city a delta-pulse profile, and cultivating its natural merge with adjacent greenspace.

These points have already been made in the 2008 Nelson Urban Growth Strategy.

Thank you for the opportunity to submit.

A stylized, handwritten signature in black ink, consisting of several loops and a long, sweeping underline.

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Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities

A Global Assessment

A Part of the Cities and Biodiversity Outlook Project

 Springer

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Chapter 11

Urban Ecosystem Services

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Erik Andersson, Zoé Hamstead, and Peleg Kremer**

Abstract We explore the potential of urban ecosystem services for improving resilience and quality of life in cities. First, we classify and categorize important ecosystem services and disservices in urban areas. Second, we describe a range of valuation approaches (cultural values, health benefits, economic costs, and resilience) for capturing the importance of urban ecosystem service multiple values. Finally, we analyze how ecosystem service assessment may inform urban planning and governance and provide practical examples from cities in Africa, Europe, and America. From our review, we find that many urban ecosystem services have already been

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identified, characterized and valued, and have been found to be of great value and importance for human well-being and urban resilience. We conclude that the use of the concept of urban ecosystem services can play a critical role in reconnecting cities to the biosphere, and reducing the ecological footprint and ecological debt of cities while enhancing resilience, health, and quality of life of their inhabitants.

11.1 Reconnecting Cities to the Biosphere

Cities are interconnected globally through political, economic, and technical systems, and also through the Earth's biophysical life-support systems (Jansson 2013). Cities also have disproportionate environmental impacts at the local, regional, and global scales well beyond their borders (Grimm et al. 2000, 2008; Seto et al. 2012), yet they provide critical leadership in the global sustainability agenda (Folke et al. 2011). Although urbanized areas cover only a small portion of the surface of the planet, they account for a vast share of anthropogenic impacts on the biosphere. Still, the impacts of urbanization on biodiversity and ecosystems as well as the potential benefits from ecosystem restoration in urban areas remain poorly understood (see e.g., McDonald and Marcotullio 2011). For further discussion on urban restoration ecology, also see Chap. 31.

11.1.1 *Ecology of vs. Ecology in Cities*

Cities appropriate vast areas of functioning ecosystems for their consumption and waste assimilation (see Chaps. 2 and 26). Most of the ecosystem services consumed in cities are generated by ecosystems located outside of the cities themselves, often half a world away (Rees 1992; Folke et al. 1996; Rees and Wackernagel 1996;

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Deutsch and Folke 2005, see Chap. 2). Folke et al. (1997) estimated that the 29 largest cities in the Baltic Sea Drainage Basin, taking into account only the most basic ecosystem services such as food production and assimilation of nitrogen and carbon, appropriate ecosystem areas equivalent to the size of the entire drainage basin, several hundred times the area of the cities themselves (Chap. 26). Thus, our analysis needs to go beyond what is sometimes referred to as “the ecology *in* cities” (Niemelä et al. 2011), which often focuses on single scales and on designing energy-efficient buildings, sustainable logistics, and providing inhabitants with functioning green urban environments, to put more focus on “the ecology *of* cities” characterized by interdisciplinary and multiscale studies with a social-ecological systems approach (Grimm et al. 2000; Pickett et al. 2001, see also Chap. 3). This framework acknowledges the total dependence of cities on the surrounding landscape and the links between urban and rural, viewing the city as an ecosystem itself (Grimm et al. 2008). We need to be concerned with the generation potential, not only to uphold and safeguard the well-being of city inhabitants, but also to effectively manage the potential of cities as arenas for learning (this aspect is discussed in detail in Chap. 30), development, and transformation.

11.1.2 Urban Ecosystems and Ecological Infrastructure

Definitions of urban areas and their boundaries vary between countries and regions (for a discussion on “What is urban?” see Chap. 1). The focus of this chapter is on the services and benefits provided by urban ecosystems, defined here as those areas where the built infrastructure covers a large proportion of the land surface, or as those in which people live at high densities (Pickett et al. 2001). In the context of urban planning, urban ecosystems are often portrayed as embedding both the built infrastructure and the ecological infrastructure. The concept of ecological infrastructure captures the role that water and vegetation in or near the built environment play in delivering ecosystem services at different spatial scales (building, street, neighborhood, and region). It includes all ‘green and blue spaces’ that may be found in urban and peri-urban areas, including parks, cemeteries, gardens and yards, urban allotments, urban forests, single trees, green roofs, wetlands, streams, rivers, lakes, and ponds (EEA 2011). Defining clear boundaries for urban ecosystems often proves difficult because many of the relevant fluxes and interactions necessary to understand the functioning of urban ecosystems extend far beyond the urban boundaries defined by political or biophysical reasons. Thus, the relevant scope of urban ecosystem analysis reaches beyond the city area itself; it comprises not only the ecological infrastructure within cities, but also the hinterlands that are directly affected by the energy and material flows from the urban core and suburban lands (Pickett et al. 2001, p. 129), including city catchments, and peri-urban forests and cultivated fields (La Rosa and Privitera 2013). Whilst virtually any ecosystem is relevant to meet urban ecosystem service demands, the focus here is on services provided within urban areas.

11.2 Classifying Urban Ecosystem Services

In recent years a mounting body of literature advanced our understanding of urban ecosystem services in their biophysical, economic, and socio-cultural dimensions. Furthermore, urban ecosystem services were addressed by major initiatives like the Millennium Ecosystem Assessment (Chapter 27 in MA 2005) and The Economics of Ecosystems and Biodiversity (TEEB 2011), and also have received increasing attention as part of the policy debate on ecological infrastructure. Yet, despite the fact that more than half of the world's population today lives in cities, the attention given to urban ecosystems in the ecosystem services literature has yet been relatively modest as compared to other ecosystems like wetlands or forests. This section aims at classifying and describing ecosystem services provided in urban areas and how these may contribute to increase quality of life in cities.

Building on previous categorizations of ecosystem services (Daily 1997; de Groot et al. 2002), the Millennium Ecosystem Assessment (MA 2005) and The Economics of Ecosystem Services and Biodiversity (TEEB 2010) grouped ecosystem services in four major categories: provisioning, regulating, habitat, and cultural and amenity services (TEEB 2010) (Fig. 11.1). Provisioning services include all the material products obtained from ecosystems, including genetic resources, food and fiber, and fresh water. Regulating services include all the benefits obtained from the regulation by ecosystem processes, including the regulation of climate, water, and some human diseases. Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience as well as their role in supporting knowledge systems, social relations, and aesthetic values. Finally, supporting or habitat services are those that are necessary for the production of all other ecosystem services. Examples include biomass production, nutrient cycling, water cycling, provisioning of habitat for species, and maintenance of genetic pools and evolutionary processes.

Because different habitats provide different types of ecosystem services, general classifications need to be adapted to specific types of ecosystems. Urban ecosystems are especially important in providing services with direct impact on human health and security such as air purification, noise reduction, urban cooling, and runoff mitigation. Yet, which ecosystem services in a given scale are most relevant varies greatly depending on the environmental and socio-economic characteristics of each geographic location. Below we provide a classification and description of important ecosystem services provided in urban areas using the Millennium Ecosystem Assessment and the TEEB initiative as major classification frameworks, and drawing on previous research on the topic (e.g., Bolund and Hunhammar 1999; Gómez-Baggethun and Barton 2013).

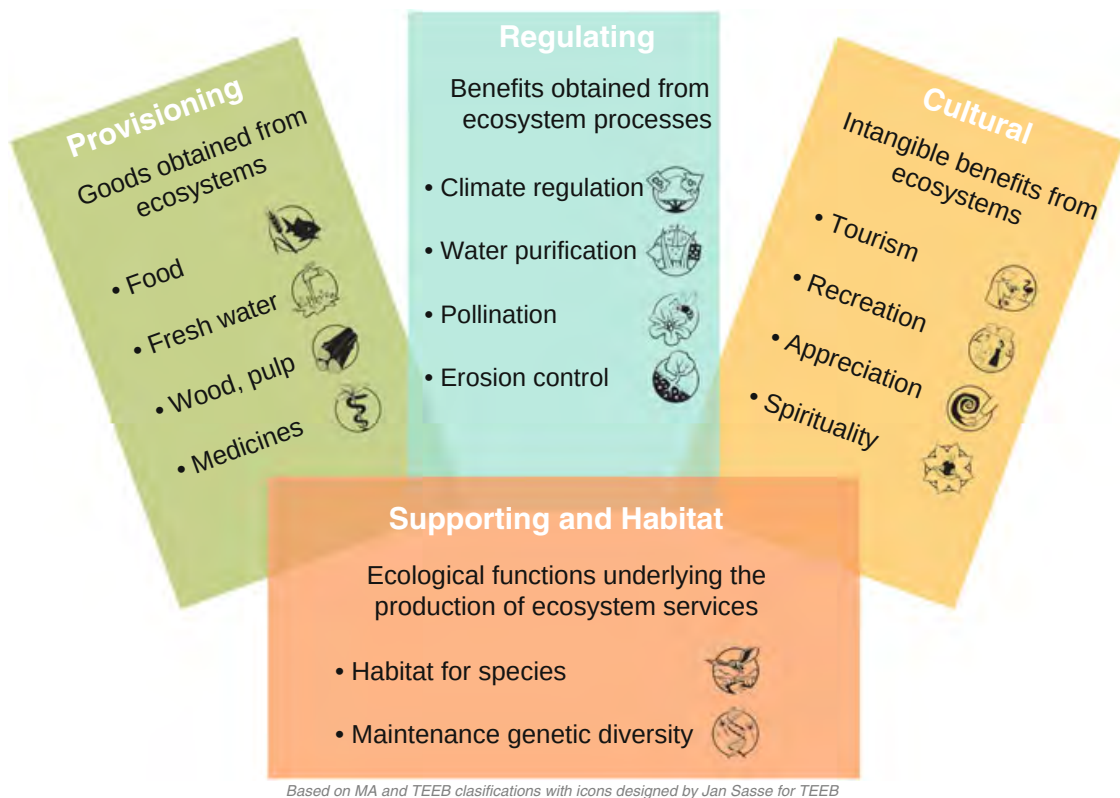


Fig. 11.1 Classification of ecosystem services based on the Millennium Ecosystem Assessment (MA 2005) and the Economics of Ecosystems and Biodiversity initiative (TEEB 2012) (Produced by Gómez-Baggethun 2013 with icons designed by Jan Sasse for TEEB. Icons reproduced from Jan Sasse for TEEB. Published with kind permission of © Jan Sasse and TEEB 2013. All Rights Reserved)

11.2.1 Provisioning Services

11.2.1.1 Food Supply

Urban food production takes place in peri-urban farm fields, on rooftops, in backyards, and in community gardens (Andersson et al. 2007; Barthel et al. 2010). In most geographical contexts, cities only produce a small share of the food they consume, depending largely on other areas to meet their demands (Folke et al. 1997; Ernstson et al. 2010). In some geographical areas and in particular periods, however, food production from urban agriculture can play an important role for food security, especially during economic and political crises (Smit and Nasr 1992; Moskow 1999; Page 2002; Buchmann 2009; Barthel et al. 2011; Barthel and Isendahl 2013). Altieri et al. (1999) estimated that in 1996 food production in urban gardens of Havana included 8,500 t of agricultural products, 7.5 million eggs and

3,650 t of meat. Moustier (2007) provides an extensive summary of the importance of urban agriculture in 14 African and Asian cities. Among the results they found that 90 % of all vegetables consumed in Dar es Salaam (Jacobi et al. 2000) and 60 % of vegetables consumed in Dakar (Mbaye and Moustier 2000) originate from urban agriculture. With regards to staple foods such as rice, plantain banana, and maize, the situation is highly variable among cities. In Asia, the share of rice supplied by the city to urban residents ranges from 7 % (in Phnom Penh) to 100 % (in Vientiane, where pressure on land is low); Hanoi is an intermediary case with 58 % (Anh 2004; Ali et al. 2005). For a detailed examination of the connection between urbanization and food systems, see Chap. 26.

11.2.1.2 Water Supply

The growth of cities throughout the world presents new challenges for securing water to meet societal needs (Fitzhugh and Richter 2004). Ecosystems provide cities with fresh water for drinking and other human uses and by securing storage and controlled release of water flows. Vegetation cover and forests in the city catchment influences the quantity of available water (for a global overview of cities' relationships with freshwater ecosystem services, see Chap. 3). One of the most widely cited examples of the importance of functioning ecosystems for city water supply is the New York City Watershed. This watershed is one of New York State's most important natural resources, providing approximately 1.3 billion gallons of clean drinking water to roughly nine million people every day. This is the largest unfiltered water supply in the United States (Chichilnisky and Heal 1998). Another example is the Omerli Watershed outside Istanbul, Turkey. The Omerli Watershed is the most important among the seven Mediterranean watersheds that provides drinking water to Istanbul, a megacity with over ten million people. The watershed, however, is threatened by urban development in and around its drinking water sources, and it faces acute, unplanned pressures of urbanization with potentially serious impacts on water quality and biodiversity (Wagner et al. 2007). For a detailed assessment on Istanbul, including further discussion on the Omerli Watershed, see Chap. 16.

11.2.2 *Regulating Services*

11.2.2.1 Urban Temperature Regulation

Ecological infrastructure in cities regulates local temperatures and buffers the effects of urban heat islands (Moreno-Garcia 1994). For example, water areas buffer temperature extremes by absorbing heat in summertime and by releasing it in wintertime (Chaparro and Terradas 2009). Likewise, vegetation reduces temperature in the hottest months through shading and through absorbing heat from the air by

evapotranspiration, particularly when humidity is low (Bolund and Hunhammar 1999; Hardin and Jensen 2007). Water from the plants absorbs heat as it evaporates, thus cooling the air in the process (Nowak and Crane 2000). Trees can also regulate local surface and air temperatures by reflecting solar radiation and shading surfaces, such as streets and sidewalks that would otherwise absorb heat. Decreasing the heat loading of the city is among the most important regulating ecosystem services trees provide to cities (McPhearson 2011).

11.2.2.2 Noise Reduction

Traffic, construction, and other human activities make noise a major pollution problem in cities, affecting health through stress. Urban soil and plants can attenuate noise pollution through absorption, deviation, reflection, and refraction of sound waves (Aylor 1972; Kragh 1981; Fang and Ling 2003). In row plantings of trees, sound waves are reflected and refracted, dispersing the sound energy through the branches and trees. It has also been shown that different plant species mitigate noise differently (see e.g., Ishii 1994; Pathak et al. 2007). Empirical research has found that vegetation factors important for noise reduction include density, width, height and length of the tree belts as well as leaf size and branching characteristics. For example, the wider the vegetation belt, the higher the density, and the more foliage and branches to reduce sound energy, the greater the noise reduction effect (Fang and Ling 2003). Noise reduction is also affected by factors beyond the characteristics of vegetation. For example, climate influences the velocity of sound propagation (Embleton 1963) and noise attenuation increases with distance between the source point and the receiver due to friction between atmospheric molecules when sound progresses (Herrington 1976).

11.2.2.3 Air Purification

Air pollution from transportation, industry, domestic heating, and solid urban waste incineration is a major problem for environmental quality and human health in the urban environment; it leads to increases in respiratory and cardiovascular diseases. Vegetation in urban systems can improve air quality by removing pollutants from the atmosphere, including ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter less than 10 μm (PM10) (Nowak 1994a; Escobedo et al. 2008). While significant differences in performance have been found between plant species (e.g., between deciduous and evergreen species), urban trees have been shown to be especially important in intercepting air pollutants (Aylor et al. 2003). The distribution of different particle size fractions can differ both between and within species and also between leaf surfaces and in waxes (Dzierzanowski et al. 2011). Removal of pollution takes place as trees and shrubs filter out airborne particulates through their leaves (Nowak 1996). Performance of pollution removal also follows daily variation because during the night the plant

stomata are closed and do not absorb pollutants, and monthly variation because of the changes in light hours and because of the shedding of the leaves by deciduous forest during the winter.

11.2.2.4 Moderation of Climate Extremes

Climate change is increasing the frequency and intensity of environmental extremes; this poses increasing adaptation challenges for cities, especially for those located in coastal areas (Meehl and Tebaldi 2004; Zahran et al. 2008). In Europe, heat waves have been the most prominent hazard with regards to human fatalities in the last decade. The European 2003 heat wave, for example, accounted for more than 70,000 excess deaths (EEA 2010). Ecological infrastructure formed by mangroves, deltas and coral reefs can act as natural barriers that buffer cities from extreme climate events and hazards, including storms, heat waves, floods, hurricanes, and tsunamis; this infrastructure can drastically reduce the damage caused to coastal cities (Farber 1987; Danielsen et al. 2005; Kerr and Baird 2007). Vegetation also stabilizes the ground and reduces the likelihood of landslides. Devastating effects caused by events like the Indian Ocean Tsunami in 2004 and Hurricane Katrina in 2005 have led a number of scientists to call for a new vision in risk management and vulnerability reduction in cities, based on wise combinations in the use of built infrastructure (e.g., levees) and ecological infrastructure (e.g., protective role of vegetation) (Danielsen et al. 2005; Depietri et al. 2012).

11.2.2.5 Runoff Mitigation

Increasing the impermeable surface area in cities leads to increased volumes of surface water runoff, and thus increases the vulnerability to water flooding. Vegetation reduces surface runoff following precipitation events by intercepting water through the leaves and stems (Villarreal and Bengtsson 2005). The underlying soil also reduces infiltration rates by acting as a sponge by storing water in the pore spaces until it percolates as through-flow and base-flow. Urban landscapes with 50–90 % impervious cover can lose 40–83 % of rainfall to surface runoff compared to 13 % in forested landscapes (Bonan 2002). Interception of rainfall by tree canopies slows down flooding effects and green areas reduce the pressure on urban drainage systems by percolating water (Bolund and Hunhammar 1999; Pataki et al. 2011). Street trees in New York, for instance, intercept 890 million gallons of stormwater annually (Peper et al. 2007). Other means of reducing urban stormwater runoff include linear features (bioswales), green roofs, and rain gardens (Clausen 2007; Shuster et al. 2008). For example, green roofs can retain 25–100 % of rainfall, depending on rooting depth, roof slope, and the amount of rainfall (Oberndorfer et al. 2007). Also, green roofs may delay the timing of peak runoff, thus lessening the stress on storm-sewer systems. Rain gardens and bioretention filters can also reduce surface runoff (Clausen 2007; Villarreal and Bengtsson 2005; Shuster et al. 2008).

11.2.2.6 Waste Treatment

Ecosystems filter out and decompose organic wastes from urban effluents by storing and recycling waste through dilution, assimilation and chemical re-composition (TEEB 2011). Wetlands and other aquatic systems, for example, filter wastes from human activities; this process reduces the level of nutrients and pollution in urban wastewater (Karathanasis et al. 2003). Likewise, plant communities in urban soils can play an important role in the decomposition of many labile and recalcitrant litter types (Vauramo and Setälä 2010). In urban streams, nutrient retention can be increased by adding coarse woody debris, constructing in-channel gravel beds, and increasing the width of vegetation buffer zones and tree cover (Booth 2005).

11.2.2.7 Pollination, Pest Regulation and Seed Dispersal

Pollination, pest regulation and seed dispersal are important processes in the functional diversity of urban ecosystems and can play a critical role in their long term durability (Andersson et al. 2007). However, pollinators, pest regulators and seed dispersers are threatened by habitat loss and fragmentation due to urban development and expansion. In this context, allotment gardens (called community gardens in North America, i.e. a plot of land made available for individual, non-commercial gardening), private gardens and other urban green spaces have been shown to be important source areas (Ahrné et al. 2009). Also, research in urban ecosystem services shows that a number of formal and informal management practices in allotment gardens, cemeteries and city parks promote functional groups of insects that enhance pollination and bird communities, which in turn enhance seed dispersal (Andersson et al. 2007). To manage these services sustainably over time, a deeper understanding of how they operate and depend on biodiversity is crucial (Nelson et al. 2009). Jansson and Polasky (2010) have developed a method for quantifying the impact of change in pollination potential in the regional urban landscape. Their results indicate that while the impact of urban development on the pollination service can be modest, the erosion of the resilience of the service, measured through change in response diversity, could be potentially high. For discussion on response diversity see Elmqvist et al. (2003).

11.2.2.8 Global Climate Regulation

Because urban areas exhibit multiple artificial surfaces and high levels of fossil fuel combustion, climate change impacts may be exacerbated in cities (Meehl and Tebaldi 2004). Emissions of greenhouse gases in cities include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (NO₂), chlorofluorocarbons (CFCs), and tropospheric ozone (O₃). Urban trees act as a sinks of CO₂ by storing excess carbon as biomass during photosynthesis (Birdsey 1992; Jo and McPherson 1995; McPherson and Simpson 1999). Because the amount of CO₂ stored is proportional to the biomass

of the trees, increasing the number of trees can potentially slow the accumulation of atmospheric carbon in urban areas. Thus an attractive option for climate change mitigation in cities is tree-planting programs. The amount of carbon stored and sequestered by urban vegetation has often been found to be quite substantial, for instance, 6,187 t/year in Barcelona (Chaparro and Terradass 2009) and 16,000 t/year in Philadelphia (Nowak et al. 2007b). Urban soils also act as carbon pools (Nowak and Crane 2000; Pouyat et al. 2006; Churkina et al. 2010). Yet, the amount of carbon a city can offset locally through ecological infrastructure is modest compared to overall city emissions (Pataki et al. 2011).

11.2.3 Cultural Services

11.2.3.1 Recreation

Because city environments may be stressful for inhabitants, the recreational aspects of urban ecosystems are among the highest valued ecosystem service in cities (Kaplan and Kaplan 1989; Bolund and Hunhamar 1999; Chiesura 2004; Konijnendijk et al. 2013). Parks, forests, lakes and rivers provide manifold possibilities for recreation, thereby enhancing human health and well-being (Konijnendijk et al. 2013). For example, a park experience may reduce stress, enhance contemplativeness, rejuvenate the city dweller, and provide a sense of peacefulness and tranquility (Kaplan 1983). The recreational value of parks depends on ecological characteristics such as biological and structural diversity, but also on built infrastructure such as availability of benches and sport facilities. The recreational opportunities of urban ecosystems also vary with social criteria, including accessibility, penetrability, safety, privacy and comfort, as well as with factors that may cause sensory disturbance (i.e., recreational value decreases if green areas are perceived to be ugly, trashy or too loud) (Rall and Haase 2011). Urban ecosystems like community gardens also offer multiple opportunities for decommodified leisure and nowadays represent important remnants of the shrinking urban commons.

11.2.3.2 Aesthetic Benefits

Urban ecosystems play an important role as providers of aesthetic and psychological benefits that enrich human life with meanings and emotions (Kaplan 1983). Aesthetic benefits from urban green spaces have been associated with reduced stress (Ulrich 1981) and with increased physical and mental health (e.g., Maas 2006; van den Berg et al. 2010a). Ulrich (1984) found that a view through a window looking out at greenspaces could accelerate recovery from surgeries, and van den Berg et al. (2010b) found that proximity of an individual's home to green spaces was correlated with fewer stress-related health problems and a higher general health perception. People often choose where to live in cities based in part on the characteristics

of the natural landscapes (Tyrväinen and Miettinen 2000). Several studies have shown an increased value of properties (as measured by hedonic pricing) with greater proximity to green areas (Tyrväinen 1997; Cho et al. 2008; Troy and Grove 2008; Tyrväinen and Miettinen 2000; Jim and Chen 2006).

11.2.3.3 Cognitive Development

Exposure to nature and green space provide multiple opportunities for cognitive development which increases the potential for stewardship of the environment and for a stronger recognition of ecosystem services (Krasny and Tidball 2009; Tidball and Krasny 2010). As an example, urban forests and allotment gardens are often used for environmental education purposes (Groening 1995; Tyrväinen et al. 2005) and facilitate cognitive coupling to seasons and ecological dynamics in technological and urbanized landscapes. Likewise, urban allotments, community gardens, cemeteries and other green spaces have been found to retain important bodies of local ecological knowledge (Barthel et al. 2010), and embed the potential to compensate observed losses of ecological knowledge in wealthier communities (Pilgrim et al. 2008). The benefits of preserving local ecological knowledge have been highlighted in terms of increased resilience and adaptive capacities in urban systems (Buchmann 2009), and the potential to sustain and increase other ecosystem services (Colding et al. 2006; Barthel et al. 2010). For further discussion on how urban landscapes can serve as learning arenas for biodiversity and ecosystem services management, see Chap. 30.

11.2.3.4 Place Values and Social Cohesion

Place values refer to the affectively charged attachments to places (Feldmann 1990; Altman and Low 1992). Research conducted in Stockholm, for example, found sense of place to be a major driver for environmental stewardship, with interviewees showing strong emotional bonds to their plots and the surrounding garden areas (Andersson et al. 2007). Attachment to green spaces in cities can also give rise to other important societal benefits, such as social cohesion, promotion of shared interests, and neighborhood participation (Gotham and Brumley 2002). Examples include studies conducted in Chicago, Illinois, United States, and Chefffield, United Kingdom (Bennett 1997). Environmental authorities in the European Union have emphasized the role of urban green space in providing opportunities for interaction between individuals and groups that promote social cohesion and reduce criminality (European Environmental Agency 2011; Kázmierczak 2013). Likewise, urban ecosystems have been found to play a role in defining identity and sense of community (Chavis and Pretty 1999; Gotham and Brumley 2002). Research on sense of community in the urban environment indicates that an understanding of how communities are formed enable us to design housing that will be better maintained and will provide for better use of surrounding green areas (Newman 1981).

11.2.4 *Habitat Services*

11.2.4.1 *Habitat for Biodiversity*

Urban systems can play a significant role as refuge for many species of birds, amphibians, bees, and butterflies (Melles et al. 2003; Müller et al. 2010). Well-designed green roofs can provide habitat for species affected by urban land-use changes (Oberndorfer et al. 2007; Brenneisen 2003). In cold and rainy areas, golf courses in urban setting can have the potential to contribute to wetland fauna support (Colding and Folke 2009; Colding et al. 2009). Old hardwood deciduous trees in the National City Park of Stockholm, Sweden are seen as an important resource for the whole region for species with high dispersal capacity (Zetterberg 2011). Diversity of species may peak at intermediate levels of urbanization, at which many native and non-native species thrive, but it typically declines as urbanization intensifies (Blair 1996).

A synthesis of the above classification of urban ecosystem services is provided in Table 11.1

11.2.5 *Ecosystem Disservices*

Urban ecosystems not only produce ecosystem services, but also ecosystem disservices, defined as “functions of ecosystems that are perceived as negative for human well-being” (Lyytimäki and Sipilä 2009, p. 311). For example, some common city tree and bush species emit volatile organic compounds (VOCs) such as isoprene, monoterpenes, ethane, propene, butane, acetaldehyde, formaldehyde, acetic acid and formic acid, all of which can indirectly contribute to urban smog and ozone problems through CO and O₃ emissions (Geron et al. 1994; Chaparro and Terradas 2009). Urban biodiversity can also cause damages to physical infrastructures; microbial activity can result in decomposition of wood structures and bird excrements can cause corrosion of stone buildings and statues. The root systems of vegetation often cause substantial damages by breaking up pavements and some animals are often perceived as a nuisance as they dig nesting holes (de Stefano and Deblinger 2005; Lyytimäki and Sipilä 2009).

Green-roof runoff may contain higher concentrations of nutrient pollutants, such as nitrogen and phosphorus, than are present in precipitation inputs (Oberndorfer et al. 2007). Further disservices from urban ecosystems may include health problems from wind-pollinated plants causing allergic reactions (D’Amato 2000), fear from dark green areas that are perceived as unsafe, especially by women at night-time (Bixler and Floyd 1997; Koskela and Pain 2000; Jorgensen and Anthopoulou 2007), diseases transmitted by animals (e.g., migratory birds carrying avian influenza, dogs carrying rabies), and blockage of views by trees (Lyytimäki et al. 2008). Likewise, just as some plants and animals are perceived by people as services, as

Table 11.1 Classification of important ecosystem services in urban areas and underlying ecosystem functions and components

Ecosystem functions	Ecosystem service type	Examples	Key references
Energy conversion into edible plants through photosynthesis	Food supply	Vegetables produced by urban allotments and peri-urban areas	Altieri et al. (1999)
Percolation and regulation of runoff and river discharge	Runoff mitigation	Soil and vegetation percolate water during heavy and/or prolonged precipitation events	Villarreal and Bengtsson (2005)
Photosynthesis, shading, and evapotranspiration	Urban temperature regulation	Trees and other urban vegetation provide shade, create humidity and block wind	Bolund and Hunhammar (1999)
Absorption of sound waves by vegetation and water	Noise reduction	Absorption of sound waves by vegetation barriers, specially thick vegetation	Aylor (1972); Ishii (1994); Kragh (1981)
Dry deposition of gases and particulate matter	Air purification	Absorption of pollutants by urban vegetation in leaves, stems and roots	Escobedo and Nowak (2009); Jim and Chen (2009); Chaparro and Terradas (2009); Escobedo et al. (2011)
Physical barrier and absorption of kinetic energy	Moderation of environmental extremes	Storm, flood, and wave buffering by vegetation barriers; heat absorption during severe heat waves; intact wetland areas buffer river flooding	Danielsen et al. (2005); Costanza et al. (2006b)
Removal or breakdown of xenic nutrients	Waste treatment	Effluent filtering and nutrient fixation by urban wetlands	Vauramo and Setälä (2010)
Carbon sequestration and storage by fixation in photosynthesis	Global climate regulation	Carbon sequestration and storage by the biomass of urban shrubs and trees	Nowak (1994b); McPherson (1998)
Movement of floral gametes by biota	Pollination and seed dispersal	Urban ecosystem provides habitat for birds, insects, and pollinators	Hougnier et al. (2006); Andersson et al. (2007)

(continued)

Table 11.1 (continued)

Ecosystem functions	Ecosystem service type	Examples	Key references
Ecosystems with recreational values	Recreation	Urban green areas provide opportunities for recreation, meditation, and relaxation	Chiesura (2004); Maas et al. (2006)
Human experience of ecosystems	Cognitive development	Allotment gardening as preservation of socio-ecological knowledge	Barthel et al. (2010); Groening (1995); Tyrväinen et al. (2005)
Ecosystems with aesthetic values	Aesthetic benefits	Urban parks in sight from houses	Tyrväinen (1997); Cho et al. (2008); Troy and Grove (2008)
Habitat provision	Habitat for biodiversity	Urban green spaces provide habitat for birds and other animals that people like watching	Blair (1996); Blair and Launer (1997)

Modified from Gómez-Baggethun and Barton (2013) based on a literature review

Note: The suitability of indicators for biophysical measurement is scale dependent. Most indicators and proxies provided here correspond to assessment at the plot level

Table 11.2 Ecosystem disservices in cities (Modified from Gómez-Baggethun and Barton 2013)

Ecosystem functions	Disservice	Examples	Key references
Photosynthesis	Air quality problems	City tree and bush species emit volatile organic compounds (VOCs)	Chaparro and Terradas (2009); Geron et al. (1994)
Tree growth through biomass fixation	View blockage	Blockage of views by trees standing close to buildings	Lyytimäki et al. (2008)
Movement of floral gametes	Allergies	wind-pollinated plants causing allergic reactions	D'Amato (2000)
Aging of vegetation	Accidents	Break up of branches falling in roads and trees	Lyytimäki et al. (2008)
Dense vegetation development	Fear and stress	Dark green areas perceived as unsafe in night-time	Bixler and Floyd (1997)
Biomass fixation in roots; decomposition	Damages to infrastructure	Breaking up of pavements by roots; microbial activity	Lyytimäki and Sipila (2009)
Habitat provision for animal species	Habitat competition with humans	Animals/insects perceived as scary, unpleasant, disgusting	Bixler and Floyd (1997)

Modified from Gómez-Baggethun and Barton (2013)

discussed above, animals such as rats, wasps and mosquitoes, and plants such as stinging nettles, are perceived by many as disservices. A summary of disservices from urban ecosystems is provided in Table 11.2.

11.3 Valuing Urban Ecosystem Services

11.3.1 Ecosystem Services Values

Valuation of ecosystem services involves dealing with multiple, and often conflicting value dimensions (Martinez Alier et al. 1998; Chan et al. 2012; Martín-López et al. 2013). In this section, we broaden the traditional focus of the ecosystem services literature on biophysical measurement and monetary values to explore a range of value domains, including biophysical, monetary, socio-cultural, health, and insurance values, and discuss concepts and methods through which they may be measured and captured.

11.3.1.1 Biophysical Values

Quantifying ecosystem service performance involves the use of biophysical measures and indicators. The difficulty of measuring ecosystem services in biophysical terms increases as the focus shifts from provisioning, to regulating to habitat, to cultural services. Thus, while most provisioning and some regulating ecosystem services can be quantified through direct measures, such as tons of food per hectare per year, or tons of carbon sequestered per hectare per year, in most cases measurement in biophysical terms involves the use of proxies and indicators.

Biophysical measures of ecosystem services are often presented as a prerequisite for sound economic valuations. While this may hold true, biophysical measures themselves often provide powerful information to guide urban planning. Thus, various biophysical indexes of urban green areas have been used for guiding planning procedures in cities (revised in Farrugia et al. 2013). An early attempt was made in Berlin, Germany with the Biotope Area Factor (BAF), which scored land surface types in development sites according to their ecological potential and formulated target BAFs for specific urban functions which developers were obliged to meet in order to obtain approval for any development proposal. Malmö City Council in Sweden adopted a similar system to incorporate green and blue infrastructure in land use planning, while aiming to reduce the extent of impervious surfaces in any development plans (Kruuse 2011). Another attempt to quantify the value of green areas was made in Kent Thameside in the United Kingdom (Defra 2008), which scored ecosystem services such as biodiversity, recreation and flood regulation using surrogates. The Southampton City Council in the United Kingdom developed a version of the Green Space Factor (GSF) tool to evaluate the contribution of green areas to water regulation flood control (Finlay 2010).

A summary with examples of indicators and proxies to measure ecosystem services and disservices is provided in Table 11.3.

11.3.1.2 Economic Values

Conventional economic valuations are restricted to priced goods and services, which represent only a limited subset of ecosystem services (i.e., those which are exchanged in markets). As price formation is conditioned to the existence of supply and demand relations, every change in human well-being lacking a market is invisible to conventional economic accounts. The economic literature refers to these effects as environmental externalities, which can be either negative (e.g., pollution) or positive (e.g., ecosystem services). The public good nature of most ecosystem services implies that their economic value is often not adequately reflected in management decisions that are mainly based on economic information (e.g., cost-benefit analysis). Consequently, it is argued, ecosystem services with no explicit economic value tend to be depleted.

Table 11.3 Examples of indicators and proxies for measuring urban ecosystem services and disservices in biophysical terms

Ecosystem services	Examples of biophysical indicators and proxies
<i>Provisioning services</i>	
Food supply	Production of food (t/year)
Freshwater supply	Water flow (m ³ /year)
<i>Regulating services</i>	
Water flow regulation and runoff mitigation	Soil infiltration capacity; % sealed relative to permeable surface (ha)
Urban temperature regulation	Leaf Area Index
Noise reduction	Leaf area (m ²) and distance to roads (m); noise reduction [dB(A)]/vegetation unit (m)
Air purification	O ₃ , SO ₂ , NO ₂ , CO, and PM ₁₀ µm pollutant flux (g/cm ² /s) multiplied by tree cover (m ²)
Moderation of environmental extremes	Cover density of vegetation barriers separating built areas from the sea
Waste treatment	P, K, Mg and Ca in mg/kg compared to given soil and water quality standards
Climate regulation	CO ₂ sequestration by trees (carbon multiplied by 3.67 to convert to CO ₂)
Pollination and seed dispersal	Species diversity and abundance of birds and bumble bees
<i>Cultural services</i>	
Recreation and health	Area of green public spaces (ha)/inhabitant (or every 1,000 inhabitants); self-reported general health
Cognitive development and knowledge preservation	Participation, reification, and external sources of social-ecological memory
<i>Habitat for biodiversity</i>	
Habitat for biodiversity	Abundance of birds, butterflies and other animals valued for their aesthetic attributes
<i>Ecosystem disservices</i>	
<i>Examples of indicators proxies</i>	
Air quality problems	Emission of VOCs (t/year)/vegetation unit
View blockage	Tall trees close to buildings
Allergies	Allergenicity (e.g., OPALS ranking)
Accidents	Number of aged trees
Fear and stress	Area of non-illuminated parks
Damages on infrastructure	Affected pavement (m ²) wood (m ³)
Habitat competition with humans	Abundance of insects, rats, etc.

Modified from Gómez-Baggethun and Barton (2013), based on various sources

Because biodiversity loss generally involves long-term economic costs that are not adequately reflected in conventional economic accounts (Boyer and Polasky 2004; Tyrväinen et al. 2005; TEEB 2010; EEA 2011; Escobedo et al. 2011; Elmqvist et al. [forthcoming](#)) economic valuation of ecosystem services attempts to make visible the ‘hidden’ economic costs from the conversion of ecological infrastructure to built infrastructure (or from natural capital to human-made capital). These may include sanitary costs related to health damages from air pollution (Escobedo et al. 2008, 2011; Escobedo and Nowak 2009) and costs from increased property damages with loss of natural barriers to climate extremes (Costanza et al. 2006a).

Over the last few decades, a range of methods have been developed to calculate economic costs resulting from loss of ecological infrastructure. Avoided cost methods, for example, show that loss of urban vegetation can lead to increased energy costs in cooling during the summer season (McPherson et al. 1997; Chaparro and Terradas 2009). Likewise, decline of water regulation services from land-use change and loss of vegetation in the city catchments increase the dependence on water purification technologies, which are generally very costly (Daily and Ellison 2003). Economic costs may also derive the loss of ecosystem services such as air purification (McPherson et al. 1997; Nowak and Crane 2002), noise reduction by vegetation walls (Bolund and Hunhammar 1999), carbon sequestration by urban vegetation (McPherson et al. 1999; Jim and Chen 2009), buffering of climate extremes by natural barriers (Costanza et al. 2006a), and regulation of water flows (Xiao et al. 1998). These costs are not merely hypothetical. In most cases they are real economic costs derived from the partial substitution of ecological infrastructure and ecosystem services by built infrastructure and different economic services. Table 11.4 shows examples of quantitative measures of economic values directly or indirectly attached to ecosystems services in the urban context.

When pollutants are not specified, calculations include NO₂, SO₂, PM₁₀, O₃ and CO). Results from Jim and Chen (2009) converted from RMB to \$US after Elmqvist et al. forthcoming. Not all figures were normalized to net present values and therefore they should be taken as illustration only.

Using combinations of valuation methods is often necessary to address multiple ecosystem services (Boyer and Polasky 2004; Costanza et al. 2006b; Escobedo et al. 2011). The choice of valuation methods is determined by factors including the scale and resolution of the policy to be evaluated, the constituencies that can be contacted to obtain data, and supporting data constraints, all subject to a study budget (Table 11.5).

Avoided expenditure or replacement cost methods are often used to address values of regulating services such as air pollution mitigation and climate regulation (Sander et al. 2010). Meta-analyses on economic valuations of ecosystem services show that hedonic pricing (HP) and stated preference (SP) methods (and contingent valuation in particular), have been the methods most frequently used in urban contexts (Boyer and Polasky 2004; Tyrväinen et al. 2005; Costanza et al. 2006b; Kroll and Cray 2010; Sander et al. 2010; Brander and Koetse 2011). Economic valuation using hedonic pricing has often been used to capture recreational and amenity benefits (Tyrväinen and Miettinen 2000), views and aesthetic benefits (Anderson and Cordell 1985; Sander et al. 2010), noise reduction (Kim et al. 2007), air quality (Smith and Huang 1995; Bible et al. 2002; Chattopadhyay 1999), and water quality (Leggett and Bockstael 2000). A review by Kroll and Cray (2010) shows that hedonic pricing methods have been used mainly to value property features at neighborhood scales, especially in relation to open space, vegetation, and wetlands (Table 11.6).

Table 11.7 suggests potential valuation methods that can inform urban planning issues at different scales.

Table 11.4 Examples of economic valuations of five urban ecosystem services. Examples from empirical studies conducted in Europe, USA, and China

Ecosystem service	City	Ecological infrastructure	Biophysical accounts	Economic valuation	Reference
Air purification	Barcelona, Spain	Urban forest	305.6 t/y	€1,115,908	Chaparro and Terradas (2009)
	Chicago, USA	Urban trees	5,500 t/y	US\$ 9 million	McPherson et al. (1997)
	Washington, USA	Urban trees	540 t/y	–	Nowak and Crane (2000)
			0.12 t/ha/y		
	Modesto, USA	Urban forest	154 t/y	US\$ 1.48 million	McPherson et al. (1999)
			3.7 lb/tree	US\$ 16/tree	
Microclimate regulation	Sacramento, USA	Urban forest	189 t/y	US\$ 28.7 million	Scott et al. (1998)
				US\$ 1,500/ha	
	Lanzhou, China	Urban plants	28,890 t pm/y	US\$ 102	Jim and Chen 2009
			0.17 t pm/ha/y	US\$ 6.3/ha	
			1.8 million t SO ₂ /y	–	
			10.9 t SO ₂ /ha/y		
	Beijing, China	Urban forest	2,192 t SO ₂ /y	US\$ 4.7 million	Jim and Chen (2009)
			1,518 t pm/y	US\$ 283/ha	Elmqvist et al. (Forthcoming)
			2,192 t SO ₂ /y		
			(132 t SO ₂ /ha/y)		
	Chicago	City trees	Saved heating 2.1 GJ/tree	US\$ 10/tree	McPherson et al. (1997)
			Saved cooling 0.48 GJ/tree	US\$ 15/tree	McPherson (1992)
	Modesto, USA	Street and park trees	Saved 110,133 Mbtu/y	US\$ 870,000	McPherson et al. (1999)
				US\$ 10/tree	
	Sacramento, USA	Urban vegetation	Saved 9.8 MW/ha/y	US\$ 1,774/ha/y	Simpson (1998)
	Beijing, China	Urban forest	1.4kWH/ha/day	US\$ 12.3 million	Jim and Chen (2009)
				US\$ 1,352/ha/y	

(continued)

Table 11.4 (continued)

Ecosystem service	City	Ecological infrastructure	Biophysical accounts	Economic valuation	Reference
Carbon sequestration	Barcelona, Spain	Urban forest	113,437 t (gross)		Chaparro and Terradas (2009)
			5,422 t (net)		
	Modesto, USA	Urban forest	13,900 t or 336 lb/tree	US\$ 460,000 or US\$ 5/tree	McPherson et al. (1999)
	Washington DC, USA	Urban forest	16,200 t	US\$ 299,000/y	Elmqvist et al. (Forthcoming)
			3,500 t/ha/y	US\$ 653/ha/y	
	Philadelphia, USA	Urban forest	530,000 t (gross)	US\$ 9.8 million (gross)	Nowak et al. (2007b)
Regulation of water flows			96 t/ha	US\$ 297,000 (net)	
			16,100 t (net)		
			2.9 t/ha/y		
	Beijing, China	Urban forest	4, 200,000 t	US\$ 20,827/ha/y	Jim and Chen (2009)
			256 t/ha/y		
	Modesto, USA	Urban forest	Reduced runoff 292,000 m ³	US\$ 616,000	McPherson et al. (1999)
Aesthetic information			or 845 gal/tree	or US\$ 7/tree	
	Sacramento	Urban trees	Annual rainfall reduced by 10 %	US\$ 572/ha	Xiao et al. (1998)
			88,235 trees		
	Modesto, USA	Urban forest		US\$ 1.5 million	McPherson et al. (1999)
				US\$ 17/tree	
	Guangzhou, China	Urban green space	7,360 ha	US\$ 17,822/ha/y	Jim and Chen (2009)

Modified from Gómez-Baggethun and Barton (2013)

Legend: *PM* particulate matter, *t* ton, *y* year, *lb* pound, *ha* hectare, *GJ* gigajoule, *Mbtu* million British Thermal Units, *MW* megawatt, *m*³ meters cubed, *gal* gallon, *kWh* kilowatt hours

Table 11.5 Economic valuation of ecosystem services in urban planning

Scale	Urban planning issue	Role of economic valuation	Methodological challenges
Region	Prioritizing urban growth alternatives between different areas	Valuing benefits and costs of (i) urban revitalization (ii) urban infill (iii) urban extension (iv) suburban retrofit (v) suburban extension (vi) new neighborhoods with (vii) existing infrastructure (ix) new infrastructure (x) in environmentally sensitive areas	Comprehensive benefit-cost analysis at multiple scales and resolutions at multiple locations is expensive
	Fair and rational location of undesirable land uses (LULUs)	Value of the impacts and disservices of e.g., power plants and landfills and foregone ecosystem service values of ecological infrastructure	Using benefit-cost analysis to allocate infrastructure with local costs versus regional benefits may not achieve fair outcomes
	Preservation of productive peri-urban farm belt	Willingness to pay for preservation of open space and 'short distance' food	Large import substitution possibilities for locally produced food
	Water availability to support urban growth	Valuation to support full cost pricing of water supply. Incentive effects of removing water subsidies	Can require inter-regional geographical scope of valuation
	Using transferable development rights (TDR) to concentrate growth and achieve zoning	Determine farmer opportunity costs and benefits of foregoing urban development as a basis for predicting the size of a TDR market	
	Preserving views, open spaces, and parks in neighborhoods	Willingness to pay of households for quality and proximity of recreational spaces	Accounting for substitute sites and recreational activities
	Conserving soil drainage conditions and wetlands	Valuation of replacement costs of man-made drainage and storage infrastructure	Hydrological and hydraulic modeling required
	Conserving water	Costs of household water harvesting, recycling and xeriscapes	Cost-benefit evaluation requires comparison with full costs of water supply
	Natural corridors	Quantify opportunity costs of preserving corridors	Difficulty in specifying habitat connectivity requirements of corridors
	Local farm produce Edible gardens	Willingness to pay for local, fresh produce Recreational value of home gardens	Large import substitution possibilities for locally produced food

(continued)

Table 11.5 (continued)

Scale	Urban planning issue	Role of economic valuation	Methodological challenges
Street-scape	Street trees	Value pedestrian safety through slowing traffic; disamenities of heat islands; absorption of stormwater, and airborne pollutants	Associating ecosystem service values at neighborhood and street level to individual trees
	Green pavements for stormwater management	Willingness to pay of households for green streetscape; additional costs of larger dimension storm-water	
Building	Green rooftops	Additional costs of traditional stormwater management; mitigation of heat island	Associating ecosystem service values at neighborhood and street level to individual roofs, trees and lawns
	Yard trees		
	Lawns vs. xeriscapes		

Produced by Barton et al. (2012), based on a listing by Duany et al. (2010)

Table 11.6 Overview of hedonic pricing studies in cities

Scale	Property feature	# of studies
National/regional	Policies affecting property rights	5
Regional/neighborhood	Open space	28
	Water & wetlands	24
Neighborhood/streetscape	Open space vegetation & trees	20
Streetscape	Pavement type	7
Streetscape/property	Climate & temperature	5
Building	Energy efficiency	7

Produced by Barton et al. (2012), adapted from Kroll and Cray (2010)

11.3.1.3 Social and Cultural Values

People bring various material, moral, spiritual, aesthetic, and other values to bear on the urban environment; their values can affect their attitudes and actions toward ecosystems and the services they provide. These include emotional, affective and symbolic views attached to urban nature that in most cases cannot be adequately captured by commodity metaphors and monetary metrics (Norton and Hannon 1997; Martinez Alier et al. 1998; Gómez-Baggethun and Ruiz-Pérez 2011; Daniel et al. 2012). Here, we refer to these values broadly as social and cultural values. The ecosystem services literature has defined cultural values as “aesthetic, artistic, educational, spiritual and/or scientific values of ecosystems” (Costanza et al. 1997, p. 254) or as “non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience” (Millennium Ecosystem Assessment 2005, p. 894).

Social and cultural values are included in all prominent ecosystem service typologies (Daily et al. 1997; de Groot et al. 2002; Millennium Ecosystem Assessment 2005). Yet, compared with economic and biophysical values, social, cultural, and other non-material values of ecosystems and biodiversity have generally been neglected in much of the ecosystem services literature. Moreover, social and cultural values may be difficult to measure, often necessitating the use of more holistic approaches and methods that may include qualitative measures, constructed scales, and narration (Patton 2001; Chan et al. 2012). In some cases, tools have been developed to measure these values using constructed scales, as in the case of sense of place (Williams and Roggenbuck 1989; Shamai 1991) and local ecological knowledge (Gómez-Baggethun et al. 2010a). In other cases translating cultural values into quantitative metrics may be too difficult or produce results that are nonsensical or meaningless.

Recent research has made substantial progress in the quest to better integrate social perspectives and valuation techniques into the ecosystem services framework, and to enable a fuller representation of socio-cultural values in research and practice (e.g., Chan et al. 2012). Articulation of social and cultural values in decision-making processes may require, in most cases, some sort of deliberative

Table 11.7 Potential valuation methods for urban ecosystem service valuation

Valuation method	Types of value, ecosystem services		Scale	Constituencies	Constraints
	Use values (option value)	Cultural services (amenities)			
Hedonic pricing (Revealed Preferences)			Building, streetscape and neighborhood characteristics	Home and property owners	Observable quality variables. Spatially explicit Autocorrelation and latent variables
Travel cost (Revealed Preferences)	Use values		Regional park/recreational destinations	Recreational visitors	No/low travel costs to neighborhood open spaces. Spatially explicit.
Contingent valuation (Stated Preferences)	Cultural services (amenities) Use and non-use values All ecosystem services, but often amenities Service bundles		All infrastructure scales, easier for location specific policy scenario	Households or individuals, often as voters	Locational self-selection. Hypothetical, question framing issues, information burden Usually not spatially explicit
Choice experiments (Stated Preferences)	Use and non-use values All ecosystem services, but often amenities. Incremental service levels, controlling for bundles		All infrastructure scales, but easier for location specific policy choice alternatives	Households or individuals, often as consumers	Hypothetical, question framing issues, Information burden Usually not spatially explicit
Production	Use values		Neighborhood and regional scale	Natural scientists, experts	Requires spatially explicit biophysical modeling.
Function/Damage cost Replacement cost	Regulating services Use values All services, but often regulating services		Building, streetscape, neighborhood level municipal infrastructure	Engineers, experts	Determining service equivalence for man-made replacement; depends on health and safety standards

Produced by Barton et al. (2012)

Table 11.8 Socio-cultural values of ecosystems and biodiversity

Socio-cultural values	Explanation	References
Spiritual values	In many places, especially among peoples with animistic religions, ecosystems and biodiversity are deeply intertwined with spiritual values	Stokols (1990)
Sense of place	Emotional and affective bonds between people and ecological sites	Altman and Low (1992), Feldman (1990), Williams et al. (1992), Norton and Hannon (1997)
Sense of community	Feelings towards a group and strength of attachment to communities	Doolittle and McDonald (1978), Chavis and Pretty (1999)
Social cohesion	Attachment as source of social cohesion, shared interests, and neighborhood participation	Bennett (1997), Gotham and Brumley (2002), Kázmierczak (2013)

Produced by Gómez-Baggethun (2013)

process, use of locally defined metrics, and valuation methods based on qualitative description and narration. A set of values that may be labeled as socio-cultural and associated descriptions is provided in Table 11.8.

11.3.1.4 Health Values

Multiple connections between urban vegetation and human health have been identified (Tzoulas et al. 2007; Bowler et al. 2010a), and the study of the links between green areas, human health and recovery rates is a rapidly expanding field of research (Grahn and Stigsdotter 2003). For example, access to green space in cities was shown to correlate with longevity (Takano et al. 2002), with recovery from surgeries (Ulrich 1984) as well as with self-reported perception of health (Maas 2006; van den Berg et al. 2010a). Proximity to green space reduced stress in individuals (Korpela and Ylén 2007), and children with attention deficit disorder have showed improved alertness (Taylor and Kuo 2009). Evidence also exists of other health benefits that correspond to green space availability (Hu et al. 2008; Bedimo-Rung et al. 2005; Ohta et al. 2007). Kaczynski and Henderson (2007) reviewed 50 quantitative studies that looked at the relationship between parks and physical activity and found that proximity to parks was associated with increased physical activity.

Green spaces have also been shown to influence social cohesion by providing a meeting place for users to develop and maintain neighborhood ties (Maas et al. 2009; Kázmierczak 2013). Other studies suggest that urban ecosystem services like air pollution reduction (Lovasi et al. 2008; Pérez et al. 2009) and urban cooling (Bowler et al. 2010b) have multiple long term health benefits. However, although the evidence of most studies suggests that green spaces have beneficial health effects, it should be noted that establishing a causal relationship has proven very difficult (Lee and Maheswaran 2010).

11.3.1.5 Environmental Justice Values

Social practices not only affect which ecosystem services are produced through the management of urban ecosystems (Andersson et al. 2007), but also who in society benefits from them (Ernstson 2012). Urban political ecology is the study of ecological distribution conflicts (i.e., conflicts on the access to ecosystem services and on the burdens of pollution). Environmental justice (Hofrichter 1993) represents the perspective within political ecology that conceives of balanced access to ecosystem services and balanced exposure to pollution across groups as a fundamental right. The notion was first used in relation to environmental conflicts in cities of the United States, where minority groups including African Americans, Latinos, and Native Americans bore disproportionate burdens of urban pollution and exposure to toxic waste (Martínez Alier 2005). While the bulk of the literature has focused on unequal exposure to pollution, the study of environmental conflicts related to unequal access to the benefits of ecosystem services are likely to become an important field of research for political ecology in the coming years. A recent study by Ernstson (2012) draws on empirical studies from Stockholm, Cape Town, and other cities to inform a framework to relate ecosystem services to environmental justice in urban areas.

Ecological distribution conflicts not only emerge from unequal access to ecosystem services within cities but also from asymmetries in the appropriation of ecosystem services by cities vis-à-vis their surrounding environment and more distant regions (Hornborg 1998). Extensive research has shown that urban growth depends on the appropriation of vast areas of ecosystem services provision beyond the city boundaries (Folke et al. 1997; Rees 1992; Rees and Wackernagel 1996). Thus, an important associated value of urban ecosystem services resides in their potential to reduce the ecological footprint of cities, and thus, cities' ecological debt to the non-urban environment. Building on the ecosystem services concept, Gutman (2007) calls for a new rural–urban compact, where cities channel more employment opportunities and more income to the rural areas in exchange for a sustainable supply of products and ecosystem services provided by restored rural environments.

11.3.1.6 Insurance Values

Urban ecological infrastructure and ecosystem services can play a major role in increasing the resilience of cities through enhancing their ability to cope with disturbance and adapt to climate and other global change. The contribution of ecological infrastructure and ecosystem services to increased resilience and reduced vulnerability of cities to shocks has been referred to as a form of insurance value (Gómez-Baggethun and de Groot 2010). Ecosystem services that are critical to the resilience of cities in response to specific disturbances include urban temperature regulation, water supply, runoff mitigation, and food production. For example, urban temperature regulation can be critical to buffer the effects of heat waves

Table 11.9 Sources of resilience and carriers of social-ecological memory to deal with disturbance and change in urban allotments

Category	Examples found in allotment gardens
Habits/rituals (<i>participation</i>)	Imitation of practices, exchange of seeds, embodied habits
Oral tradition (<i>participation</i>)	Ongoing negotiations, mentor programs, daily small talk
Rules-in-use (<i>reification</i>)	Norms of social conduct, norms towards the environment, property rights
Physical forms/artifacts (<i>reification</i>)	Written material, pictures, the gardens, tools, stories
External memory sources	Media and organizations external to individual allotment gardens

Produced by Jansson (2012), modified from Barthel et al. (2010)

(Laforteza et al. 2009; EEA 2010; Depietri et al. 2012), ecological infrastructure that enhances water supply can increase resilience to drought, and runoff mitigation provided by urban vegetation can reduce the likelihood of damages by flooding and storms (Villarreal and Bengtsson 2005).

Special attention has been given to the role that food production in urban allotments can play in increasing food security and building resilience to shocks, especially in times of economic and political crisis (Smit and Nasr 1992; Moskow 1999; Page 2002; MA 2005; UNEP 1996). The Millennium Ecosystem Assessment notes that “for many of today’s urban dwellers, urban agriculture provides an important source of food and supplementary income” (MA 2005, p. 810). In Cuba, urban agriculture that emerged in response to the decline of Soviet aid and trade and the persistence of the trade embargo came to play a major role in food security (Altieri et al. 1999; Moskow 1999). Likewise, urban agriculture has provided an important safety net for landless peoples in sub-Saharan Africa (Maxwell 1999). At present, urban social movements associated with allotments gardens are emerging all around Europe (Barthel et al. 2010). Table 11.9 provides examples of how urban allotments can contribute to increasing resilience and storing social-ecological memory to deal with shocks.

Recent contributions have also noted the role of urban ecosystems in maintaining living bodies of local ecological knowledge (Andersson et al. 2007). Because local and traditional knowledge systems embed accumulated knowledge and practices to cope with environmental change, maintaining these bodies of knowledge can be essential for resilience to shocks (Barthel et al. 2010; Gómez-Baggethun et al. 2012).

Measuring the insurance value of resilience remains a challenging task. For example, there is growing evidence that increased resilience can bring multiple indirect economic benefits (Walker et al. 2010). Yet, translating the value of resilience into monetary metrics can be complicated and in some cases also useless. Because the economic value of ecosystem services is affected by the distance to ecological thresholds, trying to capture the value of resilience with economic valuation at the margin can be risky and even misleading (Limburg et al. 2002);

when thresholds are close, small changes can trigger abrupt shifts in ecosystem services and related values (Scheffer et al. 2001; Walker and Meyers 2004; Pascual et al. 2010).

11.4 Ecosystem Services and Urban Governance

11.4.1 Connecting Ecosystem Service Values to Urban Policy and Governance

Local authorities in many cities throughout the world are looking for innovative ways to maintain and increase ecological infrastructure as a part of urban planning and design (Rosenzweig et al. 2009; see also Chap. 27). Yet, many studies have suggested that the ability of local authorities to implement ecological infrastructure is not sufficiently recognized and hence lacks further integration into spatial planning systems (Kruuse 2011). Economic and non-economic valuation of ecosystem services is often demanded by policy makers and practitioners as supporting information to guide decisions in urban planning and governance. Ways in which valuation can inform urban planning include awareness raising, economic accounting, priority-setting, incentive design, and litigation, thus broadly reflecting the objectives of “recognizing, demonstrating, and capturing value” as suggested in the TEEB report (TEEB 2010) (Fig. 11.2).

The demand for accuracy and reliability of valuation methods increase successively when moving from a policy setting, requiring simply awareness raising (e.g. regarding costs of ecosystem service loss); to including ecological infrastructure in accounting of municipal assets; to priority-setting (e.g. for location of new neighborhoods); to instrument design (e.g. user fees to finance public utilities); or finally to calculation of claims for damage compensation in a litigation (e.g. siting of locally undesirable land-uses (LULUs)). While several monetary valuation methods are potentially applicable at different spatial scales, valuation studies in urban areas for support in any given decision-making context are more demanding because of requirements for higher spatial resolution and multiple scales of analysis. Using valuation of urban ecosystem services for decisions about ecological infrastructure requires attributing service values to the particular assets at specific locations. For regulating services this requires some form of spatially explicit biophysical modeling which increases valuation costs with increasing geographical scale and resolution (Fig. 11.2).

11.4.2 Ecosystem Services in Urban Planning and Design

A better understanding of ecosystem services, their spatial characteristics and inter-relations is very much needed in order to move ecosystem services from an

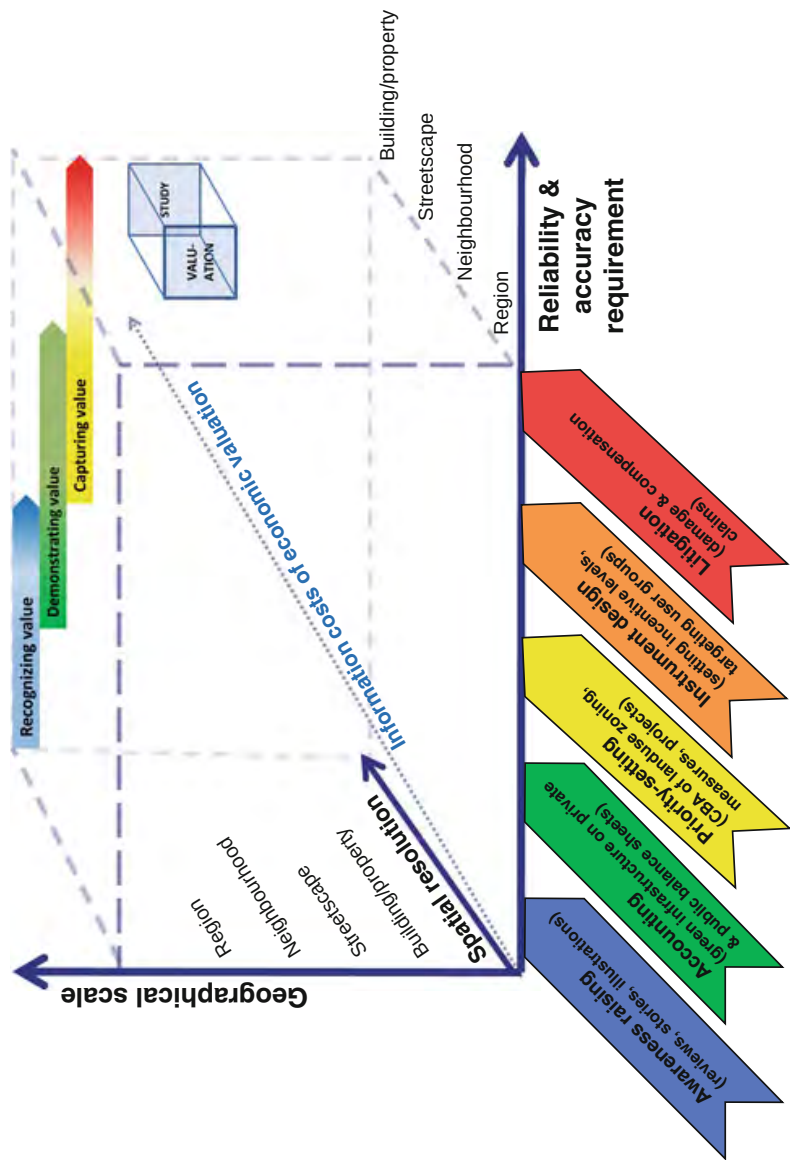


Fig. 11.2 Trade-offs between scale, resolution, and accuracy in recognizing, demonstrating and capturing values in different decision-support contexts of valuation (Source: Adapted from Gómez and Baggethun 2012; Modified from Gómez-Baggethun and Barton 2013, p. 241. Published with kind permission of © Elsevier 2012. All Rights Reserved)

assessment tool to a practical instrument for planning and design (Troy and Wilson 2006). For a discussion of patterns and trends in urban biodiversity and design, with applications to ecosystem services, see Chap. 10. Ecosystem service research is slowly merging with landscape ecology and spatial planning to address the issue of the scales and structures related to the generation and utilization of ecosystem services (see e.g., Fisher et al. 2009). There are several possible spatial relationships between the scale at which one ecosystem service is generated and the scale at which people may benefit from it. Some services can only be enjoyed at the source (e.g., shading from vegetation or many recreational uses of green areas), whereas others spill over into adjacent areas (e.g., noise reduction, wind breaks and pollination). Such spill-over may be unidirectional or directional, the latter partly due to physical geography (e.g., of waterways, topography, and location of roads) and the location of the beneficiaries. The connection between ecosystem service source areas and end-users is mediated by social structures such as built infrastructure and institutions defining access to land. There are a wide range of solutions for providing the people in different cities with similar ecosystem services and city-specific scales of relevance for addressing each ecosystem service.

Spatial scales and landscape structure affect the possibilities and constraints for ecosystem service planning. Efforts to address bundles of services to create or maintain multifunctional landscapes have seen considerable progress in the last decade. On larger scales, access to multiple ecosystem services can be achieved by ensuring generation of different ecosystem services in different parts of the landscape—as long as they are accessible to the users (see Brandt and Vejre 2003). However, the scale in these studies is often coarse and is not well suited to pick up the small-scale heterogeneity of the urban landscape. When the potential service-providing areas are few and situated in a matrix of many and diverse users, the number of services expected from each of these areas is likely to increase. Multiple interests coupled with limited size will highlight trade-offs between services and potentially lead to conflicts.

The urban mosaic is often complex and characterized by multiple spatial boundaries between different land-uses. With such heterogeneity, relative location and context can be expected to be especially important. Some ecosystem services will rely on species that require easy access to two or more habitat types (Andersson et al. 2007). For example, Lundberg et al. (2008) described how long-term maintenance of an oak dominated landscape with highly valued cultural and aesthetical qualities in Sweden depends also on patches of coniferous forest, the latter providing the main seed disperser, Eurasian Jay (*Garrulus glandarius*), with breeding habitat. Other ecosystem services such as pest control or pollination rely on close proximity to a source area (e.g. Blitzer et al. 2012).

Many ecosystem services are directly mediated or provided by different organisms (Kremen 2005) and can thus be addressed through a focus on these organisms. From a temporal perspective, long-term provisioning of ecosystem services within cities raises concerns about population dynamics, including the risks of extinction (at least on the local scale) and potential for re-colonization. For many species, habitat within cities may be perceived as quite fragmented, suggesting

not only that future urban development should try to avoid further fragmentation but also that increased connectivity should be one of the prime objectives for restoration efforts (Hanski and Mononen 2011). It seems reasonable that the general character of urban green structures should be as similar as possible to that of the hinterlands in order to benefit the most from potential near-city source areas of ecosystem-service-providing organisms. To draw on these source areas, cities need a connected green structure that reaches all the way through urban and peri-urban areas into the rural.

From a spatial perspective, at least two distinct strategies for ensuring ecosystem service generation can be identified (see Forman 1995). The first draws on traditional conservation planning and is foremost concerned with enhancing and securing internal values within a bounded area, for example biodiversity or recreational opportunities within a protected area. This approach advocates large areas, and if spatial issues are considered at all it is usually in terms of green area networks where “green areas” are not necessarily the same as ecosystem service generating areas. The second strategy adopts more of a landscape management perspective in which the focus is on enhancing the performance of all parts of the landscape (see Fahrig et al. 2011), not just the few large areas suggested in the first approach. Instead, this perspective highlights the potential of smaller units interspersed throughout an area (for example, small clumps of trees mixed with residential development may enhance overall biodiversity or aesthetic values). The two approaches are by no means incompatible or always opposing, but their focus, prioritizations, and trade-offs differ. Both are needed and address different aspects of ecosystem services.

11.5 Ecosystem Services in Three Cities

Since appropriate management strategies for ecosystems outside and within cities may differ due to, for example, the difference in social, ecological and economic pressures, it is essential to acquire a fairly detailed outline of a city’s ecosystem service needs, both within and outside the city boundaries. The information on where different ecosystem services are being produced (i.e., the location of the production unit), whether inside the city itself or elsewhere, is also significant in determining how vulnerable or resilient a city and its inhabitants are to potential disruptions in the generation of ecosystem services when exposed to change. Assessing restoration/transformation potential in the urban landscape is important for mitigating disruptions in service generation and can be a powerful tool for urban planning. Furthermore, since the generation of ecosystem services in a specific ecosystem often affects the generation potential in other ecosystems, it is also crucial to identify spill-over effects. In the following tables a review of ecosystem services for three different cities are presented: Cape Town, New York, and Barcelona (in-depth assessments on Cape Town and New York are presented in Chaps. 24 and 19, respectively).

11.5.1 *Cape Town*

The city of Cape Town is home to approximately 3.7 million people. It is characterized by apartheid city planning with racially distinct urban residential areas and a massive disparity in development between these areas. Key socio-economic challenges within the city include the provision of housing, education, transport infrastructure, nutrition and healthcare. Current development strategies acknowledge these issues and also recognize that population growth and migration to this city will increase the magnitude of these challenges.

The Cape Floristic region in which Cape Town is located is a globally recognized biodiversity hotspot. The city is home to 19 of the 440 national vegetation types, and hosts 52 % of the nationally critically endangered vegetation types (Rebello et al. 2011). Cape Town is also a major tourism destination in Africa, a function of the heterogeneous natural environment, which provides multiple other ecosystem services. The Table Mountain National Park, which is surrounded by the city, is a key conservation area for retaining both the biodiversity as well as the ecosystem services that support local residents (Anderson and O'Farrell 2012). The lowland areas within the City area are not well protected and are under extreme and constant pressure of transformation, particularly for much-needed housing (see Chap. 24). In a recent assessment of the ecosystem services found within Cape Town, O'Farrell et al. (2012) examined the effect of transformation on a number of services by contrasting historical landscape structure (500 years prior) with current conditions, and in addition explored potential future transformation effects (using a scenario where all undeveloped land not under formal conservation protection was transformed to formal housing) (Fig. 11.3). Their study indicated that all services had decreased from their potential level; provisioning services were particularly affected, with reductions between 30 and 50 % depending on the service. The study highlights the significance of the loss of regulating services, which while less threatened than other services in the study, are potentially more problematic when lost, as these services must be delivered in situ. Whereas provisioning services can be outsourced to areas beyond the city boundaries (such as the provision of food), this is not possible with most regulating services (such as flood mitigation and coastal zone protection) (see Table 11.10).

Recognized important ecosystem services to the City of Cape Town are the provision of water supply, flood mitigation, coastal zone protection and tourism (see Table 11.10). Many of these services, and the biodiversity and ecological infrastructure on which they depend, have been degraded. There are a number of examples where there are programs and projects in place aimed at attempting to restore these and thereby enhance ecosystem service benefits.

Invasive alien plants have become a dominant feature in the catchments that supply Cape Town with water. These plants use significantly more water than the indigenous vegetation, and thereby decrease surface run-off and ultimately water supply and security (Le Maitre et al. 1996). The Working for Water program was established in 1995 as a direct response to the loss of this critical resource

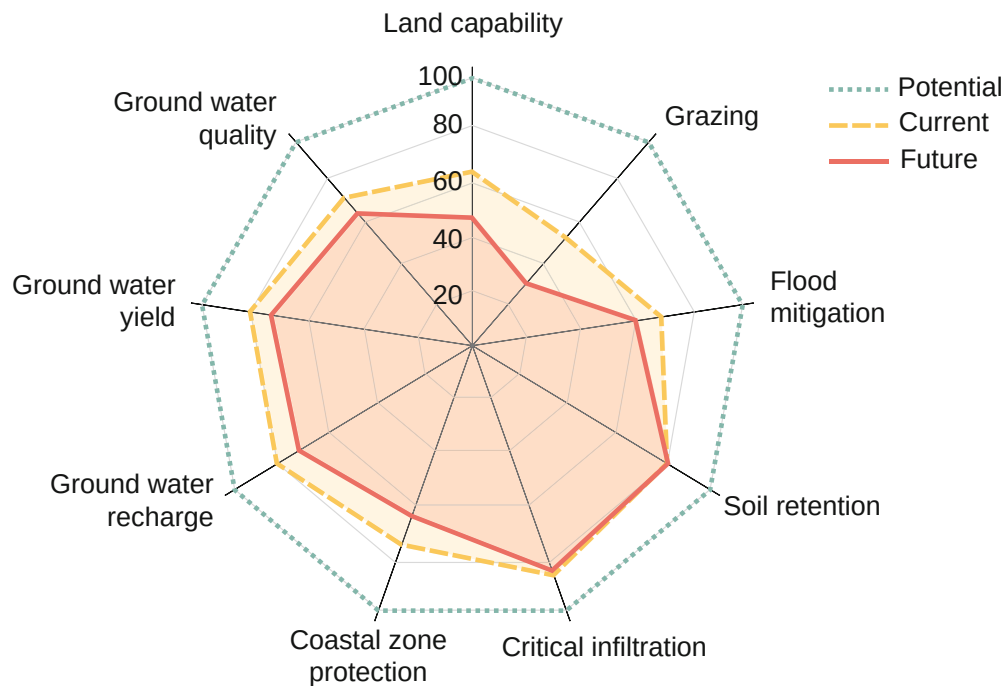


Fig. 11.3 Present and potential changes in ecosystem service supply for Cape Town shown as a percentage of the potential service produced (Modified from O'Farrell et al. 2012, p. 6. Published with kind permission of © Ecology and Society 2012. All Rights Reserved)

(Van Wilgen et al. 1998) (see Chap. 24). Clearing teams are continuing to remove invasive plants from these catchments in an attempt to restore optimal water flows, which are critical to the growth and development of the city.

Within this restoration space, interventions are emerging at many tiers of society. Smaller initiatives driven by local communities or smaller government agencies aimed at restoring natural vegetation have been shown to have considerable ecosystem service benefit (Avlonitis 2011). While these often emerge in a cultural space, or towards recreational ends, there are evident ecological spin-offs. A study by Avlonitis (2011) has shown the potential of communities to work in conjunction with larger government initiatives such as Working for Wetlands, where community initiative and labor are used to promote the development of indigenous vegetation gardens. Here, cultural agendas are forwarding the restoration of regulating services. This study points to the value of targeting sites where multiple agendas can be met through intervention. Restoration initiatives should take advantage of community interest and energy and align interventions with local cultural needs. An examination of the relevance of urban green space to the local population shows multiple opportunities to find these nodes of congruent opportunity (Pitt and Boulle 2010).

The opportunity for restoring the regulating services of coastal zone protection are largely lost where there has been considerable historic development close to the coastal zones. These areas tend to be associated with erosion problems and are a major financial sink for City management who strive to protect settlements, often

Table 11.10 Ecosystem services in Cape Town

Location of production: local, regional, global		Restoration, transformation potential				
Ecosystem services	Production unit	Spill over effects	Unit affected by spill over	ES affected	References	
Provisioning						
Food (broken down below) (Vegetables)	Local	Private gardens, community gardens	Recreation, food security, reduced biodiversity, community cohesion, pollution and N & P into ground water	Biodiversity remnant patches, open space, ground water sources affected locally	Positive recreation benefits, livestock production and water purification negatively impacted	
(Crop production)	Local	Urban agricultural areas	Biodiversity loss, green house gas (GHG) emissions.		O'Farrell et al. (2012)	
(Livestock)	Local, regional	Vegetated areas, urban open space	GHG emissions, biodiversity loss, social well-being, cultural identity	Biodiversity remnant patches, open space	Cultivation, biodiversity conservation, negatively impacted	
				Land management programs to reverse degradation are possible	O'Farrell et al. (2012); Lannas and Turpie (2009); Battersby (2011)	

(Freshwater fish)	Local	Dams & wetlands	Food security and conservation	Dams & wetlands	Recreation	Possible with reduced extraction	
(Seafood)	Local, Regional, global	Ocean, lagoons, estuaries	Ecological functioning (supporting services)	Ocean, lagoons, estuaries	Recreation	Possible with reduced extraction	Turpie et al. (2003)
Natural medicinal, ornamental and food resources	Local, regional	Natural vegetation	Possible population level impacts and loss of biodiversity	Natural vegetation	Biodiversity conservation	Possible with reduced extraction	Petersen et al. (2012)
Drinking water supply	Berg, Breede Disa, Palmiet and Steenbras river catchments	Surrounding mountain catchment and watersheds	Local climate regulation; Recreation, biodiversity conservation in mountain catchments, invasion by alien plants	Catchments	Agriculture	Clearing catchments of invasive alien plants	Brown and Magoba (2009); Van Wilgen et al. (1998)
Fuel wood	Local	Natural vegetation (degraded)	Positive biodiversity effects – clearing of invasive alien vegetation	Open spaces, conservation areas, catchments	Natural vegetation remnants (positive effect)	Harvesting fuel wood typically a restoration benefit as harvested species are invasive alien plant species	Lannas and Turpie (2009)

(continued)

Table 11.10 (continued)

Ecosystem services	Location of production: local, regional, global	Unit affected by spill over				References
		Production unit	Spill over effects	ES affected	Restoration, transformation potential	
Fiber harvest	Local and regional	Wetlands, coastal plains	Habitat impacted	Wetland edges, coastal plains (restios)	Water quality regulation (negatively affected) Soil retention	
<i>Regulating</i>						
Water purification	Berg, Breede Disa, Palmiet and Steenbras river catchments	Wetlands, rivers, vleis	Positive biodiversity and conservation impacts, agricultural practices curtailed	Mountain catchments, river systems and their buffer areas	Agriculture	Brown and Magoba (2009)
Water infiltration/ groundwater recharge	Local	Natural vegetation, gardens, open space	Reduced flooding potential, increased pollution of ground water sources if water polluted	Local level	Vegetation and biodiversity restoration	O'Farrell et al. (2012)
Soil retention	Local	Natural vegetation, gardens, open space	Restricted agricultural practices on steep slopes with high rainfall		Vegetation and biodiversity restoration	O'Farrell et al. (2012)

Carbon sequestration	Local and regionally	All natural vegetation remnants, plantations, parkland street trees	Climate regulation, shade provision, high water consumption effects possible, and biodiversity impacts	Catchments and water bodies	Water provision	Vegetation restoration
Flood control and mitigation	Local and regional	Natural vegetation remnants	Filtration and absorption of water and waterborne pollutants, agricultural land use food provision restricted, recreational use of rivers areas enhanced	Open space, remaining natural remnants, river buffer areas	Cultivation areas restricted (negative effect), ground water recharge enhanced	Wetland and vegetation restoration O'Farrell et al. (2012); Musungu et al. (2012); Bouchard et al. (2007)
Coastal storm surge protection	Local	Natural vegetation remnants	Restricted use of coastal environments	Coastal dune systems (extending from water's edge to 1 km inland)		Coastal vegetation restoration O'Farrell et al. (2012)

(continued)

Table 11.10 (continued)

Ecosystem services	Location of production: local, regional, global		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
Noise reduction	Locally		Street trees, plantations,		Heat island reduction, carbon sequestration		City planting, recreation	
N retention	Regionally		Wetlands				Restoration of wetlands, creation of new wetlands	
Pollination	Local, regionally		Gardens, parks, golf courses, natural vegetation remnants and nature reserves	Retaining pollinators requires maintaining ES production units, transformation to certain crops and timber is restricted	Local open space effects	Production of timber, crops	Increase % semi-natural areas, connectivity	O'Farrell et al. (2012)

<i>Cultural</i> Health	Local, regional, national	Green open space	Pollination, Biological control, infiltration, flood mitigation, coastal protection are all positively affected	Macro-scale urban planning, creative design of open space	De Wit et al. (2012)
Recreation	Local, regional	Beaches, nature reserves, parks, urban green space, gardens	Sense of place; education; health; increase in property value and tax revenue	Individuals, communities, Neighbourhoods	
Tourism	Local, regional	All natural assets			De Wit et al. (2012); O'Farrell et al. (2012)
(continued)					

Table 11.10 (continued)

	Location of production: local, regional, global	Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
Ecosystem services	Local, regional, national	Conservation areas, wetlands, rivers, estuaries, beaches	Environmental values; improved ecosystem function	Individuals, communities, urban vegetation remnants and reserves, urban waterways, breaches	All locally-produced services		O'Farrell et al. (2012)
Sense of place cultural ties	Local, national	Rural areas, usually distant, national parks	Increased well-being				De Wit et al. (2012)
Cultural rites/initiation	Local	Open green natural space, isolated area	Affects social cohesion, human-nature interactions,	Individuals, communities	Sense of well-being, sense of place		

Produced by O'Farrell (2013)

with expensive engineering interventions. Opportunities need to be sought for the effective incorporation of existing regulating services into ongoing and future developments. Large buffer zones protecting coastal dune systems with an associated functioning ecology are a critical service and one likely to become more so with projected sea rise and increased storm surge. A spatial plan needs to be developed assessing where restoration might be an option, and where engineering interventions must be considered. Remnant areas need the strictest protection as the city continues to grow within these areas (see Chap. 24 for additional discussion on this challenge).

There are numerous cases where ecosystem services may be effectively delivered outside of the natural indigenous biodiversity framework. For example, certain urban agricultural areas may be effective sites of groundwater recharge serving as a site of effective regulation, and forest plantations provide much enjoyed recreation sites serving an important cultural service. What is apparent is a suite of emerging novel ecosystems that speak to ecosystem service delivery, but do not necessarily meet biodiversity conservation goals. The high endemic biodiversity and global conservation significance of the vegetation of South Africa's Western Cape means that conservation agendas tend to predominate in this discourse. This is where ecosystem services and biodiversity conservation agendas may diverge. Future spatial planning and development as well as restoration activities must pay due attention to both conservation priorities and the ecosystem service needs and delivery potential of the remaining open spaces within the city.

11.5.2 New York

New York City is a classic example of a complex social-ecological system (SES) (McGrath and Pickett 2011; McPhearson 2011) situated in a large urban region along the northeast coast of the United States. The metropolitan region encompasses a dense urban core, surrounded by sprawling suburban and exurban development housing over 20 million people with unparalleled ethnic and social diversity. New York is both the largest city in the U.S. and the densest. Though people may often think of the city as a network of tightly-knit architectural forms and elaborately paved infrastructure, New York has a higher percentage of open space than any other major city in the U.S. (The Trust for Public Land 2011).

Throughout the five municipal boroughs of Manhattan, Brooklyn, Queens, Bronx, and Staten Island, there are approximately 11,300 ha of city parkland—nearly 40 % of which (4,450 ha) is still natural—harboring freshwater wetlands, salt marshes, rocky shorelines, beaches, meadows and forests. Ensconced within these ecosystems are more than 40 % of New York State's rare and endangered plant species. As a result, scientists are beginning to view New York City as an ecological hot spot—more diverse and richer in nature than the suburbs and rural counties that surround it. Regional ecosystems beyond the city boundaries also provide critical ecosystem services to New Yorkers including drinking water,

climate regulation, food production, recreation, and more, some of which have yet to be documented and described (Table 11.11).

Nonetheless, valuation of ecosystem services in New York has moved from economic valuation assessment of wetlands and forests to planning and legislation aimed at expanding and improving the management of ecosystems in the city for the purpose of improving the health and well-being of urban residents. The most prominent example is the recent 20-year economic and environmental sustainability plan, PlaNYC, which includes 132 initiatives. These ambitious initiatives range from revamping aging infrastructure to cutting greenhouse gas emissions 30 % by 2030 (New York City 2011). Since its inception, PlaNYC has gained tremendous attention both nationally and internationally and has been acknowledged around the world as one of the most ambitious and pragmatic sustainability plans anywhere (see Chap. 19, Local Assessment of New York).

One of the many ecosystem service-focused initiatives of PlaNYC is MillionTreesNYC, a public-private partnership between the NYC Department of Parks & Recreation and the New York Restoration Project, with the goal of planting and caring for one million trees across the city's five boroughs over the next decade. By planting one million trees, New York City intends to increase the size of its urban forest by 20 %. Since MillionTreesNYC began in 2007, over 600,000 trees have already been planted on city streets, private land, and public parkland. The impetus for such a significant investment in trees is the ecosystem services that the urban forest provides to city residents. One recent study by the U.S. Forest Service put the compensatory value of the city's urban forest at over \$5 billion (Nowak et al. 2007a). Nowak and colleagues estimated that the urban forest stores 1.35 million tons of carbon, a service valued at \$24.9 million. The forest sequesters an additional 42,300 t of carbon per year (valued at \$779,000 per year) and about 2,202 t of air pollution per year (valued at \$10.6 million per year; Nowak et al. 2007a). Urban trees provide a direct ecological service to cities by reducing urban surface and air temperatures through shading and evapotranspiration, yet the indirect effects of trees are just as important. For example, a cooler city leads to substantial reductions in energy use for air-conditioning. The U.S. Forest Service found that New York City's street trees provide an estimated \$27 million a year in energy savings through shading buildings. Trees can also regulate local surface and air temperatures by reflecting solar radiation and shading surfaces, such as streets and sidewalks that would otherwise absorb heat. Decreasing the heat loading of the city and thereby mitigating the urban heat island effect may be the most important ecological service trees provide to cities (McPhearson 2011). If an urban area like New York City eventually adds one million additional trees to its urban forest, the total cooling effect could decrease the heat of the city by a full degree or more (Rosenzweig et al. 2009).

Urban trees also capture rainfall on their leaves and branches and take up water through their roots, acting as natural stormwater capture and retention devices. Capturing stormwater to prevent pollution loading to local streams, rivers, and estuaries is a major goal of PlaNYC. Street trees in NYC intercept almost 900 million gallons of stormwater annually, or 1,500 gallons per tree on average. The total value

Table 11.11 Ecosystem services in New York

Ecosystem service	Location of production:		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
	local, regional, global (%)	global (%)						
Provisioning								
Food (broken down below) (Produce and crops)	Food (broken down below)		Private gardens, community gardens	Food security, stormwater retention, energy efficiency, and waste reduction; increased habitat and biodiversity; urban landscape beautification, increased property values and tax base	Floral and faunal species, individuals, communities	Recreation, sense of place, education, social-ecological memory	Expanding local food movement and urban farming	Ackerman (2011); Farming Concrete (2010); Gittleman et al. (2010); Voicu and Been (2008); McPhearson and Tidball (2012)
	Local < 1% ^a							
(continued)								

(continued)

Table 11.11 (continued)

Ecosystem service	Location of production: local, regional, global (%)	Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
	Regional – New York Metropolitan Area	Agriculture fields	Food security, decreased water quality, N, P leakage, Biodiversity loss, GHG emissions	Birds, bees, wildlife, individuals, communities, wetlands, lakes, rivers and streams, estuary	Seafood production, water quality, recreation, sense of place, educational opportuni- ties, carbon storage, carbon sequestration	2.2 % NYC; 34 % for New York State; value of sales of organic production \$54 million; 131,796 acres; many regional groups work on sustainable and organic agriculture practices (e.g., NYSWAG, NOFA-NY)	USDA (2007); Peters et al. (2009, 2007)
	Global ^b – overwhelm- ing majority (common knowledge)	Agriculture fields	Biodiversity loss, GHG emissions, N, P leakage	Birds, bees, wildlife, individuals, communities, wetlands, lakes, rivers and streams, estuaries, coral reefs	Soil building, seafood production, carbon storage, carbon sequestration		

(Livestock)	Regional – New York Metropolitan Area	Agriculture fields	Food Security, GHG emissions, biodiversity loss	Birds, bees, wildlife, wetlands, lakes, rivers and streams, wildlife, individuals, communities, airshed ^c	Seafood production, water quality, carbon storage, carbon sequestration	USDA (2007)
(Seafood)	Regional – 13 % of seafood purchased by Fulton Market is from New York fishermen and other NY suppliers	Lakes, rivers, wetlands, estuaries, ocean	Sustainability of fisheries, food security	Regional fisheries	Recreation, educational opportunities, sense of place	New York Sea Grant (2001)
	Global – 20 % of seafood purchases by Fulton Market are from foreign sources and 67 % are from other US states	Lakes, rivers, wetlands, estuaries, ocean	Decreased biodiversity, sustainability of fisheries	Global fisheries	Recreation	New York Sea Grant (2001)

(continued)

Table 11.11 (continued)

Ecosystem service	Location of production: local, regional, global (%)		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
Drinking water supply	Regional: 100 % Catskill-Delaware Watershed. In previous years, 10 % came from Croton watershed		Watershed ^d	NYC Dept. of Environmental Protection funds the Watershed Agricultural Council to implement water quality enhancement programs including purchasing conservation easements and paying farmers to manage farmland for water quality. While some of these programs support agriculture, they may also remove land from agricultural production and limit logging	Agricultural land, forests, wetlands, lakes, rivers and streams	Recreation, sense of place, social-ecological memory, education opportunities, food, wood and fiber	The Watershed Agricultural Council has an ongoing commitment to supporting Whole Farm Planning, in which it incentivizes farmers to manage risks to the water supply, protecting watershed land through conservation easements, and incentivizing landowners to engage in forest management planning.	Pires (2004); NYC Environmental Protection (2010a); New York State Department of Environmental Conservation (2010); Watershed Agricultural Council (2011, 2012)

Table 11.11 (continued)

Ecosystem service	Location of production:		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
	Local	local, regional, global (%)						
Flood control	Local		Urban forest	Filtration and absorption of water and waterborne pollutants	Wetlands, lakes, rivers and streams	Stormwater quality	Using ecological infrastructure to capture 1 st inch of rainfall on 10 % of impervious areas in combined sewer watersheds would result in reduced combined sewer overflows of 1,514 million gallons yearly	USDA Forest Service (2007); NYC Environmental Protection (2010b)
Stormwater quality enhancement (N, P, coliform, Total Suspended Solids)	Local, Regional		Watershed, Forest	Absorption of water	Wetlands, lakes, rivers and streams	Flood control	Could vegetate between 1,085 and 3,255 acres of impervious surface to absorb pollutants	NYC Environmental Protection (2010b)

Table 11.11 (continued)

Ecosystem service	Location of production:		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
	local, regional, global (%)	global (%)						
C sequestration	Local, Regional		Forests and other green spaces		Airshed		Local: Canopy cover could be increased by 11,836 acres (6 % increase to = 30 % total canopy cover) = 2,486 t/year additional C sequestration MillionTreesNYC restoration effort will increase C sequestration	Grove et al. (2006); McPhearson (2011); Nowak et al. (2007a)
C storage	Local, Regional		Forests and other green spaces		Airshed		Canopy cover could be increased by 11,836 acres (6 % increase to = 30 % total canopy cover) = 80,485 t additional C storage MillionTreesNYC restoration effort will increase C storage	Grove et al. (2006); McPhearson (2011); Nowak et al. (2007a)

Temperature regulation	Local, Regional	Forests and other green spaces	Shading and evapotranspiration lowers air temperature and results in less use of air conditioning, reduced O ₃ formation, and avoided CO ₂ emissions (Nowak et al. 2007a)	Individuals, communities, airshed	Air purification, sense of well-being	Greening half of NYC roofs (7,698 acres) would reduce temperature by 0.8 °F. MillionTreesNYC restoration effort will help regulate temperature	McPhearson (2011); Nowak et al. (2007a); NYC Environmental Protection (2010b); Rosenzweig et al. (2009)
Noise mitigation	Local	Forests and other green spaces	Psychological benefits, people engage in more outdoor activity	Individuals, communities	Recreation, sense of well-being, sense of place		
<i>Cultural</i> Aesthetic value	Local	Forests and other green spaces	Increased property value, gentrification, people engage in more outdoor activity	Individuals, communities	Recreation, sense of well-being, sense of place	Trees increase nearby property values by \$90/tree Community gardens in NYC add 9.4 % to the value of properties around them	USDA Forest Service (2007); Voicu and Been (2008)

(continued)

Table 11.11 (continued)

Ecosystem service	Location of production: local, regional, global (%)		Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
	Local							
Recreation	Local		Pocket parks, Neighborhood parks, destination parks, regional parks	Sense of place; education; health; increase in property value and tax revenue (Appelseed 2009)	Individuals, communities		The city adopted a standard of 1.5 acres per 1,000 population in addition to specific PlaNYC goals: park within 10 min walk for all population, expansion of park land by additional 2,700 acres, increased hours, increased usage functions Planned investment: 400 million to be invested in new regional parks in the city ^e	New York City (2007, 2011)
Educational opportunities	Local, Regional		Forests, other green space, aquatic ecosystems, urban gardens, urban farms	Increased civic engagement, social connectedness, environmental values; improved ecosystem function	Individuals, communities, urban forest, urban waterways, airshed	All locally-produced services		Tidball and Krasny (2010); McPhearson and Tidball (2012)

Sense of place	Local, Regional	Forests, other green space, aquatic ecosystems, urban gardens, urban farms	People engage in more outdoor activities in their communities	Individuals, communities	Recreation, sense of well-being, education
Sense of well-being	Local	Forests, other green space, aquatic ecosystems, urban gardens, urban farms	People engage in more outdoor activities in their communities	Individuals, communities	Recreation, sense of place
Social-ecological memory	Local, Regional	Forests, other green space, aquatic ecosystems, urban gardens, urban farms	Can affect social cohesion, human-nature interactions, increased affinity for ecosystem stewardship	Individuals, communities	Sense of well-being, sense of place, recreation, education

Produced by McPhearson et al. (2013)

^aProposed calculation: based on average production per sq ft for different urban agricultural types: community gardens, urban farms, home gardens

^bThe notion that the majority of food arrives at NYC from great distances was already substantiated in 1913 (Miller et al. 1913)

^cAn airshed is an area of the atmosphere that shares an air supply and can become uniformly polluted

^dA watershed is a land area in which water that is under and drains off it all flow to the same place

^eThere are survey results for what people want to see in the revamped regional parks: http://www.nycgovparks.org/email_forms/planyc_surveys/McCarren_Results.pdf

of this benefit to New York City is over \$35 million each year. A comprehensive accounting of the ecosystem services of New York's urban forest and other green spaces is part of research in progress, but it is clear that urban ecological infrastructure is providing additional social and ecological benefits to the city including increased wildlife habitat, forestry products, materials for community projects, neighborhood beautification, places for social bonding, increased safety, neighborhood stability, and social-ecological resilience (Grove et al. 2006).

For example, ecological infrastructure in New York provides a number of cultural services to city. New York City's park system offers numerous recreational opportunities to residents from large urban parks such as Central Park in Manhattan and Prospect Park in Brooklyn, to playgrounds, sport fields and small pocket and neighborhood parks. While the city's park system is one of the largest in the world, PlaNYC acknowledges that many communities still lack sufficient access to park and open space. Therefore, the City has set a target of 1.5 acres of open space per 1,000 people, coupled with the goal of having a park within a 10-min walk for all city residents. To achieve these goals, the City has committed to expanding the park system by 2,700 acres, improving existing facilities and offering extended hours in various park facilities. US\$400 million are slated for investment in the creation of new regional parks within the city boundaries (New York City 2007, 2011).

Ecological infrastructure is also important for the provisioning of food for New York residents (Table 11.11). Though only a small fraction of food consumed is produced locally, the vibrant and growing local food movement is one of the promising trends in urban ecosystem services. Urban gardens in private homes, community gardens, rooftop gardens and urban farms contribute to urban ecosystems by providing habitat to support biodiversity and increased resilience. In addition they provide varied ecosystem services such as runoff retention, recreation and education opportunities, and support sense of place and are sites for social-ecological memory. The New York local food movement is diverse, comprised of NGOs, research and education institutions, government organizations and many individuals. Programs such as the City's GreenThumb (<http://www.greenthumbnyc.org/>), Farming Concrete (<http://farmingconcrete.org/>), 596 acres (<http://596acres.org/>), Five Borough Farm (http://www.designtrust.org/projects/project_09farm.html) and many others are working tirelessly to convert built acres into ecologically sound, productive spaces. With over 1,000 gardens, 30 urban farms and 2,000 acres of still vacant land, the trend is only beginning to fulfill its potential.

That the human components of the social-ecological system are intimately tied to the ecological components through ecosystem services is becoming better understood in policy and planning in New York City. The last decade has shown significant progress towards resilience and sustainability planning, most recently through PlaNYC. Still, it will continue to be essential for city planners, managers, and policy makers to better understand trade-offs and synergies in the provisioning of ecosystem services in order to generate best practices for managing and enhancing biodiversity and ecosystem services in the New York metropolitan region.

11.5.3 *Barcelona*

Barcelona is a compact city located at the Mediterranean shore in North-Eastern Spain. The Barcelona Metropolitan Region (BMR) has been described as a circular structure, comprised of two extensive outer metropolitan rings, a dense middle ring and the municipality of Barcelona as the compact inner core (Catalán et al. 2008). The BMR, with around five million inhabitants—including the municipality of Barcelona with 1.62 million inhabitants—is the second largest urban area in Spain. Population density is relatively low in the outer rings and increases to over 16,000 inhabitants per km² in the inner core (Census 2012, IDESCAT), which makes Barcelona one of the densest cities in Europe. While the population size of the BMR showed stability within the last decades, its distribution pattern changed considerably. The horizontal expansion of the city—in form of a migratory movement from the dense core to outer rings of the BMR—more than doubled the size of the urbanized area since 1975 (Domene and Saurí 2007; Catalán et al. 2008). This urban sprawl movement has been described as beneficial to the population of the BMR, considering trade-offs between the loss of rural landscape in the outer parts and an increase of green space per capita in the inner city (Garcia and Riera 2003).

Currently, the total green space within the municipality of Barcelona amounts to 28.93 km², representing 28.59 % of the total municipal area and 17.91 m² of green space per inhabitant (Barcelona City Council, Statistical Yearbook 2012). However, most of this green space corresponds to the peri-urban forest of Collserola (Boada et al. 2000). In the core of Barcelona—excluding Collserola forest—green space per capita amounts to no more than 6.80 m² per inhabitant, which is a very low ratio in comparison with other European cities (Fuller and Gaston 2009). On the contrary, the number of single street trees—with almost 160,000 units and a ratio of almost 1 tree per 10 inhabitants—is comparatively high (Pauleit et al. 2002).

The urban street trees and the urban forests of Barcelona have been documented to provide a wide range of benefits to the city dwellers by generating a variety of regulating ecosystem services such as urban temperature regulation, noise reduction, and water flow regulation (Table 11.12). Chaparro and Terradas (2009) estimate that urban forests in Barcelona contribute to GHG emission offsets by carbon storage amounting to 113,437 t (11.2 t/ha) and by carbon sequestration amounting to net 5,422 t/year (0.54 t/ha/year). Urban forests also contribute to air purification, an important policy issue in Barcelona due to elevated air pollution levels (Toll and Baldasano 2000; Pérez et al. 2009). Air purification by urban forest, shrubs, and street trees in Barcelona has been estimated in 305.6 t/year, including 166 t/year PM10 removal, 72.6 t/year of O₃, 54.6 t/year of NO₂, 6.8 t/year of SO₂, and 5.6 t/year of CO removal (Chaparro and Terradas 2009). Decreases in air pollution levels can provide considerable health benefits. For example, previous research has suggested that urban vegetation of Barcelona could decrease current PM10 levels from 50 to 20 mg/m³, thereby increasing the average life expectancy of its inhabitants by 14 months (Pérez et al. 2009).

Table 11.12 Ecosystem services in Barcelona

Location of production: local, regional, global		Restoration, transformation potential					
Ecosystem service	Production unit	Spill over effects	Unit affected by spill over	ES affected	References		
Provisioning							
Food provisioning	Local	community gardens (Anguelovski 2012), vegetable gardens (Domene and Saurí 2007)	People engage in (outdoor) activities in their communities, human-nature interchange, potential disruption perception of disorder within planned infrastructure (Domene and Saurí 2007)	Individuals, planning entities	Increased sense of place, education, social-ecological memory and social cohesion, potentially reduced aesthetics (Domene and Saurí 2007)	Long term environmental revitalization and neighborhood rehabilitation (Anguelovski 2013)	Domene and Saurí (2007); Anguelovski (2012)
Drinking water supply	Regional	Freshwater wetland, open freshwater, riparian buffer (Brenner et al. 2010)	Conservation/restoration of catchment area	Catchment area	Habitat, aesthetic, and spiritual experiences (Brenner et al. 2010)		Brenner et al (2010)

Regulating Water flow regulation and runoff mitigation	Local, Regional	Forests and other green spaces (Chaparro and Terradas 2009), urban green space (Brenner et al. 2010)	Potential of rainwater retention and use (Núñez et al. 2010)	Lower parts, areas with high slopes, aquifers	Flood control, erosion control, Drinking Water Supply	Chaparro and Terradas (2009); Brenner et al (2010)
	Air purification/ air quality regulation	Local, Regional Urban Forests (Chaparro and Terradas 2009), urban green space (Brenner et al. 2010)	Decrease of air quality (increase of O ₃ -levels) due to VOC-emissions (Chaparro and Terradas 2009; Toll and Baldasano 2000)	Individuals, whole city	Aesthetic and recreation (Brenner et al. 2010)	Pérez, Sunyer and Künzli (2009); Chaparro and Terradas (2009); Toll and Baldasano (2000); Brenner et al. (2010)
					Increased tree cover would lower health risk and mortality, e.g. lowering PM10 levels to 20 mg/m ³ reduces deaths by 3,500 (Pérez et al. 2009), Maximization of species emitting few VOCs to reduce the formation of O ₃ and CO (Chaparro and Terradas 2009)	

(continued)

Table 11.12 (continued)

Ecosystem service	Location of production:		Production unit	Spill over effects	Unit affected by		Restoration, transformation potential	References
	local,	regional, global			ES affected	spill over		
(Global) Climate regulation	Local,	Regional	Forests and other green spaces (Chaparro and Terradas 2009)				Expansion of tree cover to increase C-storage, recycling of timber from pruning or dead trees to increase C-storage time (Chaparro and Terradas 2009)	Chaparro and Terradas (2009)

Table 11.12 (continued)

Ecosystem service	Location of production: local, regional, global	Production unit	Spill over effects	Unit affected by spill over	ES affected	Restoration, transformation potential	References
<i>Cultural</i>							
Amenity and aesthetic	Local	Urban green space (Brenner et al. 2010)					Brenner et al. (2010); Domene and Saurí (2007)
Recreation (physical and mental)	Local	Urban green space (Brenner et al. 2010)					Brenner et al. (2010)
Environmental education and cognitive development	Local	Community gardens (Anguelovski 2012), vegetable gardens (Domene and Saurí 2007)	Enrichment due to “caring activity” (Domene and Saurí 2007)	Individuals, communities, urban parks (Anguelovski 2012)	Food security, knowledge preservation (Domene and Saurí 2007)	Social cohesion potential, decreased health-care costs	(Anguelovski 2012); Domene and Saurí (2007)
Spiritual experience and sense of place	Local						
Sense of well-being	Local	Allotment gardens, vegetable gardens (Domene and Saurí 2007)	People engage in (outdoor) activities in their communities	Individuals, communities	Recreation, sense of place, social cohesion		Domene and Saurí (2007)

Knowledge preservation	Local	community gardens (Anguelovski 2012), vegetable gardens (Domene and Saurí 2007)	Human-nature interactions, unplanned change/degradation of ecosystems	Riverbanks, brown fields	Food security, cognitive development, habitat loss (Domene and Saurí 2007)	Increased resilience, maintenance of cultural identity by immigrant (Domene and Saurí 2007)	(Anguelovski 2012); Domene and Saurí (2007)
Social cohesion	Local	Community gardens (Anguelovski 2012)	People engage in (outdoor) activities in their communities, integration of marginalized (immigrant) societal groups (Anguelovski 2012)	Surrounding neighborhoods	Recreation, sense of place	Development potential for waste/brown fields	(Anguelovski 2012)

Produced by Langemeyer (2013)

However, the importance of green space for biodiversity and the generation of ecosystem services has only gained stronger recognition in urban policy making recently, as manifested in Barcelona's *Pla del Verd i la Biodiversitat* (Plan of Green Space and Biodiversity), a strategic plan with the goal to enhance Barcelona's ecological infrastructure. Because Barcelona is a highly compact city and available space for the restoration of green space is relatively low, urban planning needs to account for trade-offs between different ecosystem services as favored under different policy and land-use scenarios. The perceived scarcity of available green space in Barcelona and a disregard of the need for specific ecosystem services by urban planning has led to many individual and community-based informal greening initiatives (Domene and Saurí 2007; Arbaci and Tapada-Berteli 2012). An outstanding example is the creation of the "Pou de la Figuera," a green space located in the old town of the city. This area, which was previously intended for the construction of parking spaces and high-end apartments, is today a popular green space created by the initiative of neighbors and environmental activists. It embeds planted areas, sports areas, and a community garden, all of which provide support for a variety of ecosystem services including recreational activities, social cohesion, environmental education, and food production (see Anguelovski 2012).

The provision of cultural ecosystem services is also crucial in urban parks, which have been in the focus of urban planning in Barcelona since the end of the nineteenth century (Roca 2000, p.405). For example, the Park Montjuïc, which—with more 300 ha—is the biggest inner city park in Barcelona, provides a broad range of cultural ecosystem services and receives about 16 million visitors per year (Ajuntament de Barcelona, Modificació del Pla General Metropolità de la Muntanya de Montjuïc 2010). Simultaneously Montjuïc embeds the city's highest levels of biodiversity and serves as habitat for multiple species (Boada et al. 2000). The limited amount of green space in the dense city of Barcelona necessitates a broader knowledge about trade-offs and synergies between the supply of different ecosystem services. It further requires a broader acknowledgement of citizens' needs in the planning of urban green spaces. Waste and brown-fields, even if they are very limited in their extension, have a high potential to provide ecosystem services when used—for example—as community gardens.

11.6 Conclusions

Urbanization and technological progress has fostered the conception of an urban society that is increasingly disconnected and independent from ecosystems. However, demands on natural capital and ecosystem services keep increasing steadily in our urbanized planet (Gómez-Baggethun and de Groot 2010; Guo et al. 2010). Decoupling of cities from ecosystems can only occur locally and partially, thanks to the appropriation of vast areas of ecosystem services provision beyond the city boundaries. Just as any other social-ecological system, cities depend on ecosystems and their components to sustain long-term conditions for life, health, good

social relations and other important aspects of human well-being. If taken seriously in urban policy, ecosystem services can play an important role in reconnecting cities to the biosphere (Jansson 2013).

The present review synthesizes research that outlines the potential role of urban ecological infrastructure in enhancing resilience and quality of life in cities. Ecosystem services that can be especially relevant in urban contexts include noise reduction, urban temperature regulation, moderation of climate extremes, outdoor recreation, cognitive development, and social cohesion. Besides their contribution to quality of life, urban ecosystem services can be a major source of resilience for cities, thereby enhancing capacity to deal with environmental and socio-economic shocks. For example, temperature regulation by vegetation reduces health impacts from heat waves, and natural barriers such as mangroves and coral reefs in coastal cities reduce the potential damages from storms and waves. Likewise, urban allotment gardens can improve food security in times of crises.

The importance of urban ecosystem services can be approached from multiple, sometimes conflicting, value perspectives, each of which may capture a relevant dimension of urban environmental policy (Martínez Alier 2002). Ethics and aesthetics, health, environmental justice, economic costs, and resilience are all relevant languages in the valuation of urban ecosystem services. They each emphasize different forms of value that cannot simultaneously be maximized or reduced to single measurements. Loss of green space may simultaneously involve health impacts and increased vulnerability to shocks but may (or may not) also provide additional economic benefits. Clearing a patch of forest to create a park enhances recreational values but generally reduces biodiversity. Thus, trade-offs arise not only across ecosystem services but also across the different dimensions of value of those services (Martín-López et al. 2013). Furthermore, specific ecosystem processes and components that may be perceived as services by some, may be perceived as disservices by others. Green areas in cities can be simultaneously perceived by different people as pleasant sites for recreation (Chiesura 2004) or as dangerous places to walk at night (Bixler and Floyd 1997). Likewise, large street trees may be positively seen as providing shade and aesthetic benefits by pedestrians, while people living in the buildings close to them may perceive them as a nuisance because they reduce sunlight and block views out of their windows. Reaching a comprehensive picture of the multiple potential benefits and nuisances of restoring or losing urban ecosystems therefore involves endorsing integrated valuation approaches capable of combining multiple value dimensions, stakeholder perspectives, knowledge systems and fields of expertise.

Framing and achieving a new vision to enhance the sustainability of cities based on the restoration of ecological infrastructure and ecosystem services means moving away from conventional approaches to economics and engineering and towards the application of ideas from broader, more transdisciplinary fields (Costanza et al. 2006a; Lundy and Wade 2011). Although the ecosystem services perspective has led to great progress in our understanding of specific forms of human-nature relations, it should be noted that awareness of the links between urban ecosystems and human well-being is not a novel finding of the ecosystem service approach

(Gómez-Baggethun et al. 2010b). Meteorologists, urban architects, urban planners, urban ecologists, and urban sociologists, among others, also have studied the effects of urban vegetation in cooling, pollutant reduction, noise attenuation, aesthetics, and also the role of green space for human enjoyment and quality of life in cities—though not necessarily under the terms of what we today call urban ecosystem services. An important contribution of the ecosystem service approach has been to provide a framework to integrate information from various fields of knowledge concerned with the urban environment and to facilitate an arena for interdisciplinary dialogue.

Despite mounting evidence of the links between urban ecosystems and quality of life, direct relations of specific ecosystem services to well-being components should not be taken for granted or extrapolated in simplistic ways into urban planning processes. Commonly cited benefits of urban ecosystems are still poorly supported by empirical evidence, and our understanding of their links to well-being is uneven. For example, a recent study by Pataki et al. (2011) found that to date, there is little data showing that urban green space can reduce urban greenhouse-gas emissions or air and water pollutant concentrations but that there is wide evidence supporting substantial reductions in urban runoff and effects in local temperature regulation. These authors also suggest that improvements in human health do not seem to be related in simple ways to absorption of air pollutants by urban forest. The effectiveness of solutions to urban problems based on ecological infrastructure should also be compared against other strategies, and often considered as a complement to them. For example, whereas restoration of urban forests is likely to be an effective measure to enhance biodiversity and opportunities for recreation, caps on car use or taxes on fuels may be a more effective measure to reduce urban greenhouse-gas emissions and to improve air quality in cities.

The same cautionary note holds for over simplistic narratives on the economic benefits of restoring urban ecological infrastructure. Including the economic value of ecosystem services in cost-benefit analysis does not guarantee that solutions based on ecological infrastructure will be cheaper when compared to solutions based on built infrastructure and technology. Moreover, when using the approach of economic values, serious economic analysis should not only take into account benefits from ecosystem services but also costs from ecosystem disservices. Multiple valuation languages come at play in our interaction with urban nature and perspectives relying on single values are unlikely to capture the complexity of ecosystem services. Urban development projects that make economic sense may not be acceptable if they affect important cultural values, human health, habitats for rare species, or if they violate basic principles of environmental justice.

Urban ecosystem services and ecological infrastructure can play a key role in reconnecting cities to the biosphere, restoring local commons, reducing ecological footprints, orchestrating disciplinary fields and stakeholder perspectives, and guiding policies to improve quality of life in cities. Strategies aimed at restoring and enhancing urban ecosystem services should play a major role in the transition towards more healthy, resilient, and sustainable cities.

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References

- Ackerman, K. (2011). *The potential for urban agriculture in New York City: Growing capacity, food security, & green infrastructure*. Retrieved from <http://www.urbandesignlab.columbia.edu/?pid=nyc-urban-agriculture>
- Ahrné, K., Bengtsson, J., & Elmqvist, T. (2009). Bumble bees (*Bombus* spp.) along a gradient of increasing urbanization. *PLoS ONE*, 4(5), e5574.
- Ali, M., de Bon, H., & Moustier, P. (2005). Promoting the multifunctionality of urban and peri-urban agriculture. *Urban Agriculture Magazine*, 15, 9–11.
- Altieri, M. A., Companioni, N., Cañizares, K., et al. (1999). The greening of the ‘barrios’: Urban agriculture for food security in Cuba. *Agriculture and Human Values*, 16(2), 131–140.
- Altman, I., & Low, S. M. (1992). *Human behavior and environment* (Vol. 12). New York: Plenum.
- Anderson, L. M., & Cordell, H. K. (1985). Residential property values improved by landscaping with trees. *Southern Journal of Applied Forestry*, 9(3), 162–166.
- Anderson, P. M. L., & O’Farrell, P. J. (2012). An ecological view of the history of the establishment of the City of Cape Town. *Ecology and Society*, 17(3), 28.
- Andersson, E., Barthel, S., & Ahrné, K. (2007). Measuring social-ecological dynamics behind the generation of ecosystem services. *Ecological Applications*, 17(5), 1267–1278.
- Anguelovski, I. (2012). Environment and health, yes... but for other reasons: Asserting control, sovereignty and transgression in Barcelona. In T. Tejerina & I. Perugorria (Eds.), *From social to political. New forms of mobilization and democratization (conference proceedings)* (pp. 247–264). Bilbao: University of the Basque Country.
- Anguelovski, I. (2013). Beyond a livable and green neighborhood: Asserting control, sovereignty and transgression in the Casc Antic of Barcelona. *International Journal of Urban and Regional Research*, 37(3), 1012–1034.
- Anh, M. T. P. (2004). *Urban and peri-urban agriculture in Hanoi: Opportunities and constraints for safe and sustainable food production* (Technical Bulletin/World Vegetable Center; no. 32). Shanhua: AVRDC.
- Appleseed. (2009). *Valuing Central Park’s contributions to New York City’s economy*. New York: Central Park Conservancy.
- Arbaci, S., & Tapada-Berteli, T. (2012). Social inequality and urban regeneration in Barcelona City Centre: Reconsidering success. *European Urban and Regional Studies*, 19(3), 287–311. Available at: <http://eur.sagepub.com/cgi/doi/10.1177/0969776412441110>. Accessed 25 Feb 2013.
- Avlonitis, G. (2011). *Understanding urban ecology: Exploring the ecological integrity of small scale greening interventions in the City of Cape Town*. Unpublished Masters Dissertation. Cape Town: University of Cape Town.
- Aylor, D. (1972). Noise reduction by vegetation and ground. *Journal of the Acoustical Society of America*, 51, 197–205.
- Aylor, D., Garner, J. H., & Johnson, D. (2003). Ecological effects of particulate matter. *Environment International*, 29(2–3), 213–239.
- Barthel, S., & Isendahl, C. (2013). Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. *Ecological Economics*, 86, 224–234.
- Barthel, S., Folke, C., & Colding, J. (2010). Social–ecological memory in urban gardens: Retaining the capacity for management of ecosystem services. *Global Environmental Change*, 20(2), 255–265.
- Barthel, S., Folke, C., & Colding, J. (2011). Urban gardens: Pockets of social-ecological memory. In *Greening in the red zone disaster, resilience and community greening*. Dordrecht: Springer.

- Barton, D. N., Lindhjem, H., Magnussen, K., et al. (2012). *Valuation of ecosystem services from Nordic watersheds. From awareness raising to policy support? (VALUESHED)*. Copenhagen: Nordic Council of Ministers.
- Battersby, J. (2011). Urban food insecurity in Cape Town, South Africa: An alternative approach to food access. *Development Southern Africa*, 28(4), 545–561.
- 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(2S2), 159–168.
- Bennett, L. (1997). *Neighborhood politics: Chicago and Sheffield*. New York: Garland Publishing.
- Bible, D. S., Hsieh, C., Joiner, G., et al. (2002). Environmental effects on residential property values resulting from the contamination effects of a creosote plant site. *Property Management*, 20(5), 383–391.
- Birdsey, R. A. (1992). *Carbon storage and accumulation in United States forest ecosystems*. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Bixler, R. D., & Floyd, M. F. (1997). Nature is scary, disgusting, and uncomfortable. *Environment and Behavior*, 29(4), 443–467.
- Blair, R. B. (1996). Land use and avian species diversity along an urban gradient. *Ecological Applications*, 6(2), 506–519.
- Blair, R. B., & Launer, A. E. (1997). Butterfly diversity and human land use: Species assemblages along an urban gradient. *Biological Conservation*, 80, 113–125.
- Blitzer, E. J., Dormann, C. F., Holzschuh, A., et al. (2012). Spillover of functionally important organisms between managed and natural habitats. *Agriculture, Ecosystems & Environment*, 146(1), 34–43.
- Boada, M., Capdevila Solà, L., & Barcelona (Catalunya) Ajuntament. (2000). *Barcelona: biodiversitat urbana*. Barcelona: Ajuntament de Barcelona (in Catalan).
- Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, 29(2), 293–301.
- Bonan, G. B. (2002). *Ecological climatology: Concepts and applications*. Cambridge: Cambridge University Press.
- Booth, D. B. (2005). Challenges and prospects for restoring urban streams: A perspective from the Pacific Northwest of North America. *Journal of the North American Benthological Society*, 24(3), 724–737.
- Bouchard, B., Goncalo, A., & Susienka, M et al. (2007, December 13) *Improving flood risk management in informal settlements of Cape Town*. An interactive qualifying project submitted to the faculty of Worcester Polytechnic Institute in partial fulfilment of the requirements for the degree of bachelor of science. City of Cape Town: Roads & Stormwater Department.
- Bowler, D. E., Buyung-Ali, L., Knight, T., et al. (2010a). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, 10(1), 456.
- Bowler, D. E., Buyung-Ali, L., Knight, T. M., et al. (2010b). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning*, 97(3), 147–155.
- Boyer, T., & Polasky, S. (2004). Valuing urban wetlands: A review of non-market valuation studies. *Wetlands*, 24(4), 744–755.
- Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, 92(10), 2763–2773.
- Brandt, J. & Vejre, H. (2003). *Multifunctional landscapes: Vol. 1. Theory, values and history*. Southampton: WIT Press.
- Brenneisen, S. (2003). *Ökologisches ausgleichspotenzial von extensiven dachbegrünungen: bedeutung für den arten- und naturschutz und die stadtentwicklungsplanung*. Doctoral dissertation, Institute of Geography, University of Basel.
- Brenner, J. J. A., Jiménez, R. S., & Alvar, G. (2010, January). An assessment of the non-market value of the ecosystem services provided by the Catalan Coastal Zone, Spain. *Ocean and*

- Coastal Management*, 53(1), 27–38. doi:10.1016/j.ocecoaman.2009.10.008. <http://linkinghub.elsevier.com/retrieve/pii/S0964569109001422>.
- Brown, C., & Magoba, R. (2009). *Rivers and wetlands of Cape Town: Caring for our rich aquatic heritage*. Pretoria: Water Research Commission.
- Buchmann, C. (2009). Cuban home gardens and their role in social–ecological resilience. *Human Ecology*, 37(6), 705–721.
- Catalán, B., Saurí, D., & Serra, P. (2008). Urban sprawl in the Mediterranean? *Landscape and Urban Planning*, 85(3–4), 174–184. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S0169204607002848>. Accessed 13 Mar 2012.
- Chan, K. M. A., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics*, 74, 8–18.
- Chaparro, L., & Terradas, J. (2009). *Ecological services of urban forest in Barcelona*. Centre de recerca ecològica i aplicacions forestals, Universitat autònoma de Barcelona Bellaterra.
- Chattopadhyay, S. (1999). Estimating the demand for air quality: New evidence based on the Chicago housing market. *Land Economics*, 75(1), 22.
- Chavis, D. M., & Pretty, G. (1999). Sense of community: Advances in measurement and application. *Journal of Community Psychology*, 27, 635–642.
- Chichilnisky, G., & Heal, G. (1998). Economic returns from the biosphere. *Nature*, 391, 629–630.
- Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning*, 68(1), 129–138.
- Cho, S.-H., Poudyal, N. C., & Roberts, R. K. (2008). Spatial analysis of the amenity value of green open space. *Ecological Economics*, 66(2–3), 403–416.
- Churkina, G., Zaehle, S., Hughes, J., et al. (2010). Interactions between nitrogen deposition, land cover conversion, and climate change determine the contemporary carbon balance of Europe. *Biogeosciences*, 7(9), 2749–2764.
- Clausen, J. C. (2007). *Jordan Cove watershed project 2007 final report*. Storrs: Department of Natural Resource Management and Engineering, University of Connecticut.
- Colding, J., & Folke, C. (2009). The role of golf courses in biodiversity conservation and ecosystem management. *Ecosystems*, 12(2), 191–206.
- Colding, J., Lundberg, J., & Folke, C. (2006). Incorporating green-area user groups in urban ecosystem management. *AMBIO: A Journal of the Human Environment*, 35, 237–244. doi:10.1579/05-A-098R.1.
- Colding, J., Lundberg, J., Lundberg, S., et al. (2009). Golf courses and wetland fauna. *Ecological Applications*, 19(6), 1481–1491.
- Costanza, R., d'Arge, R., & deGroot, R., et al. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387, 253–260.
- Costanza, R., Mitsch, W. J., & Day, J. W. (2006a). A new vision for New Orleans and the Mississippi delta: Applying ecological economics and ecological engineering. *Frontiers in Ecology and the Environment*, 4(9), 465–472.
- Costanza, R., Wilson, M. A., Troy, A., et al. (2006b). *The value of New Jersey's ecosystem services and natural capital*. Burlington: Gund Institute for Ecological Economics, University of Vermont for New Jersey, Department of Environmental Protection.
- Crush, J., Hovorka, A., & Tevera, D. (2010). *Urban food production and household food security in southern African cities* (Urban food security series no. 4). Kingston/Cape Town: Queen's University and AFSUN.
- D'Amato, G. (2000). Urban air pollution and plant-derived respiratory allergy. *Clinical and Experimental Allergy*, 30, 628–636.
- Daily, G. C., Alexander, S., Ehrlich, P. R., et al. (1997). Ecosystem services: Benefits supplied to human societies by natural ecosystems. *Issues in Ecology* 2.
- Daily, G. (1997). *Nature's services: Societal dependence on natural ecosystems*. Washington, D.C.: Island Press.
- Daily, G., & Ellison, K. (2003). *The new economy of nature: The quest to make conservation profitable*. Washington, DC: Island Press.

- Daniel, T. C., Muhar, A., Arnberger, A., et al. (2012). Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences*, 109, 8812–8819.
- Danielsen, F., Sørensen, M. K., Olwig, M. F., et al. (2005). The Asian tsunami: A protective role for coastal vegetation. *Science*, 310(5748), 643.
- de Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, 41(3), 393–408.
- de Stefano, S., & Deblinger, R. D. (2005). Wildlife as valuable natural resources vs. intolerable pests: A suburban wildlife management model. *Urban Ecosystems*, 8, 179–190.
- de Wit, M., van Zyl, H., Crookes, D., et al. (2012). Including the economic value of well-functioning urban ecosystems in financial decisions: Evidence from a process in Cape Town. *Ecosystem Services*, 2, 38–44.
- Depietri, Y., Renaud, F. G., & Kallis, G. (2012). Heat waves and floods in urban areas: A policy-oriented review of ecosystem services. *Sustainability Science*, 7, 95–107.
- Deutsch, L., & Folke, C. (2005). Ecosystem subsidies to Swedish food consumption from 1962 to 1994. *Ecosystems*, 8(5), 512–528.
- Domene, E., & Saurí, D. (2007). Urbanization and class-produced natures: Vegetable gardens in the Barcelona Metropolitan Region. *Geoforum*, 38(2), 287–298. Available at: <http://linking-hub.elsevier.com/retrieve/pii/S0016718506000431>. Accessed 21 Feb 2013.
- Doolittle, R. J., & Macdonald, D. (1978). Communication and a sense of community in a metropolitan neighborhood: A factor analytic examination. *Communication Quarterly*, 26(3), 2–7.
- Duany, A., Speck, J., & Lydon, M. (2010). *The smart growth manual*. New York: McGraw Hill.
- Dzierzanowski, K., Popek, R., Gawrońska, H., et al. (2011). Deposition of particulate matter of different size fractions on leaf surfaces and in waxes of urban forest species. *International Journal of Phytoremediation*, 13(10), 1037–1046.
- Elmqvist, T., Folke, C., Nyström, M., et al. (2003). Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment*, 1(9), 488–494.
- Elmqvist, T., Setälä, H., & Handel, S., et al. (Forthcoming). *Benefits of restoration of ecosystem services in cities*.
- Embleton, T. F. W. (1963). Sound propagation in homogeneous deciduous and evergreen woods. *Journal of the Acoustical Society of America*, 35, 1119–1125.
- Ernstson, H. (2012). The social production of ecosystem services: A framework for studying environmental justice and ecological complexity in urbanized landscapes. *Landscape and Urban Planning*, 109(1), 7–17.
- Ernstson, H., Leeuw, S. E., Redman, C. L., et al. (2010). Urban transitions: On urban resilience and human-dominated ecosystems. *AMBIO*, 39(8), 531–545.
- Escobedo, F. J., & Nowak, D. J. (2009). Spatial heterogeneity and air pollution removal by an urban forest. *Landscape and Urban Planning*, 90(3–4), 102–110.
- Escobedo, F. J., Wagner, J. E., Nowak, D. J., et al. (2008). Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. *Journal of Environmental Management*, 86(1), 148–157.
- Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution*, 159(8–9), 2078–2087.
- European Environmental Agency. (2010). *Mapping the impacts of natural hazards and technological accidents in Europe. An overview of the last decade* (EEA Technical Report no. 13/2010).
- European Environmental Agency. (2011). *Green infrastructure and territorial cohesion. The concept of green infrastructure and its integration into policies using monitoring systems*. Luxembourg: European Environment Agency.
- Fahrig, L., Baudry, J., Brotons, L., et al. (2011). Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. *Ecology Letters*, 14(2), 101–112.

- Fang, C.-F., & Ling, D.-L. (2003). Investigation of the noise reduction provided by tree belts. *Landscape and Urban Planning*, 63(4), 187–195.
- Farber, S. (1987). The value of coastal wetlands for protection of property against hurricane wind damage. *Journal of Environmental Economics and Management*, 14, 143–151.
- Farming Concrete. (2010). Report. <http://www.scribd.com/doc/53285030/FC-2010-report>. Accessed 19 Feb 2013.
- Farrugia, S., Hudson, M. D., & McCulloch, L. (2013). An evaluation of flood control and urban cooling ecosystem services delivered by urban green infrastructure. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 9, 136–145. doi:[10.1080/21513732.2013.782342](https://doi.org/10.1080/21513732.2013.782342).
- Feldmann, R. M. (1990). Settlement identity: Psychological bonds with home places in a mobile society. *Environment and Behavior*, 22, 183–229.
- Finlay, E. (2010). *Green infrastructure to combat climate change*. Northwest Climate Change Action Plan and GRaBS project. Edinburgh: Community Forest Northwest.
- Fisher, B., Turner, R., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics*, 68(3), 643–653.
- Fitzhugh, T. W., & Richter, B. D. (2004). Quenching urban thirst: Growing cities and their impacts on freshwater ecosystems. *Bioscience*, 54, 741–754.
- Folke, C., Larsson, J., & Sweitzer, J. (1996). Renewable resource appropriation by cities. In R. Costanza, O. Segura Bonilla, & J. Martínez Alier (Eds.), *Getting down to earth: Practical applications of ecological economics* (pp. 201–221). Washington, DC: Island Press.
- Folke, C., Jansson, Å., Larsson, J., et al. (1997). Ecosystem appropriation by cities. *Ambio*, 26(3), 167–172.
- Folke, C., Jansson, Å., Rockström, J., et al. (2011). Reconnecting to the biosphere. *AMBIO: A Journal of the Human Environment*, 40(7), 719–738.
- Forman, R. T. T. (1995). Some general principles of landscape and regional ecology. *Landscape Ecology*, 10(3), 133–142.
- Fuller, R., & Gaston, K. J. (2009). The scaling of green space coverage in European cities. *Biology Letters*, 5(3), 352–355. Available at: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2679924&tool=pmcentrez&rendertype=abstract>. Accessed 2 Nov 2012.
- Garcia, D., & Riera, P. (2003). Expansion versus density in Barcelona: A valuation exercise. *Urban Studies*, 40(10), 1925–1936. Available at: <http://usj.sagepub.com/cgi/doi/10.1080/0042098032000116040>. Accessed 25 Feb 2013.
- Geron, C. D., Guenther, A. B., & Pierce, T. E. (1994). An improved model for estimating emissions of volatile organic compounds from forests in the eastern United States. *Journal of Geophysical Research*, 99(D6), 12773–12791.
- Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, 86, 235–245.
- Gómez-Baggethun, E., & de Groot, R. (2010). Natural capital and ecosystem services: The ecological foundation of human society. In R. E. Hester & R. M. Harrison (Eds.), *Ecosystem services: Issues in environmental science and technology* (Vol. 30, pp. 118–145). Cambridge: Royal Society of Chemistry.
- Gómez-Baggethun, E., & Ruiz-Perez, M. (2011). Economic valuation and the commodification of ecosystem services. *Progress in Physical Geography*, 35(5), 613–662.
- Gómez-Baggethun, E., Mingorría, S., Reyes-García, V., et al. (2010a). Traditional ecological knowledge trends in the transition to a market economy: Empirical study in the Doñana natural areas. *Conservation Biology*, 24(3), 721–729.
- Gómez-Baggethun, E., de Groot, R., Lomas, P., et al. (2010b). The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics*, 69, 1209–1218.
- Gómez-Baggethun, E., Reyes-García, V., Olsson, P., et al. (2012). Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain. *Global Environmental Change*, 22(3), 640–650.

- Gotham, K., & Brumley, K. (2002). Using space: Agency and identity in a public-housing development. *City and Community*, 1, 267–289.
- Grahn, P., & Stigsdotter, U. A. (2003). Landscape planning and stress. *Urban Forestry and Urban Greening*, 2(1), 1–18.
- Grimm, N. B., Grove, J. M., Pickett, S. T. A., et al. (2000). Integrated approaches to long-term studies of urban ecological systems. *BioScience*, 50(7), 571–584.
- Grimm, N. B., Faeth, S. H., Golubiewski, N. E., et al. (2008). Global change and the ecology of cities. *Science*, 319(5864), 756–760.
- Groening, G. (1995). School garden and kleingaarten: For education and enhancing life quality. *Acta Horticulturae*, 391, 53–64.
- Grove, J. M., O'Neil-Dunne, J., Pelletier, K., et al. (2006). *A report on New York City's present and possible urban tree canopy prepared for NYC parks & recreation*. South Burlington: USDA Forest Service, Northeastern Research Station.
- Guo, Z., Zhang, L., & Li, Y. (2010). Increased dependence of humans on ecosystem services and biodiversity. *PLoS One*, 5, 1–7.
- Gutman, P. (2007). Ecosystem services: Foundations for a new rural–urban compact. *Ecological Economics*, 62, 383–387.
- Hanski, I., & Mononen, T. (2011). Eco-evolutionary dynamics of dispersal in spatially heterogeneous environments. *Ecology Letters*, 14(10), 1025–1034.
- Hardin, P. J., & Jensen, R. R. (2007). The effect of urban leaf area on summertime urban surface kinetic temperatures: A Terre Haute case study. *Urban Forestry and Urban Greening*, 6, 63–72.
- Herrington, L. P. (1976). Effect of vegetation on the propagation of noise in the out-of-doors. *USDA Forest Service General Technical Report, US Rocky Mountain Forest Range Experimental Station*, 25, 229–233.
- Hofrichter, R. (1993). *Toxic struggles: The theory and practice of environmental justice*, foreword by Lois Gibbs. Philadelphia: New Society Publishers.
- Hornborg, A. (1998). Toward an ecological theory of unequal exchange: Articulating world system theory and ecological economics. *Ecological Economics*, 25(1), 127–136.
- Hougnér, C., Colding, J., & Söderqvist, T. (2006). Economic valuation of a seed dispersal service in the Stockholm national urban park, Sweden. *Ecological Economics*, 59(3), 364–374.
- Hu, Z., Liebens, J., & Rao, K. R. (2008). Linking stroke mortality with air pollution, income, and greenness in northwest Florida: An ecological geographical study. *International Journal of Health Geographics*, 7, 20.
- Ishii, M. (1994). Measurement of road traffic noise reduced by the employment of low 848 physical barriers and potted vegetation. *Inter-noise*, 29–31, 595–597.
- Jacobi, P., Amend, J., & Kiango, S. (2000). Urban agriculture in Dar es Salaam: Providing for an indispensable part of the diet. In N. Bakker, M. Dubbeling, S. Gündel, et al. (Eds.), *Growing cities, growing food, urban agriculture on the policy agenda. A Reader on Urban Agriculture* (pp. 257–284). Feldafing: Zentralstelle für Ernährung und Landwirtschaft (ZEL) Food and Agriculture Development Centre.
- Jansson, Å. (2013). Reaching for a sustainable, resilient urban future using the lens of ecosystem services. *Ecological Economics*, 86, 285–291.
- Jansson, Å., & Polasky, S. (2010). Quantifying biodiversity for building resilience for food security in urban landscapes: Getting down to business. *Ecology and Society*, 15(3), 20.
- Jim, C. Y., & Chen, W. Y. (2006). Impacts of urban environmental elements on residential housing prices in Guangzhou (China). *Landscape and Urban Planning*, 78(4), 422–434.
- Jo, H.-K., & McPherson, G. E. (1995). Carbon storage and flux in urban residential greenspace. *Journal of Environmental Management*, 45(2), 109–133.
- Jorgensen, A., & Anthopoulou, A. (2007). Enjoyment and fear in urban woodlands – Does age make a difference? *Urban Forestry and Urban Greening*, 6(4), 267–278.
- Kaczynski, A. T., & Henderson, K. A. (2007). Environmental correlates of physical activity: A review of evidence about parks and recreation. *Leisure Science*, 29(4), 315–354.
- Kaplan, R. (1983). The analysis of perception via preference: A strategy for studying how the environment is experienced. *Landscape and Urban Planning*, 12, 161–176.

- Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge: CUP Archive.
- Karathanasis, A. D., Potter, C. L., & Coyne, M. S. (2003). Vegetation effects on fecal bacteria, BOD, and suspended solid removal in constructed wetlands treating domestic wastewater. *Ecological Engineering*, 20, 157–169.
- Kázmierczak, A. (2013). The contribution of local parks to neighbourhood social ties. *Landscape and Urban Planning*, 109, 31–44.
- Kerr, A. M., & Baird, A. H. (2007). Natural barriers to natural disasters. *BioScience*, 57(2), 102–103.
- Kim, K. S., Park, S. J., & Kweon, Y.-J. (2007). Highway traffic noise effects on land price in an urban area. *Transportation Research Part D: Transport and Environment*, 12(4), 275–280.
- Konijnendijk, C. C., Annerstedt, M., Busse Nielsen, A., & Maruthaveeran, S. (2013). *Benefits of urban parks a systematic review*. Copenhagen/Alnarp: International Federation of Parks and Recreation Administration (IFPRA).
- Korpela, K. M., & Ylén, M. (2007). Perceived health is associated with visiting natural favourite places in the vicinity. *Health & Place*, 13(1), 138–151.
- Koskela, H., & Pain, R. (2000). Revisiting fear and place: Women's fear of attack and the built environment. *Geoforum*, 31(2), 269–280.
- Kragh, J. (1981). Road traffic noise attenuation by belts of trees. *Journal of Sound and Vibration*, 74(2), 235–241.
- Krasny, M., & Tidball, K. (2009). Community gardens as contexts for science, stewardship, and civic action learning. *Cities and the Environment (CATE)*, 2(1), 1–18.
- Kremen, C. (2005). Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters*, 8(5), 468–479.
- Kroll, C. A., & Cray, A. F. (2010). *Hedonic valuation of residential resource efficiency variables: A review of the literature*. Berkeley: University of California.
- Kruuse, A. (2011). GRaBS expert paper 6: The green space factor and the green points system. In GRaBS (Ed.), *The GRaBS project*. London: Town and Country Planning Association & GRaBS.
- Lafortezza, R., Carrus, G., Sanesi, G., et al. (2009). Benefits and well-being perceived by people visiting green spaces in periods of heat stress. *Urban Forestry and Urban Greening*, 8(2), 97–108.
- La Rosa, D., & Privitera, R. (2013). Characterization of non-urbanized areas for land-use planning of agricultural and green infrastructure in urban contexts. *Landscape and Urban Planning*, 109, 94–106.
- Lannas, K. S. M., & Turpie, J. K. (2009). Valuing the provisioning services of wetlands: Contrasting a rural wetland in Lesotho with a peri-urban wetland in South Africa. *Ecology and Society*, 14(20), 18.
- Lee, R., & Maheswaran, A. C. K. (2010). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health*, 3(2), 212–222.
- Le Maitre, D. C., Van Wilgen, B. W., Chapman, R. A., et al. (1996). Invasive plants and water resources in the western cape province, South Africa: Modeling the consequences of a lack of management. *Journal of Applied Ecology*, 33(1), 161–172.
- Leggett, C. G., & Bockstael, N. E. (2000). Evidence of the effects of water quality on residential land prices. *Journal of Environmental Economics and Management*, 39(2), 121–144.
- Limburg, K. E., O'Neill, R. V., Costanza, R., et al. (2002). Complex systems and valuation. *Ecological Economics*, 41(3), 409–420.
- Lovasi, G. S., Quinn, J. W., Neckerman, K. M., et al. (2008). Children living in areas with more street trees have lower prevalence of asthma. *Journal of Epidemiology and Community Health*, 62(7), 647–649.
- Lundberg, J., Andersson, E., Cleary, G., et al. (2008). Linkages beyond borders: Targeting spatial processes in fragmented urban landscapes. *Landscape Ecology*, 23(6), 717–726.
- Lundy, L., & Wade, R. (2011). Integrating sciences to sustain urban ecosystem services. *Progress in Physical Geography*, 35(5), 653–669.
- Lyytimäki, J., & Sipilä, M. (2009). Hopping on one leg – The challenge of ecosystem disservices for urban green management. *Urban Forestry and Urban Greening*, 8(4), 309–315.

- Lyytimäki, J., Petersen, L. K., Normander, B., et al. (2008). Nature as a nuisance? Ecosystem services and disservices to urban lifestyle. *Environmental Sciences*, 5(3), 161–172.
- MA. (2005). *Millennium ecosystem assessment: Ecosystems and human well-being: Synthesis*. Washington, DC: Island Press.
- Maas, J., Verheij, R. A., Groenewegen, P. P., et al. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology & Community Health*, 60(7), 587–592.
- Maas, J., van Dillen, S. M., Verheij, R. A., et al. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health & Place*, 15(2), 586–595.
- Martinez Alier, J. (2002). *The environmentalism of the poor. A study of ecological conflicts and valuation*. Cheltenham, Northampton: E. Elgar.
- Martínez Alier, J. (2005). *Political ecology as the study of ecological distribution conflicts*. Lecture held on 12 April 2007 on the occasion of ‘Thinking ahead’, Heinrich Böll Foundation and Wuppertal Institute for Climate, Environment and Energy, Berlin.
- Martinez Alier, J., Munda, G., & O’Neill, J. (1998). Weak comparability of values as a foundation for ecological economics. *Ecological Economics*, 26(3), 277–286.
- Martín-López, B., Gómez-Baggethun, E., García-Llorente, M., & Montes, C. (2013). Trade-offs across value-domains in ecosystem service assessment. *Ecological Indicators*, doi:<http://dx.doi.org/10.1016/j.ecolind.2013.03.003>.
- Maxwell, D. (1999). The political economy of urban food security in Sub-Saharan Africa. *World Development*, 27(11), 1939–1953.
- Mbaye, A., & Moustier, P. (2000). Market-oriented urban agricultural production in Dakar. In N. Bakker, M. Dubbeling, S. Gündel, et al. (Eds.), *Growing cities, growing food, urban agriculture on the policy agenda. A Reader on Urban agriculture* (pp. 257–284). Zentralstelle für Ernährung und Landwirtschaft (ZEL) Food and Agriculture Development Centre, Germany.
- McDonald, R., & Marcotullio, P. (2011). Global effects of urbanization on ecosystem services. In J. H. Breuste, G. Guntenspergen, N. E. McIntyre, et al. (Eds.), *Urban ecology: Patterns, processes, and applications*. Oxford: Oxford University Press.
- McGrath, B., & Pickett, S. T. A. (2011). The metacity: A conceptual framework for integrating ecology and urban design. *Challenges*, 2, 55–72.
- McPhearson, P. T., & Tidball, K. G. (2012). Disturbances in urban social-ecological systems: Niche opportunities for environmental education. In: M. Krasny, J. Justin Dillon, & P. Lang (Eds.), *Trading zones in environmental education: Creating transdisciplinary dialogue*. New York.
- McPhearson, T. (2011). Toward a sustainable New York City: Greening through urban forest restoration. In E. Slavin (Ed.), *Sustainability in America’s Cities: Creating the Green Metropolis* (pp. 181–204). Island Press: Washington, DC.
- McPherson, E. G. (1998). Atmospheric carbon dioxide reduction by Sacramento’s urban forest. *Journal of Arboriculture*, 24, 215–223.
- McPherson, E. G., & Simpson, J. R. (1999). *Carbon dioxide reduction through urban forestry: Guidelines for professional and volunteer tree planters*. USDA Forest Service Pacific Southwest Research Station General Technical Report PSW-GTR-171, Berkeley, CA.
- McPherson, E. G., Nowak, D., Heisler, G., et al. (1997). Quantifying urban forest structure, function, and value: The Chicago urban forest climate project. *Urban Ecosystems*, 1(1), 49–61.
- McPherson, G. E. (1992). Accounting for benefits and costs of urban greenspace. *Landscape and Urban Planning*, 22(1), 41–51.
- McPherson, G., Simpson, J. R., Peper, P. J., et al. (1999). Benefit-cost analysis of Modesto’s municipal urban forest. *Journal of Arboriculture*, 25(5), 235–248.
- Meehl, G. A., & Tebaldi, C. (2004). More intense, more frequent, and longer lasting heat waves in the 21st century. *Science*, 305(5686), 994–997.
- Melles, S. U. O., Glenn, S. M. G., & Martin, K. O. B. (2003). Urban bird diversity and landscape complexity: Species–environment associations along a multiscale habitat gradient. *Conservation Ecology*, 7(1), 5. Online.

- Miller, C. C., Mitchel, J. P., & Mcaneny, G. (1913). *Report of the Mayor's market commission of New York City search*. New York: J.J. Little & Ives.
- Moreno-Garcia, M. C. (1994). Intensity and form of the urban heat island in Barcelona. *International Journal of Climatology*, 14(6), 705–710.
- Moskow, A. (1999). Havana's self-provision gardens. *Environment and Urbanization*, 11(2), 127–134.
- Moustier, P. (2007). Urban horticulture in Africa and Asia, an efficient corner food supplier. *ISHS Acta Horticulturae*, 762, 145–158.
- Müller, N., Werner, P., & Kelcey, J. G. (2010). *Urban biodiversity and design*. Oxford: Wiley.
- Musungu, K., Motala, S., & Smit, J. (2012). Using multi-criteria evaluation and GIS for flood risk analysis in informal settlements of Cape Town: The case of graveyard pond. *South African Journal of Geomatics*, 1(1), 77–91.
- Nelson, E., Mendoza, G., Regetz, J., et al. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*, 7(1), 4–11.
- New York City. (2007). *PlaNYC A greener, greater New York*. New York: New York City.
- New York City. (2011). *PlaNYC A greener, greater New York*: Update April 2011. New York: New York City.
- New York Sea Grant. (2001). *The economic contribution of the sport fishing, commercial fishing and seafood industries to New York State*. New York Sea Grant Institute, Stony Brook, NY.
- New York State Department of Environmental Conservation. (2010). *New York state industrial timber harvest production and consumption*. Albany: New York State Department of Environmental Conservation.
- Newman, O. (1981). *Community of interest*. New York: Anchor Books.
- Niemelä, J., Breuste, J. H., Guntenspergen, G., et al. (2011). *Urban ecology: Patterns, processes, and applications*. Oxfordshire: Oxford University Press.
- Norton, B. G., & Hannon, B. (1997). Environmental values: A place-based theory. *Environmental Ethics*, 19(3), 227–245.
- Nowak, D. J. (1994a). Air pollution removal by Chicago's urban forest. In E. G. McPherson, D. J. Nowak, & R. A. Rowntree (Eds.), *Chicago's urban forest ecosystem: Results of the Chicago urban forest climate project* (pp. 63–81). Radnor: U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station.
- Nowak, D. J. (1994b). Atmospheric carbon dioxide reduction by Chicago's urban forest. In E. G. McPherson, D. J. Nowak, & R. A. Rowntree (Eds.), *Chicago's urban forest ecosystem: Results of the Chicago urban forest climate project* (pp. 83–94). Radnor: U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station.
- Nowak, D. J. (1996). Notes: Estimating leaf area and leaf biomass of open-grown deciduous urban trees. *Forest Science*, 42(4), 504–507.
- Nowak, D. J., & Crane, D. E. (2000). The urban forest effects (UFORE) model: Quantifying urban forest structure and functions. In M. Hansen & T. Burk (Eds.), *Integrated tools for natural resource inventories in the 21st century* (pp. 714–720). St. Paul: North Central Research Station.
- Nowak, D. J., & Crane, D. E. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution*, 116(3), 381–389.
- Nowak, D. J., Hoehn, R. E., III, Crane, D. E., et al. (2007a). *Assessing urban forest effects and values New York City's urban forest*. USDA Forest Service Northern Research Station Resource Bulletin NRS-9, Newtown Square PA.
- Nowak, D. J., Hoehn, R. E., III, Crane, D. E., et al. (2007b). *Assessing urban forest effects and values: Philadelphia's urban forest*. USDA Forest Service Northern Research Station Resource Bulletin NRS-7, Newtown Square PA.
- Núñez, M., Jordi, O.-S., Joan, R., et al. (2010, June). Water management in integrated service systems: Accounting for water flows in urban areas. *Water Resources Management*, 24(8), 1583–1604. doi:[10.1007/s11269-009-9515-1](https://doi.org/10.1007/s11269-009-9515-1). <http://dx.doi.org/10.1007/s11269-009-9515-1>.

- NYC Environmental Protection. (2010a). *New York City 2010 drinking water supply and quality report. Water Supply*. New York: New York City Department of Environmental Protection.
- NYC Environmental Protection. (2010b). *NYC green infrastructure plan: A sustainable strategy for clean waterways*. New York City Department of Environmental Protection. New York: NY.
- Oberndorfer, E., Lundholm, J., Bass, B., et al. (2007). Green roofs as urban ecosystems: Ecological structures, functions, and services. *BioScience*, 57(10), 823.
- O'Farrell, P. J., Anderson, P. M. L., Le Maitre, D. C., et al. (2012). Insights and opportunities offered by a rapid ecosystem service assessment in promoting a conservation agenda in an urban biodiversity hotspot. *Ecology and Society*, 17(3), 27.
- Ohta, M., Mizoue, T., Mishima, N., et al. (2007). Effect of the physical activities in leisure time and commuting to work on mental health. *Journal of Occupational Health*, 49(1), 46–52.
- Page, B. (2002). Urban agriculture in Cameroon: An anti-politics machine in the making? *Geoforum*, 33(1), 41–54.
- Pascual, U., Muradian, R., Rodríguez, L. C., et al. (2010). Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. *Ecological Economics*, 69(6), 1237–1244.
- Pataki, D. E., Carreiro, M. M., Cherrier, J., et al. (2011). Coupling biogeochemical cycles in urban environments: Ecosystem services, green solutions, and misconceptions. *Frontiers in Ecology and the Environment*, 9(1), 27–36.
- Pathak, V., Tripathi, B. D., & Mishra, V. K. (2007). Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation. *Environmental Monitoring and Assessment*, 146(1–3), 67–75.
- Patton, M. Q. (2001). *Qualitative research and evaluation methods*. Thousand Oaks: SAGE.
- Pauleit, S., et al. (2002). Tree establishment practice in towns and cities: Results from a European survey. *Urban Forestry and Urban Greening*, 1(2), 83–96.
- Peper, P. J., McPherson, E. G., Simpson, J. R., et al. (2007). *New York City, New York municipal forest resource analysis*. New York: Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station.
- Pérez, L., Sunyer, J., & Künzli, N. (2009). Estimating the health and economic benefits associated with reducing air pollution in the Barcelona metropolitan area (Spain). *Gaceta Sanitaria*, 23(4), 287–294. doi:10.1016/j.gaceta.2008.07.002. <http://linkinghub.elsevier.com/retrieve/pii/S0213911108000046>
- Peters, C. J., Wilkins, J. L., & Fick, G. W. (2007). Testing a complete-diet model for estimating the land resource requirements of food consumption and agricultural carrying capacity: The New York State example. *Renewable Agriculture and Food Systems*, 22(2), 145–153.
- Peters, C. J., Bills, N. L., Lembo, A. J., et al. (2009). Mapping potential foodsheds in New York State: A spatial model for evaluating the capacity to localize food production. *Renewable Agriculture and Food Systems*, 24(1), 72–84.
- Petersen, L. M., Moll, E. J., Collins, R., et al. (2012). Development of a compendium of local, wild-harvested species used in the informal economy trade, Cape Town, South Africa. *Ecology and Society*, 17(2), 26.
- Pickett, S. T. A., Cadenasso, M. L., Grove, J. M., et al. (2001). Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics*, 32(1), 127–157.
- Pilgrim, S. E., Cullen, L. C., Smith, D. J., & Pretty, J. (2008). Ecological knowledge is lost in wealthier communities and countries. *Environmental Science and Technology*, 42(4), 1004–1009.
- Pires, M. (2004). Watershed protection for a world city: The case of New York. *Land Use Policy*, 21(2), 161–175. doi:10.1016/j.landusepol.2003.08.001.
- Pitt, T., & Boulle, P. (2010). *Growing together: Thinking and practice of urban nature conservators*. Cape Town: SANBI Cape Flats Nature.
- Pouyat, R. V., Yesilonis, I. D., & Nowak, D. J. (2006). Carbon storage by urban soils in the United States. *Journal of Environment Quality*, 35(4), 1566.

- Rall, E. L., & Haase, D. (2011). Creative intervention in a dynamic city: A sustainability assessment of an interim use strategy for brownfields in Leipzig, Germany. *Landscape and Urban Planning*, 100, 189–201.
- Rebelo, A. G., Holmes, P. M., Dorse, C., et al. (2011). Impacts of urbanization in a biodiversity hotspot: Conservation challenges in Metropolitan Cape Town. *South African Journal of Botany*, 77, 20–35.
- Rees, W. E. (1992). Ecological footprints and appropriated carrying capacity: What urban economics leaves out. *Environment and Urbanization*, 4(2), 121–130.
- Rees, W. E., & Wackernagel, M. (1996). Urban ecological footprint: Why cities cannot be sustainable – And why they are a key to sustainability. *Environmental Impact Assessment Review*, 16, 223–248.
- Roca, E. (2000). *Montjuïc, la muntanya de la ciutat*. Barcelona: Institut d'Estudis Catalans, Secció de Ciències i Tecnologia.
- Rosenzweig, C., Solecki, W. D., Cox, J., et al. (2009). Mitigating New York City's heat island: Integrating stakeholder perspectives and scientific evaluation. *Bulletin of the American Meteorological Society*, 90(9), 1297–1312. doi:10.1175/2009BAMS2308.1.
- Sander, H., Polasky, S., & Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. *Ecological Economics*, 69(8), 1646–1656.
- Scheffer, M., Carpenter, S., Foley, J., et al. (2001). Catastrophic shifts in ecosystems. *Nature*, 413(6856), 591–596.
- Scott, K. I., McPherson, E. G., & Simpson, J. R. (1998). Air pollutant uptake by Sacramento's urban forests. *Journal of Arboriculture*, 24, 224–232.
- Seto, K. C., Reenberg, A., & Boone, C. G., et al. (2012). Urban land teleconnections and sustainability. *Proceedings of the National Academy of Sciences*, 109(20), 7687–7692.
- Shamai, S. (1991). Sense of place: An empirical measurement. *Geoforum*, 22(3), 347–358.
- Shuster, W., Morrison, M., & Webb, R. (2008). Front-loading urban stormwater management for success: A perspective incorporating current studies on the implementation of retrofit low-impact development. *Cities and the Environment (CATE)*, 1(2), Article 8.
- Simpson, J. R. (1998). Urban forest impacts on regional cooling and heating energy use: Sacramento County case study. *Journal of Arboriculture*, 24(4), 201–214.
- Smit, J., & Nasr, J. (1992). Urban agriculture for sustainable cities: Using wastes and idle land and water bodies as resources. *Environment and Urbanization*, 4(2), 141–152.
- Smith, K., & Huang, J. C. (1995). Can markets value air quality? A meta analysis of hedonic property value models. *Journal of Political Economy*, 103(1), 209–227.
- Stokols, D. (1990). Instrumental and spiritual views of people–environment relations. *American Psychologist*, 45, 641–646.
- Takano, T., Nakamura, K., & Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas: The importance of walkable green spaces. *Journal of Epidemiology and Community Health*, 56(12), 913–918.
- Taylor, A. F., & Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders*, 12(5), 402–409.
- TEEB. (2010). *The economics of ecosystems and biodiversity*. Ecological and Economic Foundations. Earthscan London and Washington.
- The Economics of Ecosystems and Biodiversity (TEEB). (2011). *TEEB manual for cities: Ecosystem services in urban management*. www.teebweb.org
- TEEB. (2012). In H. Wittmer & H. Gundimeda (Eds.), *The economics of ecosystems and biodiversity in local and regional policy and management*. London/Washington, DC: Earthscan from Routledge.
- Tidball, K. G., & Krasny, M. E. (2010). Urban environmental education from a conceptual framework for civic ecology education. *Environment*, 3(1), 1–20.
- Toll, I., & Baldasano, J. M. (2000, January). Modeling of photochemical air pollution in the Barcelona area with highly disaggregated anthropogenic and biogenic emissions. *Atmospheric Environment*, 34(19), 3069–3084. doi:10.1016/S1352-2310(99)00498-7. <http://linkinghub.elsevier.com/retrieve/pii/S1352231099004987>.

- Troy, A., & Grove, J. M. (2008). Property values, parks, and crime: A hedonic analysis in Baltimore, MD. *Landscape and Urban Planning*, 87(3), 233–245.
- Troy, A., & Wilson, M. A. (2006). Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer. *Ecological Economics*, 60(2), 435–449.
- Turpie, J. K., Heydenrych, B. J., & Lamberth, S. J. (2003). Economic value of terrestrial and marine biodiversity in the Cape floristic region: implications for defining effective and socially optimal conservation strategies. *Biological Conservation*, 112(1–2), 233–251.
- Tyrväinen, L. (1997). The amenity value of the urban forest: An application of the hedonic pricing method. *Landscape and Urban Planning*, 37(3–4), 211–222.
- Tyrväinen, L., & Miettinen, A. (2000). Property prices and urban forest amenities. *Journal of Environmental Economics and Management*, 39(2), 205–223.
- Tyrväinen, L., Pauleit, S., Seeland, K., et al. (2005). Benefits and uses of urban forests and trees. In C. C. Konijnendijk, K. Nilsson, T. B. Randrup, et al. (Eds.), *Urban forests and trees: A reference book* (pp. 81–114). Heidelberg: Springer.
- Tzoulas, K., Korpela, K., Venn, S., et al. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and Urban Planning*, 81(3), 167–178.
- Ulrich, R. S. (1981). Natural versus urban sciences: Some psycho-physiological effects. *Environment and Behaviour*, 13, 523–556.
- Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, 224, 420–421.
- UNEP. (1996). *Urban agriculture: Food, jobs and sustainable cities*. In: *Publication series for habitat II* (302pp.). New York: United Nations Development Programme
- US Environmental Protection Agency. (2001). *Frequently asked questions about atmospheric deposition: A handbook for watershed managers*. Washington, DC: Environmental Protection.
- USDA Forest Service. (2007a). *2007 census of agriculture – State data, New York Table 1. Historical highlights*. Washington, DC: USDA.
- USDA Forest Service. (2007b). *New York City, New York: Municipal forest resource analysis*. New York: Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station Davis, CA for Department of Parks and Recreation New York City.
- van den Berg, A. E., Maas, J., Verheij, R. A., et al. (2010a). Green space as a buffer between stressful life events and health. *Social Science & Medicine*, 70(8), 1203–1210.
- van den Berg, A. E., van Winsum-Westra, M., de Vries, S., & van Dillen, S. M. E. (2010b). Allotment gardening and health: A comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental Health*, 9, 74. doi:10.1186/1476-069X-9-74.
- Van Wilgen, B. W., Le Maitre, D. C., & Cowling, R. M. (1998). Ecosystem services, efficiency, sustainability and equity: South Africa's Working for Water Programme. *TREE*, 13(9), 378.
- Vauramo, S., & Setälä, H. (2010). Decomposition of labile and recalcitrant litter types under different plant communities in urban soils. *Urban Ecosystems*, 14(1), 59–70.
- Villarreal, E. L., & Bengtsson, L. (2005). Response of a Sedum green-roof to individual rain events. *Ecological Engineering*, 25, 1–7.
- Voicu, I., & Been, V. (2008). The effect of community gardens on neighboring property values. *Real Estate Economics*, 36, 241–283.
- Wagner, I., Marshalek, J., & Breil, P. (2007). *Aquatic habitats in sustainable urban water management: Science, policy and practice*. Leiden: Taylor & Francis/Balkema.
- Walker, B., & Meyers, J. A. (2004). Thresholds in ecological and social-ecological systems: A developing database. *Ecology and Society*, 9(2), 3. Online.
- Walker, B., Pearson, L., Harris, M., et al. (2010). Incorporating resilience in the assessment of inclusive wealth: An example from South East Australia. *Environmental and Resource Economics*, 45(2), 183–202.
- Watershed Agricultural Council. (2011). *2010 Annual report*. Program. New York: Walton.
- Watershed Agricultural Council. (2012). *Watershed agricultural council: Working farms + healthy forests = clean drinking water*. Retrieved February 20, 2012, from <http://www.nycwatershed.org/index.html>

- Williams, D. R., & Roggenbuck, J. W. (1989). *Measuring place attachment: Some preliminary results*. Blacksburg: Department of Forestry, Virginia Polytechnic Institute & State University.
- Williams, D. R., Patterson, M. E., & Roggenbuck, J. W. (1992). Beyond the commodity metaphor: Examining emotional and symbolic attachment to place. *Leisure Science*, 14, 29–46.
- Xiao, Q., McPherson, E. G., Simpson, J. R., et al. (1998). Rainfall interception by Sacramento's urban forest. *Journal of Arboriculture*, 24(4), 235–244.
- Zahran, S., Brody, S. D., Vedlitz, A., et al. (2008). Vulnerability and capacity: Explaining local commitment to climate-change policy. *Environment and Planning C: Government and Policy*, 26(3), 544–562.
- Zetterberg, A. (2011). *Connecting the dots: network analysis, landscape ecology, and practical application*. Doctoral dissertation, KTH Royal Institute of Technology, Stockholm.

ECOSYSTEM SERVICES IN NEW ZEALAND CITIES

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ABSTRACT: Urban ecosystem services affect and benefit all levels of New Zealand's urban population. They are not confined to green spaces or places with indigenous or any one kind of biodiversity. Ecosystem services are of especial significance in cities, mainly through regulating services that affect water quality, stormwater, flood and erosion control, waste disposal and air quality, and cultural services such as recreation, health and well-being, and contributing to a sense of place. These cultural services are particularly difficult to value economically, but are clearly valued very highly by most urban residents and contribute significantly to quality of life and social capital in cities, with consequences for mental well-being, innovation, and economic activity.

Focusing on known high-productivity ecosystems such as waterways, wetlands, estuaries, and areas of high quality soils can boost urban ecosystem services most effectively. High quality soils in peri-urban areas are important for food production or for contributing to biodiversity through remnants or green belts. Flourishing peri-urban agriculture using short, environmentally sensitive transport links, can not only supply food efficiently, but also help shape an agri-food system in which people have equitable access to fresh, nutritious food. Water regulation and flood control needs to use a city-wide approach or at least a catchment-wide approach in key catchments. For urban and peri-urban agriculture to be sustainable and healthy, air-borne and water-borne toxins must be ameliorated.

There is a significant potential for urban design to increase benefits from ecosystem services – amenity of both public and private areas including domestic houses and gardens, access to green and blue spaces, recreation opportunities, clean water, quality of environment generally and biodiversity. Every city has potential to become an 'eco-city' with the 'transition town' process being one pathway. This can effectively lower New Zealand's ecological footprint and progressively lead to improved quality of life for 85% of the total population.

Key words: air quality, blue space, green space, peri-urban, stormwater, recreation, social capital, transport links, urban population, waste disposal.

INTRODUCTION

The concept of ecosystem services arose from a concern that modern human societies have a limited understanding of how their well-being depends on the health of natural ecosystems. There was concern, especially, that degradation of large natural ecosystems of the world – such as the rainforests, tundra, grasslands, rivers, and ocean ecosystems – threatened the long-term sustainability of human life on the planet (e.g. Ninan 2008). While this remains one of the main ideas driving the concept, ecologists have since moved to broaden the scope to include less visible natural services embedded in cultural landscapes, that are nevertheless very significant. Further, ecologists are now inclined to view cities themselves as ecosystems, and are learning how the health of these ecosystems depends in turn on the health of component natural, or quasi-natural constructed ecosystems. Streets, roofs, walls, derelict areas, gardens, lawns, and open drains are occupied or continually being colonised by plants and animals, and play important ecological roles in the urban landscape. Like their natural counterparts, these distinctively urban ecosystems (Kotze et al. 2011) exhibit a condition and dynamism that results from on-going stress and disturbance (Grime 1977; Meurk 2004), and their benefits to the wider landscape can legitimately be viewed as ecosystem services. They are the urban counterparts to habitats found in nature – the stressed canyons, cliffs, outcrops, ledges, karst, sandy or stoney soils, dry savannah woodlands and cold tundra, and the disturbed landslide surfaces, riverbeds, beaches, rangelands, and wind-throw patches.

Globally, urban ecosystem services directly affect the well-being of more than 3 billion people, as more than half of the world's population now live in cities (Colding 2011, p. 229).

Some of these services are more important to urban inhabitants than others. The water provisioning and regulatory services provided by urban ecosystems are just as important as the provisioning services of rural ecosystems such as farmlands, while food production services of urban ecosystems may be less significant – but with the potential to increase (Morgan 2010). Our understanding of many urban ecosystem services is far from complete and benefits hitherto underestimated or unknown are now becoming better documented (Ealing LA21 2005). There is growing understanding of the importance of urban ecosystems in regulating the climate and pollution levels within cities, with consequences for human health and mortality rates, and researchers have documented both physiological and psychological health benefits of green space on human well-being (Sadler et al. 2010), especially in industrialised cities (Kuo 2010).

The new importance attached to urban ecosystems and ecosystem services has been recognised in the major international ecosystem assessments performed in the last decade. Urban ecosystems were included within the frameworks of both the Millennium Ecosystem Assessment (MEA 2005) and the United Kingdom National Ecosystem Assessment (UK NEA 2011) (Davies et al. 2010), although the authors of these assessments have noted that assembling meaningful datasets is hindered by the wide range of contributing organisations and differing descriptive typologies (Mace and Bateman 2011).

New Zealand is a green country, even in the cities. Compared with many other urban societies, New Zealanders have high exposure to green space, and correspondingly greater potential to benefit from urban ecosystem services. While urban-dwellers now make up around 85% of its total population (Mulet-Marquis

TABLE 1 Population density, percentage of total population and land area of urban areas in New Zealand (Source: Statistics New Zealand 2004)

Type of area	Population density (per km ²)	Percentage of NZ population	Percentage of NZ land area
Main urban area	522.8	71.1	1.9
Satellite urban community	232.1	3.0	0.2
Independent urban community	265.9	11.7	0.6
Rural areas with high urban influence	12.9	2.6	2.8

Note: International comparisons with these data are very difficult to make because of variable definitions of different types of urban areas, and resulting variability of density figures. Urban densities range up to 43,100 per km² in Asia (eg Manila, Delhi, Kolkata), 20 700 in Europe (eg Paris, Athens, Barcelona) and 10 200 in USA (eg New York City, San Francisco, Boston) (data from Wikipedia at http://en.wikipedia.org/wiki/List_of_cities_proper_by_population_density)

and Fairweather 2008), urban population densities have remained very low (Table 1), by international standards. Urban areas are generally greener, private gardens larger, and city parks more accessible than in cities elsewhere. Residents in three out of four New Zealand neighbourhoods are estimated to be able to travel by car to some kind of park in less than two and a half minutes, and 65% of the population lives within 5 kilometres of the sea (Witten et al. 2008). Nevertheless, we take many of these advantages and benefits for granted, and urban planners and designers need better information to ensure that green infrastructure is developed and managed appropriately, especially given the demands for more compact cities that minimise greenhouse gas emissions and pressures on surrounding arable lands. It has to also be recognised that the urban greenness in New Zealand has low biodiversity quality in that the bulk of lawns, gardens, shrubs and trees are introduced and even potentially pest species (Meurk et al. 2009).

In this chapter, we review the ecosystem services provided by urban ecosystems, examine some of the attempts at monetising these services, and then consider the challenges in planning and designing urban areas in such a way that ecosystem services are optimised. Our focus on the ‘green’ infrastructure of a city may seem restrictive, since many other elements of urban ecosystems provide ecological services, whether they be composting plants, waste treatment and recycling plants, industrial ecosystems, or environmental services from businesses or organisations, including schools and universities providing education and research services. This focus, however, is in keeping with the core intent of the ecosystem services concept, which has always been to provide a means for understanding and valuing the role that natural systems and their constructed counterparts play in underpinning the well-being of society.

PROVISION OF ECOSYSTEM SERVICES IN NEW ZEALAND CITIES

From the literature we have compiled the following inventory and commentary on provision of ecosystem services in New Zealand cities. It largely follows the format of Landcare Research’s standard classification of ecosystem services in New Zealand, under the headings of Direct Use, Indirect Use and Passive Value (Dymond et al. 2012), as used elsewhere in this book. Table 2 is based primarily on this classification but modified according to MEA (2005) and with reference to global literature including the UK National Ecosystem Assessment (UK

NEA 2011). The classification that we have adopted here, of indirect use values, particularly cultural services, is broader and more detailed than in Dymond et al. (2012), reflecting the human domination of urban ecosystems that are fundamentally directed at satisfying the economic, physical and cultural needs of their inhabitants. This contrasts with ‘natural’, wild or rural ecosystems in the hinterland where humans are much more sparsely distributed.

Ecosystem services with direct use values provide tangible material benefits or products, whether provisioning (1–8) or regulating (9–16) (Table 2). Ecosystem services with indirect use value essentially comprise all the cultural services. These contribute greatly to the sum total of what it is to be human, and are an essential component of sustainable development with a balance between ecological, social and economic values (Vejre et al. 2010), but are not easily measured in conventional economic terms.

DIRECT SERVICES

Crops

‘Crops’ includes all cultivated plant or agricultural produce harvested for human or animal consumption or medicine. The plants may be grown in commercial or private gardens. Historically, domestic vegetable gardens were very important as New Zealand cities grew (Dawson 2010). These were times when paid work was 40 hours a week, shop hours were restricted, and weekends were freer than now. Vegetable seedlings were germinated or bought, and nurtured by an urban population whose parents or grandparents were often farmers. Underpinning this informal production is soil quality, and it is unsurprising that urbanisation symbiotically expanded onto some of the most versatile soils in the country. Commercial or market gardens established around the periphery of cities to benefit from the fertile soils and feed the growing urban population. Some of these around Christchurch occupied drained peat and inevitably much stored carbon has been oxidised as the peat soils consolidated to the point where they can no longer be economically drained. Although some native species (e.g. mānuka - *Leptospermum scoparium*) produce pharmaceuticals that are marketed globally, and may have significance to indigenous peoples, this activity does not appear to have been conducted in urban areas. Some crops have been especially associated with urban Māori. Kūmara and taro have been planted in the north while puhā and watercress are collected from the semi-wild, subject to water quality.

Recent growth in community gardens, roof gardens, and allotments may be compensating to some extent for shrinking private and commercial gardens (Mathieu et al. 2007; Earle 2011). Similarly, the planting of fruit trees in newer parks may contribute to this service. In Auckland, feijoa and citrus have typically been planted in recent subdivisions such as Stonefields and Hobsonville parks, while pip fruit have been planted in areas such as Albany Civic Centre Park. The Dunedin Garden Study (Mathieu et al. 2007) set out, among other things, to understand the relationship of Dunedin householders to their gardens. In that city, domestic gardens were found to make up approximately 36% of urban land and 46% of the residential area, the largest single land use within the city. The role of gardens in producing nature has been explored in an eco-social context in Christchurch (Doody et al. 2010), while Wilcox (2012) has carried out a comprehensive evaluation of the tree assets of Auckland City including a wide variety of fruit and nut trees, which are being increasingly planted in streets, parks and schools (Figure 1). There is a well-used ‘NZ

TABLE 2 Summary of ecosystem services relevant to New Zealand urban areas

Ecosystem service	Definition (adapted from Dymond et al. 2012)	Where in NZ urban areas does it occur?
DIRECT USE VALUES		
Provisioning services		
1. Crops	Cultivated plant or agricultural produce harvested for human or animal consumption	Everywhere within urban limits – from rural land to CBD. Private and public. Includes community gardens and orchards, roof gardens and allotments, significant commercial (market) gardening
2. Animal products including aquaculture	Animals raised for domestic or commercial consumption or use. Includes fish reared in ponds, enclosures and other forms of fresh- or salt-water confinement for harvesting	Backyard chicken raising was relatively common in suburbs (probably declining). Limited elsewhere. Includes some traditional farming in enclosed or peripheral rural zones of cities. Aquaculture very limited
3. Fibre, fuel and biomass energy	Timber and wood fibre and biomass fuel from trees harvested from forest ecosystems, plantations or non-forest lands	Limited but some commercial timber plantations and firewood stands within rural limits. Harvesting of firewood takes place informally elsewhere
4. Other energy provision	Non-biomass renewable energy (e.g. wind, solar, hydro) generated within urban limits	Wind power within Wellington and Palmerston North cities (private and corporate). Dispersed solar power (building roofs); proposed elsewhere
5. Freshwater supply	Inland bodies of water, groundwater, rainwater and surface waters for household, industrial and agricultural uses	Freshwater for urban populations derived both from urban and peri-urban areas
6. Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology. Includes rare and threatened species	Gardens, natural areas, zoos, botanic gardens and arboreta
7. Physical support for structures	Places for secure and environmentally clean shelters and other structures	All built-on surfaces within urban areas
8. Provision of natural habitat and species niches	Habitat provided by ecosystems including fragments and remnants of previous natural areas and populations	Significant remnants and other habitats remain in many urban areas, in some cases critical because of extreme loss in intensively farmed lowlands. Habitats for biota in gardens and vegetated areas throughout cities
Regulating services*		
9. *Climate regulation	Influence ecosystems have on the global climate affecting carbon balance, both emission and absorption. Also includes local influences on climate, especially temperature	All permanently vegetated areas – effects of urban trees; green space, green roofs on domestic insulation and heat island effect
10. Runoff and stormwater regulation	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	Natural and constructed wetlands, vegetated waterways, detention and retention ponds
11. *Water purification, wastewater and solid waste treatment	Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water, and trapping of sediment; also assimilation and detoxification of compounds through soil and subsoil processes	Natural and constructed wetlands, vegetated waterways. Biological waste treatment plants. Treatment trains
12. *Human disease regulation	Influences ecosystems have on the incidence and abundance of human pathogens and communicable disease vectors	Everywhere. Public open space especially important where overcrowding, poor sanitation, hygiene and nutrition, and lack of outdoor activity occur in deprived urban areas
13. Pest regulation	Influence ecosystems have on the prevalence of crop and livestock pests and regulation	Mainly significant to the extent of urban agriculture, but beneficial insects may be present in many garden habitats
14. Pollination	Animal-assisted pollen transfer between plants, without which many plants cannot reproduce	Important in urban gardens, botanical gardens etc. Urban environments may provide habitats for beneficial insects and birds
15. *Air quality enhancement	Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e. serving as a source) or extracting chemicals from the atmosphere (i.e. serving as a sink)	Critical to quality of life in some cities especially where there is smog (e.g. Christchurch, Nelson)
16. Natural hazard and erosion regulation	Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes, floods, and tsunamis and to maintain natural fire frequency and intensity. Role vegetation plays in soil retention (mitigation / prevention of erosion)	Urban hill areas – Wellington, Dunedin, etc. Influence on flood occurrence and severity in many urban areas – Hutt Valley, Palmerston North, Invercargill, and many smaller towns and settlements
INDIRECT USE VALUES		
Cultural services		
17. Spiritual & religious values	Spiritual and religious values to ecosystems or their components	Many faith communities have urban retreat centres. Urban marae.
18. Aesthetic and amenity values	Natural characteristics of an area that contribute to people's appreciation of its beauty, pleasantness, aesthetic coherence, and cultural attributes	Natural areas, green spaces, neighbourhoods, other open spaces throughout urban areas
19. Cultural diversity and heritage values, including sense of place and social capital	Diversity of culture influenced by diversity of ecosystems and landscapes, i.e. all kinds of heritage. Also includes sense of identity and belonging to a place associated with recognised features of people's environment, and the social capital associated with those places	All ecosystem-associated neighbourhood or iconic places of cultural or personal urban significance. Social capital can be enhanced everywhere, especially where there are green areas adjacent to where people live

20. Health and well-being	Health and well-being benefits from contact with urban green/open/blue spaces, including recreational health benefits people derive from these spaces	Parks, open spaces and any habitats where active recreation or contact with open/ natural space takes place. New Zealanders have good access to both green and blue areas. Private and community gardens. Some variation in access between and within NZ cities but less than in other countries
21. Tourism	Recreational pleasure domestic or international tourists derive from natural or cultivated ecosystems; importance of uniqueness, point of difference from other parts of the world	Any ecosystem setting from CBD (not common except for very old facilities) to outskirts. Botanical gardens and/or zoos in all main centres
22. Education	Increasing knowledge and understanding of biodiversity, ecosystems and natural values and processes, from both formal and informal education and public awareness	All types of urban ecosystems, especially where there are green areas adjacent to where people live. Schools are important for school gardens and environmental education programmes
PASSIVE VALUES		
Option	Keeping options for future development or use potential, e.g. buffer zones, land banks	All places with above values
Existence	Value of knowing a natural ecosystem is present even if not used or visited. Includes intrinsic values of biodiversity (species and ecosystem levels)	All natural areas but especially those that are relatively wild
Bequest	Values available as bequest to future generations	All places with above values

** Note that almost all regulating services, but especially those marked with an asterisk, also have direct benefits for human health and well-being, listed here primarily as a cultural ecosystem service.*

Fruit and Food Share Map' (Google) that allows resources to be located when they are ripe.

In large European cities there has been a long tradition of public spaces allocated or leased for gardening. As intensification proceeds, growth of allotment/city gardening can compensate for loss or shrinking of private garden space (Ealing LA21 2005; Freeman et al. 2012). After a post-war lull, there are now long waiting lists for garden plots in many European cities (see <http://communitygarden.org.au/2002/10/11/looking-back-200/>).

The soils used for farming (urban and rural) provide ecosystem services themselves. They act as carbon sinks as well as sources and have the capacity to absorb rainfall, reduce stormwater peak flows, provide nutrients and a water supply buffer during drought (Ealing LA21 2005). In general, however, they are compacted and eroded and of low fertility and organic matter content compared with their rural counterparts (Effland and Pouyat 1997; Sauerwein 2011). Where they are derived from fertile alluvial soils, they can be nutrient suppliers but, at least in the past, rural soils have also been sources of contamination with persistent pesticides, fungicides and copper from former agricultural or horticultural land uses. Auckland and Wellington cities have both needed to remediate soils as suburbs have expanded

onto surrounding green fields. Residual arsenic, copper, lead and organo-chlorines (including forms of DDT) are the main contaminants detected on properties used for horticulture in Auckland. Common contaminants in urban areas in New Zealand are lead (from historical use in paint and petrol), arsenic (wood preservatives and pesticides) and polycyclic aromatic hydrocarbons (<http://www.healthychristchurch.org.nz/media/36557/contaminated-land.pdf>). At times excessive levels of pesticides and fertilisers may be applied to home gardens (CDM pers. obs.) that would leach to groundwater, reduce diversity of beneficial insects, pose health risks and lead to a kind of unhealthy dependency on high levels of chemical and artificial inputs. Redevelopment of brown-fields on former industrial or disposal sites may require removal or capping of contaminated soils and importation of clean soil.

We are unaware of national data on urban or peri-urban land use trends but there is some information in the most recent Auckland 'State of the Environment' report (Auckland Council 2010). In the Auckland Region (current Auckland Council area) between 1987 and 2006, the residential density of the urban area increased 24% to 25.7 people per hectare. Most of the population growth, however, was accommodated by a 24 % expansion of the urban area from 40 000 to 49 500 hectares. Pasture was still the most extensive type of land cover (50%) but it declined by about 2000 hectares (0.8%) between 1997 and 2002. Loss of prime agricultural land (Land Use Capability Classes I–III) to urbanisation over this period occurred at an average rate of 333.4 hectares per year. Horticultural use very slightly increased (210 hectares) between 2002 and 2007.

Greenfields subdivision continues to occur in Auckland, and fragmentation of rural land was most intense around the Auckland Metropolitan Urban Limits in the south-east and in the northern coastal areas. The efficiency of metropolitan urban limits as devices for encouraging sustainable urban development is currently a subject of intense regional and national debate. The draft Auckland Unitary Plan, currently under consultation, proposes a partial relaxation of these limits to offset negative impacts of increasing population density and impervious surfaces on environmental quality. Auckland is currently ranked in the top ten cities internationally for 'liveability' and its mayor aims to improve this standing.



FIGURE 1 Citrus, pip fruit, and feijoa planted in a recent public park in Auckland: Stonefields Park, St Johns.

These data from New Zealand's largest city suggest the trend overall is towards declining crop provision, particularly as encircled market gardens become defunct or converted to residential or other land uses with higher economic returns. Densification of suburbia causes loss of garden space, and less time and knowledge is available for home gardening. This cumulatively reduces the production from and benefits of urban gardens. This trend is probably compensated for only to a minor degree by the fledgling community garden movement. Nevertheless urban gardens undoubtedly provide an important outlet and fulfilment for many (Freeman et al. 2012).

Animal products

Most New Zealand cities include livestock-producing areas within their urban limits. Some of this land is farmed commercially, or is grazing land associated with oxidation ponds or meat works. In Auckland, regional parks and some of the larger city parks centred on volcanic cones are grazed for grass maintenance on areas too steep to mow. Among the peri-urban lifestyle blocks, boutique farming of horses, alpacas/llamas, goats, ostriches, etc. has occurred at the expense of commercial livestock farming. Domestic raising of animals for the pot (rabbits, guinea pigs, pigs, lambs, or ducks) seems to have found little favour in New Zealand – at least for the past 50 years or so. Until the 1960s, having hens in urban gardens was not uncommon. In recent decades there has been a steadily growing appetite for 'back to nature', organic or free-range production systems. Some of the land uses represent environmental innovations, such as grazing by sheep of wetland turfs to maintain small indigenous herbaceous species against competition from dense exotic grasses – a service towards biodiversity. A population of sheep descended from subantarctic Campbell Island is farmed at Travis Wetland Nature Heritage Park, preserving both sheep genetic material and uncommon native plants in the 'grazing marsh'. Overall there has probably been a downward trend in animal products derived directly from urban holdings, but with some localised increases. Urban hens and bees may have shown a recent modest increase, but because they are non-notified activities, there are no readily available statistics.

Fishing and aquaculture

Recreationally caught fish form a significant proportion of New Zealand's total catch for some species. For example, recreational landings of snapper formed 34% of the total catch in 2008 (Ministry of Agriculture and Fisheries unpublished data 2008, cited in Carbine 2011). Much of this would have come from boats domiciled within Auckland and other North Island cities and fishing within the coastal marine zone, and the waters of the Hauraki Gulf and Waitemata Harbour.

There are no documented studies of ecosystem services from commercial aquaculture in New Zealand urban areas, and attempts to create urban aquaculture in western countries have met with patchy results. Commercial aquaculture has, however, long been practised in highly settled areas in China and south-east Asia using dike-pond systems (Korn 1996). Coarse fish enthusiasts in New Zealand have, for some time, been moving perch, tench, and carp around to available water bodies, including urban ponds. This is discouraged by conservation management agencies because of the damage to water quality and predation or competition with indigenous fish species. Coarse sports fish are not generally used as human food. The native short-fin eel may be suited to urban aquaculture although the flesh is likely to be

contaminated, as the eel tolerates relatively poor water quality and survives in many degraded urban streams, and even road catch-pits connected to surface streams by stormwater pipes.

Fibre, fuel and biomass energy

Even densely populated cities contain trees and wooded areas, collectively known as urban forests, which yield timber, fuel, other forest products, as well as providing amenity. Trees are a dominant feature of many mature urban landscapes in New Zealand, and are important stores of carbon, especially the larger, old trees such as European hardwoods and New Zealand podocarps. Suburbs in Christchurch have up to 20% tree or shrub cover and 30% grass (Renard and Meurk 2004).

Several New Zealand city councils (including Dunedin, Christchurch and Wellington) own multi-purpose forests within their urban boundaries, providing commercial wood products, sludge treatment, as well as providing recreation and amenity benefits and other ecosystem services. Although urban forests have potential to be managed more effectively for multiple purposes, their main function in New Zealand is enhancement of amenity values.

Overall, services from fibre, fuel, and biomass are likely to be declining in New Zealand, despite an emerging trend towards providing larger city park areas to service medium or high density apartments, and establishing more indigenous, larger trees in those public spaces. The most widely cultivated crop that meets ongoing cultural needs of tangata whenua is the indigenous fibre



FIGURE 2 (Top) Janet Stewart Reserve, Christchurch, incorporating Te Kōrari – a cultural harakeke garden for harvesting by weavers. (Bottom) The layout of the garden is in a spiral (koru) pattern.

plant harakeke or NZ flax (*Phormium*). This is almost ubiquitous in private gardens and streetscapes, often as cultivars, but there are some dedicated public gardens that serve the needs of traditional weavers (Figure 2).

Other energy provision

Historically, New Zealand's hydroelectricity and wind energy resources have been developed by the state. Local governments were involved in small hydro-power schemes. Dunedin City developed a scheme at Waipori Gorge as early as 1907; wind farms more recently have been developed within ex-urban areas of Wellington and Palmerston North cities. Other, especially remote, settlements in windy places (such as Oban, in Stewart Island) have long been viewed as suitable candidates for alleviating domestic electricity requirements currently supplied by diesel generators. There are many precedents for renewable energy (mainly wind and solar) production from within urban areas, to the extent that generation capacity is built into the infrastructure of buildings from the outset. Coastal industrial estates, with reliable wind-run, provide significant opportunities for generating wind power without nuisance to residents (Figure 3).

Freshwater supply

In New Zealand, all fresh water for urban businesses and residential consumers comes from either aquifer or catchment sources often within urban territorial council boundaries. Wellington City's water flows from catchments in Hutt and Upper Hutt cities and artesian supplies within the Hutt Valley. Auckland City's water is supplied from the Hunua and Waitakere Ranges, within the Auckland Council area, and supplemented by drawings from the Waikato River, and groundwater sources in Onehunga. Until earthquake damage to infrastructure occurred in 2010–2011, Christchurch had the only large untreated water supply in the country resting predominantly on the specific service of artesian water. There are, however, concerns that both wasteful use beyond replenishment rates and leachate from the expansion of irrigated dairying in the hinterland could threaten this hitherto pure resource. Te Papanui Conservation Park, 60 kilometres west of Dunedin, provides the city with water for drinking, as well as power generation and irrigation for Dunedin City and surrounding residents (Butcher and Partners 2006). Most of Te Papanui Conservation Park lies within Dunedin City, although well outside the urbanised portion of the city, and is administered by the Department of Conservation. The total volume of water supplied by Te Papanui to Dunedin City is estimated to be 13



FIGURE 3 Wind energy generation technology installed in industrial areas of the Netherlands (Rotterdam) where noise restrictions are less strict than in New Zealand.

million cubic metres per year, and the park protects about 60% of the city's water catchment area. Land use of these catchments is relevant to supply; there is greater water yield from tussocks in humid and foggy upland catchments than from pasture or forests (Mark and Dickinson 2008) although the wider application of this research is controversial (Fahey et al. 2011).

There is increasing capture of fresh water from urban roofs in cisterns for on-site, non-potable uses such as flushing toilets and irrigating landscaping. This approach is encouraged in 'Green star' and other sustainability rating systems, but it requires additional energy and carbon use associated with water storage and duplication of piping as mains connection is usually still required (Mithraratne and Vale 2007). A barrier to use of urban roof runoff for potable water is the consistent implementation of simple low cost technologies or design features to improve water quality such as first-flush diverters and filtration systems to reduce the levels of pathogens and other contaminants entering rain tanks (CE Associates 2007). Rain tanks were promoted by North Shore City Council for peak flow reduction of stormwater (Nagels 2005; Vesely et al. 2005).

Genetic resources

Urban zoos, private gardens and public botanic gardens or arboreta have traditionally been important refuges for genetic resources embodied in biodiversity collections. Rare and threatened species, as well as heirloom and other valued cultivars/varieties, represented in the collections of these facilities, enhance the values of the collected genetic resources. Botanical gardens in New Zealand cities provided some of the earliest plantings of trees imported into the country, including Monterey pine (*Pinus radiata*) and Monterey cypress (*Cupressus macrocarpa*), the two most commercially important timber species in New Zealand to this day. These species are found naturally only in a few locations in California and on Guadalupe Island, where they face a number of threats. Specimens of Monterey pine within Wellington Botanic Garden are more than 130 years old and are of international significance as a genetic resource and reservoir (Brockerhoff et al. 2004). New Zealand cities also host some introduced animal species, such as the common house sparrow and finches that are declining in their homelands, and so potentially act as a gene bank for non-indigenous animals as well.

Remnant native vegetation and populations of native fauna are also found within urban boundaries and can be valuable genetic resources (Auckland Council Biodiversity Strategy 2012). For example, skink populations are found in degraded roadside environments including highly weedy sites, while McGowan (2000) documents the *rongoā* (traditional Māori medicinal) plants found in river gullies within Hamilton City gullies (see later sections for further details).

Physical support for structures

These are important in any urban, built-on surfaces, especially for high-rise buildings that depend on deep, firm foundations. More is known now about natural hazards – flooding, storms, earthquakes, volcanism, fire (see below) – and how these may affect stability of building platforms. The 2010–11 Christchurch earthquakes have dramatically revealed hazards associated with liquefaction of unconsolidated alluvial, estuarine and land-fill sediments.

Provision of natural habitat and species niches

New Zealand has a history of disregarding the importance of

urban biodiversity values, yet, internationally, cities are often regarded as biodiversity hotspots (Given and Meurk 2000; Meurk 2003, 2005)¹ and centres of biodiversity protection and recovery. This is because they frequently sit astride convergences of several biomes (terrestrial–marine–riverine–hills–plains), and there is an educated and well-resourced population interested in conservation. Although the land and vegetation are highly disturbed, there are often remnants of forest in gullies of hilly cities, coasts of coastal cities, floodplains of riverine cities and uncultivated drylands in aquifer protection zones.

Biodiversity is especially marked in Mediterranean environments, which are not only climatically supportive of species diversity, but are also pleasant places for people to live and grow crops. Some of the best examples outside the Mediterranean region itself are Adelaide and Perth, Australia, which contain much of their respective state's biodiversity (Hopper and Gioia 2004; Daniels and Tate 2005), and Cape Town/Table Mountain in South Africa, with its famous Fynbos vegetation. Certainly the areas of similar climates in New Zealand (Port Hills of Christchurch and north-facing rocky slopes in other parts of the country) show the propensity for such diversity, but have been seriously invaded by 'Mediterranean' species from other parts of the world.

Significant remnant habitats remain in many urban areas. In some cases these are especially valued because of their rarity – for example Riccarton Bush and McLeans Island in Christchurch; Claudelands Bush (Whaley et al. 1997) and river gullies in Hamilton City (Clarkson and Downs 2000; Morris 2000); Waitakere Ranges in Auckland). Gardens and vegetated areas provide a habitat matrix for biota throughout cities. However, wildlife tend not to discriminate between food sources according to their origin. Native birds such as kererū eat and disperse weed species, including holly, but a seminal work by Williams and Karl (1996) demonstrated preferences of native frugivorous birds for native plants and vice versa. With higher reproductive rates, and faster growth, many exotic species that can provide (bird-dispersed) berries or nectar are becoming selected for – in nature as well as by people. This contributes to the spread and presence of invasive exotic species, especially bird-dispersed, evergreen, shade-tolerant trees, and shrubs such as holly, ivy, monkey apple, cotoneaster, and privet. However, recent examples of kākā nesting in poplar trees in Wellington City and tūi becoming relatively common there show increasing habitat suitability within residential areas outside of Zealandia, a predator-proof-fenced inner-city ecological sanctuary (Campbell-Hunt 2002).

Within Auckland City (new Auckland Council areas), it is estimated that of the original indigenous ecosystems in the Auckland Conservancy of the Department of Conservation (closely approximating the boundaries of Auckland Council), approximately 25% remains (Lindsay et al. 2009; Auckland Council 2010). All the eight original vegetation classes believed to have occurred in pre-human Auckland are still represented within the city, with 0.5–20% (according to type) still remaining in 2009. Approximately half of these remaining indigenous ecosystems are in protected areas, but this figure is distorted by the protection of two large tracts of podocarp–broadleaved forest in the Waitakere and Hunua Ranges. Only a few percent of some of the more specialised ecosystems, such as dune vegetation, coastal forest, and volcanic boulder-fields, survive. Many ecosystem types and species are under threat from the loss and fragmentation of native habitats, and the impacts of invasive species, particularly mammals and weeds (exacerbated by release of pets

and garden waste dumping). A large number of nationally critical, endangered, vulnerable, and declining species occur within the city. Despite its relatively small size, the Auckland Region contains a large portion of New Zealand's threatened species, including 20% of its terrestrial vertebrate fauna and 19% of its threatened plant species. It also includes several endemic species that are found only in the region. Conservation of these threatened ecosystems and species is vital not only to the maintenance of ecosystem services within Auckland City, but also to protection of threatened biodiversity nationally.

A similar situation exists in Christchurch. Here the flat arable terrain leaves no place for natural habitat to hide from development, but relict populations of grasslands and woodlands occur in aquifer protection areas. Nevertheless the city is a biodiversity hotspot relative to its surrounding area because the hinterland is even more intensively and uniformly developed. There is a similar number of indigenous plant species growing wild, in albeit precarious locations, as in our national parks, and Christchurch is a centre for bird diversity because of the large area of wetland and aquatic habitat (Given and Meurk 2000). Even in Canterbury's Low Plains Ecological District, one of the most transformed in the country, all original habitats are represented, although decimated, and threatened by fragmentation, pest invasion and other human activity – such as unknowingly eliminating precarious species populations by 'tidying' up rough spots.

New Zealand trees and shrubs are primarily evergreen and mostly without flammable compounds like many fire-adapted species from arid climates; the fleshy evergreen foliage then does afford some fire-suppressive capability – a service to some city margins.

Climate regulation

The influence of urban vegetation on high temperature amelioration is well known internationally, moderating cities' heat island effect. Directly, vegetation provides shade through scattering of sunlight and exposing the boundary layer to elevated air movement. Tree foliage reduces ambient air temperature through evaporative cooling from transpiration (Gill et al. 2006; Douglas and Ravetz 2011). One estimate of the effect of this service is that if a city's tree canopy is increased by 5% in area, street temperatures will drop by 2–4°F (Garvin 2010).

There is a significant amount of carbon sequestered in urban soils that potentially moderates human-induced global warming. Much of this stored carbon is however squandered (through accelerated oxidation) during subdivision land clearance, stockpiling of topsoil and respreading it onto new sections. The build-up of carbon may then increase by, often excessive, application of fertiliser and irrigation, but decrease by continual short- and long-cycle turnover – for example on changes in property ownership with desire to stamp one's own personality onto newly acquired property – often by using heavy machinery to clear a site of its pre-existing vegetation, with attached carbon-rich topsoil, and send it to landfill, then starting afresh. The embodied carbon is further being removed from storage through infilling and densification of urban environments, with greater use of smaller, short-lived trees (Peters and Burns 2013), which end up in landfill or perhaps municipal composting or wood chips for mulch.

Runoff and stormwater regulation

Changes in land cover associated with urbanisation have a very significant influence on the timing and magnitude of runoff, flooding, and the rate of aquifer recharge, and the aggregate water



FIGURE 4 Wigram Retention Basin, Christchurch, at commencement of duck-shooting season – demonstrating the multi-purposes of flood attenuation and water filtration (raupō beds) from the Sockburn industrial estate with wildlife refuges (paradise shelducks and grey teal).

storage potential of the system. This effect is particularly marked in near-coastal areas, for example through loss of coastal wetlands, estuaries etc. Ecosystem enhancements will affect stormwater flows and can also improve water quality (Suren and Elliot 2004). Areas that may be important for stormwater regulation include natural and constructed wetlands, vegetated waterways, swales and flow paths, and detention or retention ponds. Some of these features serve also as wildlife refuges (Figure 4).

Within the Auckland Metropolitan Urban Limit, the amount of impervious area increased from 39% in 2000 to 42% in 2008 (Auckland Council 2010). Each year, an average of 8.9 kilometres of streams is subject to stream bed disturbance (on a scale that requires consent). Some information from New Zealand's 2007 State of the Environment report (Ministry for the Environment 2007, p. 229) suggests a national increase of 2.5% of impervious surfaces between 1997 and 2002, almost all in urban areas.

Water purification, waste water and solid waste treatment

One of the strongest physical themes coming out of the Low Impact Urban Design and Development research project, conducted by Landcare Research during the early 2000s (see Landcare Research's Discovery newsletter Issue 29), was the concept of treatment trains for accommodating and processing stormwater. These are series of connected devices or installations in urban environments that slow down or filter water as it proceeds from its source to the receiving environment, whether a drain, river or ocean outfall (Figure 5).

Among the significant ecosystem services provided by functioning ecosystems in the Auckland coastal environment (Townsend and Thrush 2010), removal of wastes in estuaries was found to be particularly significant. Many of the species found in coastal and estuarine soft-sediments, around the Auckland coast, play important roles in the cycling and filtration of sediments and consequently removal of organic and inorganic contaminants. For example the common cockle *Austrovenus stutchburyi*, when in sufficient density, will accelerate sediment deposition and contaminant accumulation in the sediment (rather than them remaining in suspension) through filtration from the water column (Gadd and Coco 2010).

Human disease and health regulation

All inhabited ecosystems influence the incidence and abundance of human pathogens and vectors of communicable diseases. Drinking water quality is one of the main factors in these disease pathways, and in New Zealand, town water supplies are required

to be treated to meet high public health standards (Ministry of Health 2005). However, in some suburbs, overcrowding, poor sanitation, hygiene and nutrition, cold damp houses, and lack of outdoor activity contribute to increasing levels of some communicable diseases (Jaine et al. 2008; Baker et al. 2012). Most of these suburbs are in areas of high socio-economic deprivation – especially in South Auckland, eastern Porirua and some smaller North Island centres.

Healthy ecosystems, including soils, perform a critical role in naturally regulating pests and diseases, as well as human disease (see below). Soils can, however, also harbour pathogenic contamination or inorganic poisons, especially in urban brown-fields (Alloway 2004). Overall, at present, however, the trend in disease regulation is probably neutral or downwards.

Pest regulation

Urban as well as rural ecosystems, especially soils, perform a critical role in naturally regulating pests and diseases in the ecosystem (as well as human disease, above). It is possible that there are urban habitats such as urban gardens where pests are less likely to occur than in commercial agricultural settings. In general, however, urban environments are likely to have high invertebrate diversity because of the plant and habitat diversity at small (insect size) scales. High invertebrate diversity increases the likelihood of populations of beneficial insects, provided they are not inhibited by high rates of pesticide application reported in some home gardens (Alloway 2004). The provision of 'beetle banks' (Macleod et al. 2004) to support beneficial insects in farmland may apply equally to urban environments.



FIGURE 5 The Wynyard Quarter, Auckland City waterfront, demonstrating good urban design with rain gardens and wetland treatment for recreation, biodiversity and stormwater purification before water enters the harbour.

Pollination

As for natural pest regulation, excessive use of pesticides will be detrimental to pollinators. There is a developing rural crisis regarding honey bees, one of our most prolific clover pollinators (<http://nba.org.nz/about-bees/beneficial-plants-for-bees/urban-trees-for-bees>). Urban environments can provide a refuge for beneficial insects and birds, including pollinators, if encouraged and publicised. Cities could indeed function as ‘beetle banks’ (Macleod et al. 2004) on a regional scale. Many garden plants – especially fruiting species – require external pollinators, making this a wider concern. A recent initiative in Christchurch to address this is ‘Plan-Bee’ (<http://www.stuff.co.nz/the-press/news/8524441/Plan-Bee-citys-sweet-ambition>).

Air quality enhancement

Internationally, large urban areas have been associated with poor air quality, at least in the past. Causes have principally included transport and industry, both generating emissions of chemical pollutants and particulates of various kinds. In New Zealand, poorly designed coal or wood burning home heating has been a major source of smog in places prone to atmospheric inversions. Urban vegetation mitigates the effects of pollution (research summarised in UK NEA (2011) and Fisher et al. (2007) for New Zealand). Cavanagh et al. (2008) measured a 30% winter attenuation of PM10 particulates from edge to interior of indigenous Riccarton Bush, Christchurch – a distance of less than 200 metres. Cavanagh and Clemons (2006) and Cavanagh (2008) have calculated that urban trees of Christchurch and Auckland remove between 300 and 2000 tonnes of various pollutants from the atmosphere, worth tens of millions of dollars, but representing only a few percent of total emissions. In winter, evergreen trees are more effective, although some (mainly exotic species) are also net emitters of volatile organic compounds. In addition, air quality is ameliorated by urban trees through reducing summer heat stress, especially in continental climates. Before lead in petrol was banned, air in the vicinity of roads was higher in lead from car exhausts, typically with an exponential drop off in concentration with distance from the road. Dense vegetation (Figure 6) absorbs particulates and causes a similar decay curve to steepen at this barrier.



FIGURE 6 Noise and air pollution buffer separating residential property and Queen Elizabeth II Expressway, Northwest Christchurch with high biodiversity corridor values. This is a combination of a 3m high earth embankment (main noise barrier) planted with forest species to muffle the noise: *Plagianthus* (lowland ribbonwood/mānatu), *pittosporums* (kōhūhū and lemonwood/tarata), *coprosmas* (karamū and mikimiki), *Griselinia* (broadleaf/kāpuka), *Cordyline* (cabbage tree/tī kōuka), *Dodonaea* (akeake), *Sophora* (kōwhai), *Phormium* (NZ flax/harakeke), *Pseudopanax* (five-finger/whauwhaupaku), *olearias* and *Hebe* (koromiko) and *Anemanthele* (wind grass).

Trees contribute to the aerosol mostly positively (absorbing CO₂ and emitting oxygen), but can also release greenhouse gases (<http://news.discovery.com/earth/global-warming/trees-as-a-source-of-greenhouse-gases.htm>). Vesely (2007) showed that enhancement of air quality is an important perceived benefit of urban trees in New Zealand, more than 80% of respondents ranking ‘fresh air’ as very important or important. Despite relaxation of ‘clean air’ regulations in the aftermath of Christchurch’s earthquakes and greater numbers of diesel rigs on the roads, apparent air quality is improving in New Zealand cities, both at source and from greening especially along highways. However, there remains concern that levels of the PM10 fraction crucial to human health remain too high.

Natural hazard and erosion regulation

New Zealand’s dynamic natural environment means that many urban inhabitants are potentially vulnerable to a range of natural hazards such as floods, earthquakes, and landslides. About a hundred New Zealand towns and cities are located on floodplains, and, although flooding occurred naturally on these areas before settlement, the nature of these floods has been changed significantly by the pattern of European settlement and upstream land management, especially intensive land clearance (Ministry for the Environment 2010). Places are generally only hazardous if land use and development patterns ignore the evidence from geomorphology and history. On flood plains, natural levees, wetlands and buffer zones can offer some protection from flood hazards, which may to some extent reduce the need for conventional stop banks (Kundzewicz and Menzel 2005). Gravel reserves within or adjacent to urban areas on city doorsteps can provide materials for stop banks, roads and buildings.

Landslides also affect New Zealand cities. Wellington City is susceptible to landslides from the combination of steep slopes and high intensity rainstorms (McConchie 1980, 2000; Crozier and Aggett 2000). Earthquakes may also initiate slope failures. During high intensity rainstorms, damage can be expected even on slopes where there is woody vegetation cover, and if channels designed for storm runoff are inadequate for transporting landslide debris considerable destruction and downstream flooding occurs, as has happened many times during European settlement of Wellington and the Hutt Valley.

INDIRECT SERVICES

Spiritual and religious values

Many religions attach spiritual and religious values to ecosystems or their component parts (MEA 2005) and to the extent that valued ecosystems occur within urban areas, these can heighten spiritual and religious experience. Many New Zealanders hold either spiritual, religious, or pantheistic values for which the natural world provides inspiration (Donovan 1990). Two New Zealand studies of participants in community gardening (Cleghorn et al. 2011; Earle 2011) found that this activity was a way of connecting with nature and the environment in a ‘spiritual’ way.

Aesthetic and amenity values

Many people find beauty or aesthetic value in ecosystems, as reflected in support for parks, ‘scenic drives,’ and the selection of housing locations (MEA 2005) which in turn influences market value. The range of amenity and aesthetic values that add to people’s enjoyment of living, working and recreating in particular urban locations becomes extremely important to people’s quality

of life, regardless of the socio-economic status of the neighbourhood. Green spaces and other kinds of nature in the city are an important component of aesthetic and amenity values. Trees in urban areas have values that include but go beyond amenity. Dan Burden² itemised 22 benefits of urban street trees in North America, a number of which were multiple in terms of the categories discussed here. They relate to physical service delivery, biodiversity provision and health effects as well as amenity. Vesely (2007) documented important perceived benefits of urban trees in New Zealand, including aesthetic benefits.

There appears to be consensus in Europe as to the importance of urban green space and there are guidelines for minimum amounts and accessibility of green space and wilderness (Box and Harrison 1993; Harrison et al. 1995). However, whereas in most other parts of the (continental) world, green space equates to indigenous nature, this is not often the case in urban and rural New Zealand, and poses dilemmas for planners trying to accommodate amenity, human aesthetics (or enculturation) and national biodiversity goals. Overall, there has been a burgeoning of vegetative structure in cities although, as has been mentioned, average tree sizes in domestic gardens are probably diminishing in stature and many species with potential for biosecurity risk are still being planted in New Zealand cities.

Cultural diversity and heritage values, including sense of place and social capital

The diversity of culture in any society is influenced by the diversity of ecosystems and landscapes, including cultural and historical heritage. This diversity also provides inspiration for art, folklore, national symbols, architecture, etc. Associated with cultural diversity is the sense of belonging to a place that has recognised features in the environment. All these values can be found in urban ecosystems and landscapes. Prominent urban landscape features can be and often are now century-old exotic trees, which make up the bulk of registered 'notable' or 'protected' trees in New Zealand. This contributes to extinction of experience and the loss of familiarity and identification with specifically indigenous heritage (Meurk and Swaffield 2000; Miller 2005).

In turn, ecosystems influence the types of social relationships that are established in particular cultures and this has a bearing on the nature and amount of social capital developed, in particular the value of social networks. The impact on social capital is one of the main mechanisms by which contact with nature enhances human health and well-being (Blaschke in press).

Van Heezik et al. (2012) and Freeman et al. (2012) documented the health and recreation benefits of gardens in Dunedin, largely through stress reduction. Social connections and capital were also enhanced through gardening, as was a sense of environmental stewardship. Greater knowledge and more sensitive gardening practices are normative and can be perpetuated across neighbourhoods.

Health and well-being

The 'biophilia hypothesis' (Kellert and Wilson 1993) suggests there is an instinctive bond between human beings and other living systems, and that this bond has been critical, one might say inevitable or causative, in the development and management of open spaces and other types of 'natural' areas. The health and well-being benefits (including recreational benefits) associated with green areas have been widely documented internationally (Sadler et al. 2010) but most of these studies have not carefully

distinguished between different kinds of green or natural settings (Blaschke in press). Consequently it is difficult to generalise about the benefits of urban green areas for health and well-being. To the extent that people take into account the characteristics of the natural or cultivated landscapes in a particular area (MEA 2005) when choosing where to spend their leisure time, the nature of the area contributes to other amenity and aesthetic benefits discussed above. Recreational benefits are, however, only one kind of health and well-being benefit. Blaschke (in press) has reviewed the relationship between contact with nature and health and well-being, in all types of environments. Looking specifically at urban environments internationally, greener urban neighbourhoods are associated with higher socio-economic status, but accessibility to green space, specifically for residents 'trapped' in poorer areas, is correlated with reduced rates of mortality (Mitchell and Popham 2008; Kuo 2010).

The characteristics of neighbourhoods that exert an influence on the health outcomes and behaviours of local residents in New Zealand have been reviewed by Stevenson et al. (2009). Two large cross-sectional spatial analysis studies have been recently conducted, examining the relationship between neighbourhood access to green space and health. In contrast to the above international results, neither of these studies found evidence of an association between greenness and selected health indicators at the neighbourhood level. Using health data from the nationally-representative New Zealand Health Survey, and land use data from Land Information New Zealand and Department of Conservation, Witten et al. (2008), looking at all types of inhabited environments, found no association between green space and body mass index (BMI), sedentary behaviour and physical activity. Richardson and colleagues (2010), using New Zealand-wide mortality data and looking specifically at urban environments, also found no association between the amount of green space in the area in which people live (either useable space or total space) and mortality from either cardiovascular disease (e.g. heart attacks or strokes) or lung cancer. The lack of association is likely related to the fact that New Zealanders tend generally to have good access to green or blue areas, even when living in poorer neighbourhoods (Witten et al. 2008; Richardson et al. 2010) in contrast to the results reported from older, populous and more socio-economically segregated cities. However, the most recent New Zealand study in this area confirmed that neighbourhood green space was related to some health outcomes but showed that although physical activity was higher in greener neighbourhoods, it did not fully explain the green space and health relationship (Richardson et al. 2013).

Christchurch Public Hospital has for some time engaged in 'duck therapy'³, as an example of the known therapeutic value of people interacting with other animals, especially in urban settings (Maller et al. 2008) – in this case wheeling recuperating traumatised patients into the gardens and riverside and helping feed ducks.

A recent Waitangi Tribunal report, on how New Zealand law and policy have affected Māori culture, documents the fundamental importance of *taonga* (treasured) plant and animal species to modern Māori in terms of their identity and *kaitiakitanga* (guardianship) (Waitangi Tribunal 2011). This particularly applies to plant species used in *rongoā* (traditional healing) and thus accessibility to these resources plays an important role in fulfilling Māori concepts of health and well-being (McGowan 2000).

Tourism

The health and well-being benefits from tourism are similar to those from recreation, but available to a wider group of people than just those living in a particular neighbourhood. The main distinction between recreation and tourism is the commercial nature of the latter, so many of the ecosystem services benefits arising from tourism are economic and are discussed further below. These green services are a vital part of the “clean green” brand that underpins tourist marketing of New Zealand.

Education

Ecosystems and their components and processes provide the basis for education in many societies (MEA 2005). Naturally, educational opportunities arise in urban areas frequently, not just from remaining natural areas but from a range of formal and informal settings. Not only do many zoos, botanic gardens, and urban parks offer a wide range of unstructured learning opportunities for adults and children, but some also provide formal teaching programmes. Auckland Council funds ‘learning through experience’ education and ‘Enviroschools’ programmes throughout Auckland, teaching primary school children a range of horticultural, farming, and environmental skills. More than 12 000 children participate annually, with many courses held at the Auckland Botanic Gardens and regional parks such as Ambury Farm that have facilities dedicated to education. Nationally, some 880 schools participate in the programmes coordinated by the Enviroschools Foundation⁴.

Worldwide, citizen science initiatives are flourishing, as in New Zealand. For example NatureWatch New Zealand (<http://naturewatch.org.nz/>), and its complementary programme Nature Space (www.naturespace.org.nz/), coordinate and service environmental volunteer projects. All these activities, which enhance awareness of ecosystem functions and their values for human society, are increasingly used in an urban context and are self-reinforcing.

In the Dunedin garden study, Van Heezik et al. (2012) showed how gardening enhanced environmental awareness. They also showed that greater knowledge and more sensitive gardening practices are normative so can be perpetuated across neighbourhoods. However, the knowledge needs to be accessible before uptake can occur. People are often keen to learn about their environment, but won’t necessarily go out of their way to obtain such information (Meurk et al. 2009; Doody et al. 2010).

Supporting services

These include the following:

Soil formation and maintenance: Processes by which rock is decomposed to form soil, and maintained;

Nutrient cycling: Processes by which nutrients – such as phosphorus, sulphur, and nitrogen – are extracted from their mineral, aquatic, or atmospheric sources or recycled from their organic forms and ultimately return to the atmosphere, water or soil;

Primary production: Formation of biological material through assimilation or accumulation of energy and nutrients by organisms;

Photosynthesis: Process by which carbon dioxide, water, and sunlight combine to form carbohydrate and oxygen;

Water cycling: Flow of water through ecosystems in its solid, liquid or gaseous forms;

Provision of natural habitat free of weeds and pests: Habitat supported by robust ecosystems that maintain life free of weeds, pests and diseases.

These are all essential functions that underpin healthy ecosystems and provide ecosystem services. Most of the ecosystem services presented in Table 2 and discussed above are directly dependent on these supporting services. For example, the ability of ecosystems to provide crops for human or animal consumption is dependent on all the above support functions/services. However, the impact on people of supporting services may be less direct and on a longer timescale than those of provisioning or regulating services.

Option values

Option values are the retention of opportunities for future development through conscious deferment of use. Retention of ecosystem services from the undeveloped state of the land or water resource is a ‘co-benefit’ of the retained options. An example of option values in urban areas is seen in policies for green belts around city edges that are designed to physically constrain outward urban growth, but provide future growth or use options. In the meantime ecosystem services such as biodiversity or recreation values of retained natural habitats or stormwater peak reductions from retention of pervious surfaces can be maintained. It is a holding pattern giving time (breathing space) for other solutions to be developed.

Existence values

The value of knowing that a natural ecosystem exists, even if not used or visited (its intrinsic value), applies to urban natural spaces and ecosystems as well as to iconic wilderness. Wilderness is a relative concept and there are many places within urban limits that are perceived as relatively wild, as in the phrase ‘urban wild’⁵. For example, the Waitakere Ranges in west Auckland were originally preserved for water supply purposes by the Auckland City Council as long ago as 1895, when they were far removed from urban Auckland. One hundred and thirty years later, and although fringed and encroached on by residential and other development, they still retain a feel of relative wilderness. They are highly valued for their passive existence values as well as their active recreation, biodiversity services and very important water supply. ‘Urban wild’ is generally on a much smaller scale and may be quite subtle – even an abandoned vacant lot that temporarily supports some spontaneous vegetation and wildlife. The presence of such places can be a factor in reducing the “nature deficit disorder” syndrome described by Louv (2005). A generalised desire for nature was demonstrated in a 2003 Christchurch City Council residents’ survey, where 58% of respondents wanted more native plants in their neighbourhoods and 72% wanted more native birds. Other surveys show that people may not necessarily want to visit a natural or wild area in a city, or know details about it, but they like to know it is there (Colin Meurk, unpublished).

Indeed, familiar places are often valued disproportionately compared to less familiar places, so urban natural areas are often seen to have very high existence values. New Zealanders have good access to and very highly value ‘blue space’ (lake, river and coastal reaches) and survey results confirm very high values for coastal ecosystems in Auckland (Batstone and Sinner 2010).

Bequest values

These are the values that are specifically associated with future generations. Elements of these values are seen in all planned urban natural areas (e.g. municipal botanic gardens), in which values are known to only accrue slowly – trees planted for many decades into the future, etc. To illustrate all these passive values,

the Wellington Town Belt (Figure 7) serves as a useful example. It was originally set aside, right from the birth of planned European settlement in 1840, as ‘“forever hereafter” to be used and appropriated as a public recreation Ground’ and also to be used ‘for the purposes of public utility to the City of Wellington’ (Wellington Town Belt Deed, quoted in Boffa Miskell Ltd 2001). The Town Belt has continuously provided for option values through the constraint of growth and provision of space for public amenities, existence values as a now iconic green area surrounding the city and one of the most valued components of Wellington’s heritage, and bequest values by its continued existence as guaranteed through its Deed. It has also provided for many other provisioning, regulating, and cultural ecosystem services. In the most recent draft Town Belt Management Plan (October 2012) ecosystem services are not mentioned specifically, but objectives cover many aspects discussed in this chapter, such as ‘biodiversity of the Town Belt ...function[ing] as a well-connected system’, ‘stormwater [being] managed and sedimentation minimised’, ‘citywide ecological connectivity [being] improved and existing ecosystems enhanced’; and ‘the ecological resilience of the city [being] improved’. Management of Town Belt forests for carbon storage is also addressed.

MONETARY VALUES OF URBAN ECOSYSTEM SERVICES

While much has been done to quantify non-market values, valuation remains problematic, and effectively developing the concept to be operational may come to depend significantly on adopting international conventions and typologies (Mace and Bateman 2011). Several studies of monetary values associated with the existence of native biodiversity have been undertaken (Bell et al. 2008; Kerr and Sharp 2008; Clough 2010). Little information in these studies is specifically relevant to ecosystem services or urban environments. Vesely (2007) studied the value of urban trees, through contingent valuation techniques. Her results showed quite high willingness-to-pay values (average \$184 per year to avoid 20% loss of urban trees, split fairly evenly among gender, income, etc., in a survey of 15 large and small New Zealand cities). A half of the respondents also indicated willingness to do volunteer work to maintain urban trees.

Economic values associated with the ecosystem services protected by Te Papanui Conservation Park near Dunedin were investigated by Butcher Partners (2006). Their report estimated a total net present economic value of \$136 million (using a 7.5%

discount rate) from drinking water, hydroelectric power generation, and irrigation. The largest component of this was avoided capital cost of water supply infrastructure (\$80 million). A study by Mitchell and Popham (2008) demonstrated real health benefits associated with urban green space in otherwise impoverished areas and this can yield very tangible economic benefits to a society over time.

Marketing efforts for most well-known New Zealand tourism destinations and routes, including those in urban areas, rely heavily on the beauty and integrity of their natural settings, which consequently has a clear economic value. Indeed, the whole of New Zealand tourism marketing relies very heavily on the ‘clean green, 100% pure’ image portrayed through our natural environment (Blaschke et al. 2006). Most urban centres where tourism is significant have well-known destinations that are either natural areas (e.g. Zealandia sanctuary in Wellington, North Head in Auckland, Otago Harbour and Taiaroa Albatross Colony in Dunedin, Port Hills of Christchurch), surrounded by natural areas (Auckland Domain surrounding Auckland Museum), or showcase natural areas and biodiversity (Te Papa national museum in Wellington, Kelly Tarlton marine experience in Auckland). Rescued blue penguins are a major drawcard for the Christchurch Antarctic Centre.

As a final example, Patterson et al. (2011) calculated a total value of direct and indirect use ecosystem services to the Auckland Region (i.e. ‘appropriated by the Auckland regional economy’) through a thorough and novel input-output analysis of the System of National Accounts for Auckland in the 1998 financial year. These were applied to a simple classification of ecosystem services and an analysis of ecosystem types derived from land cover imagery. Their results showed a total economic value of the region’s ecosystem services for 1998 of NZ\$2.32 billion, compared to an estimate of the regional gross domestic product for the same period of NZ\$33.2 billion. The ecosystem types providing more than 10% of total ecosystem services value were agricultural land, lakes, estuaries, mines, and forests in that order, while the ecosystem services contributing more than 10% of the total were water supply, erosion control, raw materials, nutrient cycling and food production, in order. Patterson et al. (2011) went on to assess ecosystem services appropriation by specific industries. The two industries chosen as examples of this approach, air transport and business services, drew only very small amounts on direct ecosystem services, but much more heavily on indirect services. The authors commented that ‘seemingly benign industries, far removed from localities of intensive ecological-economic interactions, may still have a large although indirect dependence on ecosystem services’.

URBAN DESIGN TO OPTIMISE ECOSYSTEM SERVICES

Urban environments are complex, spatially and temporally. This arises from the diversity of natural environments, multiple human uses, and the associated wide variety of imposed disturbances and stresses. The challenge for city planners and managers is to deliver design that maximises ecosystem services while balancing competing demands and values (Rydin et al., 2012; Sanderson and Redford 2003). Notwithstanding the efforts to build model towns, such as the softly wooded ‘New Towns’ of England or China’s Tianjin (techno) eco-city⁶, it is generally not possible to create the ideal city, even supposing agreement could be reached on what that might entail. Opportunities do arise, however, when a disaster has destroyed the existing built infrastructure, and the city’s enormous material investment and



FIGURE 7 Wellington Town Belt. As with other urban forests, this area provides multiple ecosystem services including temperature moderation, improvements in water and air quality, carbon sequestration, biodiversity, human health and wellbeing, amenity and amelioration of noise nuisance. (Photo courtesy of Wellington City Council)

commitment to the status quo no longer exists. Thus it would seem that an opportunity exists for New Zealand to use the occasion of the destruction of Christchurch by the earthquakes in 2010–2012 to create a new, ‘state of the art’ city, avoiding the need for future retrofitting and incremental renewal. Building such a city may involve, in the short term, costs not incurred in cheaper, business-as-usual rebuild alternatives. Nevertheless, design that follows ecological principles, with appropriate long-term planning horizons, has the potential to provide a foundation for a city that is much more resilient. It is clear that continuing environmental injustices (Pearce et al. 2006; Pearce and Kingham 2008) will inevitably perpetuate cumulative economic and social burdens on our society.

One approach is that of the international movement of Transition Towns (<http://www.transitiontowns.org.nz/>), which lays out the case for and steps towards achieving urban sustainability. A key requirement is to design for integration, multiple benefits, and synergies that minimise costs. This involves rethinking approaches to stormwater management, waste management and sanitation, energy (transport), climate change mitigation and carbon sequestration, eliminating smog, food production, connecting people with nature (urban gardening, livestock, forestry and environmental restoration), and integrating strategies for amenity and biodiversity. Understanding the current environment and having a vision for an aspirational future environment is one thing, but more research and effort is needed to define non-disruptive or traumatic transitions between the two states. Land is scarce in urban environments and economic benefit has to be demonstrated for desirable but space-hungry, ecological approaches such as using constructed wetlands to remove pollutants from stormwater.

In New Zealand there is growing awareness that introducing green landscape elements to provide more effective management of stormwater involves using indigenous species that avoid biosecurity risks (<http://resources.ccc.govt.nz/files/StreamsidePlantingGuide-streamsideplanting.pdf>). Private lots also need to be smaller or shared, to provide for the desired, increased public green space. Devices need to be designed to ensure natural water features have appropriate water residence times. Insufficient time can hinder pollutant removal, whereas excessive time can lead to dirty, sluggish water bodies unattractive to residents. Sustainability requires towns to be compact with public green space freely accessible to all residents within maximum distance limits (Ignatieva et al. 2008b; Witten et al. 2008), effective use of stormwater ‘treatment trains’, maximum use of on-site stormwater management, and a strong reuse and recycling ethos.

Introducing these innovations requires a mix of policies, some rules-based, and others which are more light-handed and participatory. Experience has shown that successful innovation can be facilitated through use of inclusive approaches such as a brains trust that is open to all, and maximises benefit from reserves of knowledge, experience, and creativity, and enthusiasm within the professional and wider communities. In turn, this requires a careful and deliberative approach that recognises that ‘good things take time’. Such approaches can be expected to become more feasible as awareness builds of the social and environmental costs of decision-making driven by short-term economic and business imperatives.

Structure planning

Increasingly, local authorities in New Zealand are using

formal structure plans to guide sustainable urban development. This follows conceptual, aspirational and visioning phases and provides a mechanism for applying knowledge of natural landscape processes (Meurk and Swaffield 2007), using spatial data on soils, geology, natural hazards, drainage, wetlands, landfills, remnant habitat and linkages, and sites of cultural significance and special character. The generalised pattern of proposed development integrates these factors with demographic trends, requirements for green infrastructure such as green transport arteries (Figure 6), walkways and cycleways, and recycling/re-using or waste-minimising facilities. The final configuration of built areas and public green space, determined collaboratively with stakeholders, is designed to provide an optimal balance between social and economic factors and the desire to maximise benefit from ecosystem services (Sanderson and Redford, 2003; Rydin et al. 2012). The plans typically build on experience gained from local demonstration projects that show how ecological principles are implemented in the local environment. Information to aid planners in local greening is now widely available, with useful treatments provided by Ignatieva et al. (2008a, 2011), and Stewart et al. (2007, 2009). Wider landscape considerations and design of optimum forest patch configurations in cultural landscapes are detailed in Meurk and Hall (2006) ⁷.

Built environment design

Jenkin and Pedersen Zari (2009) explore concepts of sustainability, eco-effectiveness and regenerative design to the New Zealand built environment. The authors describe current rapid changes in built environments and conclude that, while aiming for neutral or reduced environmental impacts in terms of energy, carbon, waste or water are worthwhile targets, it is becoming clear that the built environment must go beyond this. For example, solar or wind power generation can be incorporated that supports the grid during times of plenty and takes from the grid in times of need. These new-generation urban buildings aim for a net positive environmental impact on the living world. One of the most significant reductions that can be made is in reducing the city’s energy footprint through improved efficiency and insulation (Wald 2013) and moving from non-renewable (concrete) to renewable materials (e.g. hi-tech timber construction). Jenkin and Pedersen Zari explore four main development approaches: eco-efficient development; regenerative, restorative (reuse rather than recycle) and cradle-to-cradle development; perceiving the built environment as an integrated system; and changing implementation responses over time. Pedersen Zari (2012) enlarges on this approach in her thesis, which is framed in urban-built-environment responses to climate change and the loss of biodiversity. The study focuses on regenerative design (mimicking organisms or ecosystems) that increases the health of ecosystems and resilience to change by utilising the mutually reinforcing aspects of mitigation, adaptation, and restoration strategies.

Water supply, stormwater management and waste treatment

Supply of clean water, stormwater management, and sewage/wastewater treatment are all vital links between ecosystem services and urban sustainability. Vegetated surfaces underpin the treatment trains that attenuate peaks and enhance water quality. They can be accommodated within urban built environments by lengthening pathways, or incorporating filter beds or other devices. They can also be combined with enhancement of amenity values (Ignatieva et al. 2008a) from detention ponds and green roofs at the top of the urban catchment, down the treatment



FIGURE 8 (Top) Green roof, (middle) porous paving (Ellerslie International Flower Show Exhibit), and (bottom) living wall (Auckland) – aesthetically calming water attenuation devices for urban environments.

chain to living walls, rain barrels, rain gardens, pervious or porous paving, swales and wetland filters (Voyde et al. 2012; Fassman-Beck et al. 2013), in all parts of the downstream catchment (Figure 8). Treatment devices, utilising recycled or waste materials as filters, can be installed especially around runoff areas with high levels of toxic production like car parks. If predominantly indigenous species are used, then multi-use benefits arise, and ponds, for example, may provide refuges for wildlife (Figure 4). Sustainable management also involves protecting and managing domestic water supply catchments (e.g. conservative tussocks versus trees) or aquifers; avoiding the need for treatment (e.g. by making efficient use of groundwater before using surface water); reducing or eliminating profligate watering for amenity; use of xeric landscaping (St Hilaire et al. 2008); greater use of grey water for irrigation; and land disposal of organic waste. Interestingly, despite the pressure of fashion and trend in gardens, home owners will take on more sustainable and locally sourced gardening styles when they are informed and have been resident in an area longer and identify with its character and constraints (St Hilaire et al. 2010).

Solid waste treatment

Sustainable approaches involve reducing the problem at source by reusing or recycling materials, designing for longer life, reducing the volume of throwaway items in society, having innovative ways of reusing materials close to site rather than transporting long distances, and having an efficient recovery process accessible for all people. Inert materials can be used as aggregate or wearable surfaces. However, landfills and soils/substrates have a finite capacity to absorb polluted waste, a factor that is also important for low impact stormwater treatment devices. Ongoing use and management of these devices provides data that can underpin more cost-effective management in the long term and specifically factoring in the cost of the rejuvenation cycle.

Natural hazards planning and flood control

The December 2012 Hurricane Sandy that severely damaged coastal New York demonstrated, among other things, the ecosystem services provided to cities by natural coastal vegetation and trees. Specifically, coastal vegetation, whether mangroves or sea grass, can provide protection. Street trees and other trees reduced windspeeds and damage to vehicles. However, where possible, an approach based on hazard avoidance is always preferred to one based on mitigation, whether it is coastal development in the path of sea level rise and increasingly chaotic weather patterns, floodplain hazards, hazards arising from liquefaction-prone sediments or land fill, or hazards arising from slope instability.

Air quality enhancement

Leafy trees and shrubs can have significant beneficial effects on removing airborne particulates, including the highly injurious PM10 fraction. Wide banks of large leafy evergreen species are likely to have the greatest benefit (Cavanagh 2008; Cavanagh et al. 2008) as there is increasing entrapment the longer the distance from source (Figure 6). On the downside, some species – for example eucalyptus, oak, liquidambar, and plane trees – are net emitters of volatile organic compounds.

Enhancing biodiversity

This chapter is concerned primarily with the use of vegetated, and where possible, indigenous planted surfaces to enhance

multiple benefits from ecosystem services. Species options and methods for all urban niches are well documented and discussed in Ignatieva et al. (2008a). Practically, this needs to be integrated at a range of scales – the matrix (Meurk and Swaffield 2007), patches or stepping stones (Meurk and Hall 2006), and connecting corridors. Hostetler et al. (2011) particularly highlight the importance of engaging the whole wider community before during and after green developments to ensure long term success and Hostetler (2013) emphasises spatial and temporal continuity in green commitment during subdivision processes – during planning, construction and importantly post-construction. Satisfying biodiversity and cultural objectives (overcoming extinction of experience – Meurk and Swaffield 2000; Miller 2005), requires, in general terms, at least a 50:50 mix of large or dominant native and exotic species (i.e. biomass and visual equivalence). Green belts and green space provision are important mechanisms both for enhancing biodiversity, maximising other ecosystem services, and reducing transport, aerosol, and noise impacts. Cities such as Dunedin and Wellington with a green belt ‘tradition’ (also a feature of some British planning systems) have significant natural assets that provide a foundation for planning systematic optimisation of ecosystem services.

Many ecosystem services may be provided equally or better by introduced species, rather than New Zealand natives, and in theory a planner has the entire temperate biota to choose from. New Zealand indigenous species often have slower growth rates, and are unlikely to match the best from the rest of the world for any service that relates to growth and performance. However, only New Zealand’s biodiversity underpins our sense of place (silver fern), cultural values (harakeke), tourism and international obligations (indigenous forest and birds, not to mention the often forgotten ecosystem components of invertebrates, reptiles, fungi and other microbes). Some cities are now ringed with flammable species such as gums, gorse, and broom. There is a role for encouraging fire-retardant species – in particular evergreen trees and shrubs (that don’t produce fire-accelerant chemicals), and New Zealand has an abundance of these (broadleaf – *Griselinia*, ngaio – *Myoporum*, karaka – *Corynocarpus*, pittosporums, karamū – *Coprosma*, five-finger – *Pseudopanax*, etc.).

There is an opportunity for local-government-led restoration efforts to consider the ecosystem services dimensions more explicitly. Wellington City Council and Greater Wellington Regional Council, as well as some other councils nationally, explicitly recognise the goal of carbon enhancement through registration of suitable forest areas within the Permanent Forest Sink Initiative. In general, planting with a focus on restoring ecosystem function is not just a matter of inserting species, and can beneficially target maintaining if not enhancing ecosystem services, engendering a holistic and multi-purpose underpinning and awareness. In many respects ecosystems influence the types of social relationships that are established in particular cultures (Bhatti and Church 2001). Restoration of habitat and biodiversity by community volunteers provides health and other benefits from a sense of making a difference or contributing to the greater good (Blaschke (in press). Ecological restoration indeed is often as much about restoring communities and spirit as it is about ecology.

Carbon storage

The largest living carbon stores are big, old trees – or noble trees as they are known in Europe. They are tall with big trunks and root systems, have dense wood, and are long-lived. With

urban infilling and the trend towards much larger house floor areas, there is a tendency towards smaller trees, and new owners commonly replace existing small trees with those of their own preference. Provision of large urban trees (or encouragement of trees to remain long enough to become large), in public areas – streets, woodlots, green belts, and urban spaces of all kinds including ‘wasteland’ – can maximise ecosystem services, as well as other (wildlife) values (Wunder 2008).

Soil carbon is also a significant carbon pool, which should always be preserved as far as possible, not just for soil health reasons. Especially important is avoiding land surface stripping and respreading of topsoil during green-fields development, a practice that is still prevalent in New Zealand.

Parks and open space management

Providing urban green spaces is at the centre of maximising benefits from urban ecosystem services, as well as for their other values discussed here (Douglas and Revetz 2011). To illustrate the open space requirements of a group of urban residents we cite some results from a survey of central city apartment dwellers undertaken by the Wellington City Council in 2008 (City Planning 2009). These residents represent a significant portion of Wellington City’s overall recent population growth. More than 12 000 people now live within Wellington’s CBD. Over a third of survey respondents previously lived in a house in the suburbs, reflecting a growing trend for people to choose inner-city living and perhaps also a trend for ‘empty-nesters’ to downsize. Three-quarters of apartment residents, who work in the central city, walk to work (73%). Three-quarters of survey respondents also do their grocery shopping in the central area. The survey authors suggested that this pointed to a preference, among these residents, for a sustainable lifestyle. Ninety percent of respondents lived within 10 minutes’ walk of a public park and nearly half regularly used a public park. Lack of outdoor space was cited as the second most disliked aspect of living in an apartment. Nevertheless a large majority of respondents were satisfied with the current public facilities and services provided. Box and Harrison (1993) have quantified minimum guidelines for citizen access to open and green space in England, as has China in its open space policies (Chen, 2013). Meurk and Hall (2006) have provided coincidentally converging proximity metrics for New Zealand, although originating from landscape ecology analysis rather than social considerations, and these have been picked up by open space planners in Auckland and Christchurch (Renard and Meurk 2004).

Pocket parks and ecological parks were pioneered in Europe only a few decades ago, but offer the important additional value of diversity of habitat and species, and interest within small spaces. This was demonstrated in an exhibit at the 2012 Christchurch Ellerslie International Flower Show (Figure 8; <http://www.ourfuture.net.nz/Stories/192>).

Other biodiversity enhancement (gardens etc.)

Lawns are one of the largest urban biotopes (20–35% in New Zealand cities); it became convention and a matter of pride to have uniform, monocultural lawns in suburbia, with garden supply chains specifically marketing herbicides to target hydrocotyle, often the only native species in our lawns. However, this has come at a high cost in terms of use of resources and environmental impacts. Revealing statistics concerning lawns in the United States are presented at <http://ezinearticles.com/?The-Environmental-Cost-of-US-Lawns&id=1118004>. Especially if

indigenous mat and turf species are employed, a mixed, biodiverse lawn (Ignatieva et al. 2008a) requires less water, fertiliser, herbicides, and mowing (Figure 8). A mixed-species meadow provides similar benefits, including food for beneficial insects, not to mention variety and interest.

Efforts to conserve rare or threatened species need not always involve restoration of native ecosystems. Even highly artificial and contrived urban habitats may provide this benefit: traffic islands in Wellington were planted with the local *Muehlenbeckia astonii* (Sawyer 2005), a genus that is an important food source for native butterflies. The reality is that all cultural landscapes are occupied by ‘recombinant ecosystems’ (mixes of indigenous and exotic species) and always will (Meurk 2011).

Transport planning

Highways have both positive and negative effects on ecosystem services, the environment, and traveller experience (Meurk et al. 2012). Although lead has been removed from petrol, other contaminants are delivered to the environment through fumes, tyre wear and engine oil. Highways are also a significant source of urban noise. More sensitive design of roads and buffers can greatly diminish impacts on the surrounding land, water, and people, including reducing noise levels.

Public transport routes provide an opportunity for incorporating sometimes rare biodiversity. Coarse-textured substrates on north-facing batters provide habitat for dryland species (Figure 9), traffic islands provide havens for micro-fauna, and again a range of *Muehlenbeckia* species are well suited to rail corridors of coarse stones. These can provide excellent habitat for butterflies and lizards, especially if the design incorporates provision for safe ‘lizard lounges’.

Planning for active transport – encouraging walking and cycling as a regular form of personal transport for commuting, leisure, and health, often using green spaces – is essential to maximising ecosystem services (Chapman et al. 2012), provided safety issues are addressed.

Enhanced urban food production

Encouraging urban gardening – both within individual sections or allotments and in shared spaces – contributes not only to food production, but also to a number of indirect ecosystem services such as health, recreation and amenity, as has been demonstrated by the Dunedin Garden Study. Provided biodiversity-friendly fertiliser and pest control techniques are used, increased gardening



FIGURE 9 Establishing locally rare dryland species (e.g. *Dichelachne*, *Lachnagrostis*, *Geranium*, *Leptinella*, *Muehlenbeckia*) in a specially prepared stressed niche (very-free-draining, north-facing substrate) on the Christchurch Southern Motorway extension.

can also contribute to biodiversity. Bhatti and Church (2001) note that modernistic interpretations of home gardening tends to be utilitarian and consumerist, but they also reflect more complex or ambiguous social and environmental relationships that we would suggest can be nurtured for positive outcomes. Constraining use of pesticides, and providing habitat diversity, facilitate natural pest regulation; in the same way as beetle banks operate in agricultural settings (MacLeod et al. 2004). Beekeeping underpins food production from crops: Plan-bee has been described earlier. Besides providing honey, urban beekeeping can contribute, through bees foraging across the country, to pollination of agricultural crops in peri-urban areas. Potentially, urban areas can provide refuges for bees. For urban beekeeping to be successful, however, use of pesticides must be carefully controlled.

In terms of animal production, eggs and meat from poultry continue to have potential, especially in peri-urban and residential areas with larger sections. It is less practical in multi-unit and inner city, denser living areas unless enclosed roof gardens can be appropriated for the purpose.

Loss of peri-urban Class I soils and land to urbanisation represents a substantial loss of potential urban ecosystem services at the same time as it diminishes the commercial food producing capacity. Retaining farming in these areas can support commercial food production, and contribute to achieving planning objectives for urban form. However, land valuation and property rights are a significant barrier to reconfiguring these land uses.

On a regional scale, urban gardens can help reduce the environmental footprint of cities. As reported by Vitiello (2008), ‘local organic food production has a role to play in diminishing energy consumption in virtually all parts of the food system. It reduces the use of fossil fuel-based pesticides and fertilisers, limits the need for long-distance transportation and typically requires a low level of processing, packaging and refrigeration.’

In summary, increasing urban food production is not necessarily incompatible with efficient land use and intensification, whether at the local or regional scale. However, fully realising the benefits requires effective resource- and nutrient-conserving methods, such as organics, biodynamics or permaculture, and sound multi-objective planning.

CONCLUDING REMARKS

The notion of urban ecosystem services is often conflated with ‘green cities’. Birch and Wachter (2008) asked ‘What is a green city?’ They observe that ‘it is an ideal, yet to be attained by any urban place in the world, but certainly achievable in the twenty-first century. In its most perfect form, a green city is carbon neutral and fully sustainable ... a healthy place that has clean air and water, pleasant streets and parks ... It is resilient in the face of natural disasters and faces little risk of infectious disease. Its residents have strong, green behavioural habits, like taking public transport, practising recycling and water conservation, and using renewable energy.’ To understand the extent that maximising ecosystem services can contribute to attaining this ideal, some reflection on the purpose and function of a city is required. Historically, cities have concentrated and provided services to a wider hinterland, and this is still largely true in New Zealand. It is therefore unrealistic for New Zealand cities to be carbon neutral and ‘fully sustainable’ if that is taken to mean self-sufficiency. The footprint of a city cannot be judged in isolation from its hinterland. Nevertheless, if New Zealanders wish to minimise their national or local environmental footprints, city inhabitants need to play their part and balance, as far as possible, inputs with

outputs, avoid cumulative poisons, and fulfil their needs through judicious management of abundant and sustainable ecosystem services.

Most of the ecosystem services described in other chapters of this book are also provided, to varying degrees, by cities. Although often provided at smaller spatial scales, and being more fragmented or disrupted than in rural or wild environments, urban ecosystem services affect and benefit all levels of New Zealand's urban population, as in other urbanised countries. They are not confined to green spaces or places with indigenous or any one kind of biodiversity. They are of especial significance in cities, mainly through regulating and cultural services such as water quality, stormwater regulation, flood and erosion control, waste disposal, air quality, recreation, health and well-being, and contributing to a sense of place. The three last (cultural) services are particularly difficult to value economically, but are clearly valued very highly by most urban residents and contribute significantly to quality of life and social capital in cities, with consequences for mental well-being, innovation, and economic activity. Provision of these ecosystem services should therefore rank very highly in any credible well-being indicator (e.g. a 'genuine progress indicator'), and is notably absent from narrow measures such as gross domestic product.

A key source of urban ecosystem services, not commonly associated with urban areas, is the forest. Urban forests deliver an extraordinarily wide range of the ecosystem services, including temperature moderation, improvements in water and air quality, carbon sequestration and amelioration of noise levels, as well as biodiversity values. Human health and well-being, and the amenity values of most cities worldwide, except those in the highest latitudes, are strongly related to the quantity and quality of urban forests, which can be established on land of all types and quality, and do not need to compromise desires for higher population densities. Imaginative targeting and criteria for urban forestry projects may provide benefits even for the most marginalised urban dweller (Wunder 2008). In New Zealand, urban forestry projects would be given significant impetus from a realistic price on carbon so that carbon sequestration can provide a basis for the monetary valuation of ecosystem services. Dispersed urban woodlands (the cumulative biomass of scattered trees) should also be part of a more sophisticated formula for carbon banking.

It is reasonable to argue that focusing on known high-productivity ecosystems, such as wetlands, estuaries and areas of high quality soil, can boost urban ecosystem services most effectively. Protecting high quality soils in peri-urban areas is important for future option values involving food production or contributing to biodiversity through remnants or green belts. Flourishing peri-urban agriculture, using short, environmentally sensitive transport links, can not only supply food efficiently, but also help shape an agri-food system in which people have equitable access to fresh, nutritious food. On the other hand, water regulation and flood control need to use a city-wide approach or at least a catchment-wide approach in key catchments. For urban and peri-urban agriculture to be sustainable and healthy, it is of course necessary that air-borne and water-borne toxins must be ameliorated. Otherwise urban vegetables and fruits may become a health hazard.

There is a significant potential for urban design, including building design, to increase benefits from ecosystem services, and simultaneously enhance other urban characteristics valued by New Zealanders – amenity of both public and private areas including domestic houses and gardens, access to green and blue

spaces, recreation opportunities, clean water, quality of environment generally and biodiversity. Every city has potential to become an eco-city or a transition town on a path to becoming an eco-city. This can effectively lower New Zealand's ecological footprint and progressively lead to improved quality of life.

As we remarked in our introduction, urban ecosystem services are provided by a wide range of highly specialised urban habitat types. These can be viewed simply as extensions of the major natural ecosystems of the world. The fundamental difference is that because of the contraction, degradation and fragmentation of habitat or natural populations, and the intensity or frequency of disturbance, many urban ecosystems are vulnerable to being overwhelmed by flood waters, sediment, detritus, toxins, air pollution, physical impact, defoliation or pests. Accordingly the ecosystem services they provide frequently operate at a very low ebb. But because, globally, most of world's population now lives in urban environments, a democratic concern for justice has the capacity to drive equitable access to a fulfilling life that can be provided by ecosystem services. In times when climate change is leading to more erratic and dangerous weather patterns, we may need reminding that Nature can indeed 'be our friend'. If we learn about natural processes and their role in sustaining ecosystems – especially in the urban ones we inhabit – and if we look after them and enhance them, we can derive both economic benefit, pleasure, and the full range of ecosystem services from nature in the city. The unfolding story of ecosystem services will revolve around how we sum our human experience and enrich it by making sustainable use of natural processes, and develop an inclusive governance that services that ideal.

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REFERENCES

- Alloway BJ 2004. Contamination of soils in domestic gardens and allotments: a brief overview. *Land contamination and reclamation* 12: 179–187.
- Auckland Council 2010. State of the Environment report. Auckland Council.
- Baker MG, Barnard LT, Kvalsvig A, Verrall A, Zhang J, Keall M, Wilson N, Wall T, Howden-Chapman P 2012. Increasing incidence of serious infectious diseases and inequalities in New Zealand: a national epidemiological study. *The Lancet* 379: 1112–1119.
- Batstone C, Sinner J 2010. Techniques for evaluating community preferences for managing coastal ecosystems. Auckland regional stormwater case study. ARC Technical Report 2010/12.
- Bell B, Yap M, Cudby C, Scarpa R 2008. 'Valuing indigenous biodiversity'; paper prepared for FRST Project NIMMO501. Wellington, Nimmo Bell Partners.
- Bhatti, M. Church, A. 2001 Cultivating natures: homes and gardens in late modernity. *Sociology* 35: 365–383.
- Birch EL, Wachter SM eds 2008. Growing Greener Cities: urban sustainability in the twenty-first century. University of Pennsylvania Press.
- Blaschke PM In press. Health and wellbeing benefits of conservation in New Zealand. *Science for Conservation*.
- Blaschke PM, Warren J, Taylor N, Gough J, Bailly M, Pihema W, Whitney P. 2006. Nature-based tourism: panacea for sustainable development in New Zealand regions? Background paper, Review of Progress with Sustainable Development in New Zealand. Parliamentary Commissioner for the Environment, Wellington. http://www.pce.govt.nz/projects/COF2background_papers.shtml
- Boffa Miskell Ltd 2001. Green and promised land: Wellington's Town Belt. Museum of City & Sea, Wellington.
- Box J, Harrison C 1993. Natural spaces in urban places. *Town and Country Planning* 62: 231–235.
- Brockerhoff E, Given D, Ecroyd C, Palmer J, Burdon R, Stovold T,

- Hargreaves C, Hampton J, Mackay M, Blaschke P 2004. Biodiversity: conserving threatened indigenous species. Forest Research Report for Ministry of Agriculture and Forestry (operational research report).
- Butcher Partners 2006. Economic valuation of Te Papanui Conservation Park. Paper for Department of Conservation. <http://www.doc.govt.nz/publications/conservation/benefits-of-conservation/economic-benefits-of-water-in-te-papanui-conservation-park/>
- Campbell-Hunt D 2002. Developing a sanctuary – the Karori experience. Wellington, Victoria Link.
- Carbine M 2011. Understanding how ecosystems benefit Aucklanders. Paper for Ecosystem Services in Policy Workshop. Royal Society of New Zealand, August 2011. http://www.royalsociety.org.nz/media/ESPW-Megan-Carbines_AucklandCouncil.ppt#1
- Cavanagh JE 2008. Influence of urban trees on air quality in Christchurch: preliminary estimates. Landcare Research Contract Report LC0708/097.
- Cavanagh JE, Clemons J 2006. Do urban forests enhance air quality? Australasian Journal of Environmental Management 13: 120–130.
- Cavanagh JE, Zawar-Resa P, Wilson, JG 2008. Spatial attenuation of ambient particulate matter air pollution within an urbanised native forest patch. Urban Forestry and Urban Greening. Doi:10.1016/j.ufug.2008.10.002.
- CE Associates 2007. <http://www.covinoinc.com/covino-report-april-2007.htm>.
- Chapman R, Howden-Chapman P, Keall M, Witten K, Abrahamse K, Muggeridge D, et al. 2012. Evaluating the Model Communities Programme – literature, methodology and some preliminary results. Paper presented at the 2 Walking and Cycling Conference, Hastings, New Zealand.
- Chen, C. 2013. Translated from Chinese Ministry Documents in: Planning urban nature - Urban Green Space Planning in post-1949 China: Beijing as a representative case study (Unpublished PhD thesis). Lincoln University.
- City Planning 2009. Central City Apartment Dwellers Survey – a summary of results. Report to Wellington City Council.
- Clarkson BD, Downs TM 2000. A vision for the restoration of Hamilton Gullies. In: Clarkson BD, McGowan R, Downs TM eds. Hamilton Gullies – a workshop hosted by The University of Waikato and sponsored by the Hamilton City Council, 29–30 April 2000. Hamilton, University of Waikato. Pp. 48–56.
- Cleghorn M, Carter S, Logan C, Mathews J, Calman R, Ahmad MF et al. 2011. Growing individuals, growing communities: well-being outcomes of participating in ecological restoration and community gardening initiatives. Wellington, University of Otago.
- Clough P 2010. Realistic valuations of our clean green assets. NZIER Insight 19/2010 4pp. Available on <http://nzier.org.nz/sites/nzier.live.egressive.com/files/NZIER%20insight%2019%20-%20Realistic%20valuations%20of%20our%20clean%20green%20assets.pdf>
- Colding J 2011. The role of ecosystem services in contemporary urban planning. In: Niemälä J ed. Urban Ecology – patterns, processes and applications. Oxford University Press. Pp. 228–236.
- Crozier M, G Aggett 2000. A hazardous place. In: McConchie J, Winchester D, Willis R eds. Dynamic Wellington: a contemporary synthesis and exploration of Wellington. Institute of Geography, Victoria University. Pp 137–154.
- Daniels CB, Tait CJ eds. 2005. Adelaide - Nature of a city: the ecology of a dynamic city from 1836 to 2036. BioCity: Centre for Urban Habitats: Adelaide.
- Davies L, Kwiatkowski L, Gaston K, Beck H et al. 2011. Urban. Chapter 10 in UK National Ecosystem Assessment 2011. The UK National Ecosystem Assessment technical report. Cambridge, UNEP-WCMC.
- Dawson B 2010. A history of gardening in New Zealand. Auckland, Godwit.
- Donovan P ed 1990. Religions of New Zealanders. Palmerston North, Dunmore Press.
- Doody BJ, Sullivan JJ, Meurk CD, Stewart GH, Perkins HC 2010. Urban realities: the contribution of residential gardens to the conservation of urban forest remnants. Biodiversity and conservation 19: 1385–1400.
- Douglas I, Ravetz J 2011. Urban ecology – the bigger picture. In: Niemälä J ed. 2011. Urban Ecology – patterns, processes and applications. Oxford University Press. Pp. 246–262.
- Dymond J, Rutledge D, Greenhalgh S, Ausseil A-G, Herzig A, Andrew R, Dagneault D, Hart G 2012. Standard classification of ecosystem services in New Zealand. Landcare Research Contract Report C09X0912 for Ministry of Science and Innovation.
- Ealing LA21 (Ealing Local Agenda 21 Pollution and Public Health Project Group) 2005. The extent of hard surfacing of front gardens in the London Borough of Ealing (www.london21.org/ealingfrontgardens).
- Earle M 2011. Cultivating health: Community gardening as a public health intervention. Unpublished Masters in Public Health thesis. Wellington, University of Otago.
- Effland WR, Pouyat RV 1997. The genesis, mapping and classification of soils in urban areas. Urban Ecosystems 1: 217–228.
- Fahey B, Davie T, Stewart M 2011. The application of a water balance model to assess the role of fog in water yields from catchments in the east Otago Uplands, South Island, NZ. Journal of Hydrology (NZ) 50: 279–292.
- Fassman-Beck E, Simcock R, Voyde E, Hong Y 2013. 4 living roofs in 3 locations: does configuration affect runoff mitigation? Journal of Hydrology. <http://dx.doi.org/10.1016/j.jhydrol.2013.03.004>.
- Fisher G, Kjellstrom T, Kingham S, Hales S, Shrestha RI 2007. Health and air pollution in New Zealand: main report. Health Research Council, Ministry for the Environment and Ministry of Transport.
- Freeman C, Dickinson KJM, Porter S, van Heezik Y 2012. 'My garden is an expression of me': exploring householders' relationships with their gardens. Journal of Environmental Psychology 32:135–143.
- Gadd J, Coco G 2010. Interactions between heavy metals, sedimentation and cockle feeding and movement Part 3. Prepared for Auckland Regional Council.
- Garvin A 2010. Greening cities: a public realm approach. Chapter 4 In Birch EL, Wachter SM eds. Growing Greener Cities: urban sustainability in the twenty-first century. University of Pennsylvania Press.
- Gill SE, Handley JF, Ennios AR, Pauleit S 2006. Adapting cities for climate change: the role of the green infrastructure. Built Environment 33: 115–133.
- Given DR, Meurk CD 2000. Biodiversity of the urban environment: the importance of indigenous species and the role urban environments can play in their preservation. In: Stewart GH, Ignatieva ME eds Urban biodiversity and ecology as a basis for holistic planning and design. Proceedings of a workshop held at Lincoln University. Lincoln University International Centre for Nature Conservation Publication 1. Christchurch, Wickliffe Press Ltd. Pp. 22–33.
- Grime 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. The American Naturalist 111: 1169–1194.
- Harrison C, Burgess J, Millward A, Dawe G 1995. Accessible natural green spaces in towns and cities, A review of appropriate size and distance criteria. English Nature Research Reports 153.
- Hopper SD, Gioia P 2004. The Southwest Australian Floristic Region: evolution and conservation of a global hot spot of biodiversity. Annual Review of Ecology, Evolution, and Systematics 35: 623–650.
- Hostetler, M 2013. The Green Leap: A primer for conserving biodiversity in subdivision development. University of California Press.
- Hostetler, M, Allen, W, Meurk, C 2011. Conserving urban biodiversity? Creating green infrastructure is only the first step. Landscape and Urban Planning 100: 369–371.
- Ignatieva M, Meurk CD, van Roon M, Simcock R, Stewart G 2008a. How to put nature into our neighbourhoods – application of Low Impact Urban Design and Development (LIUDD) principles, with a biodiversity focus, for New Zealand developers and homeowners. Landcare Research Science Series No. 35. Lincoln, Manaaki Whenua Press.
- Ignatieva M, Stewart G, Meurk C 2008b. Low impact urban design and development (LIUDD): matching urban design and urban ecology. Landscape Review 12: 61–73.
- Ignatieva M, Stewart GH, Meurk C 2011. Planning and design of ecological networks in urban areas. Landscape and ecological engineering 7: 17–25.
- Jaine R, Baker M, Venugopal K 2008. Epidemiology of acute rheumatic fever in New Zealand 1996–2005. J Paediatrics Child Health 44: 564–71.
- Jenkin S, Pedersen Zari MTG 2009. Rethinking our built environments: towards a sustainable future. Report for Ministry for the Environment. 55p.
- Kellert S, Wilson EO eds 1993. The Biophilia Hypothesis. Washington, DC, Island Press.
- Kerr GN, Sharp BM 2008. The Impact of Wilding Trees on Indigenous Biodiversity: A Choice Modelling Study. AERU Research Report No. 303. Agribusiness and Economics Research Unit, Lincoln University.
- Korn, M. 1996. The dike-pond concept: sustainable agriculture and nutrient recycling in China. Ambio 25:6–13.
- Kotze JS, Venn J, Niemälä J, Spence J 2011. Effects of urbanisation on the ecology and evolution of arthropods. In: Niemälä J ed. Urban Ecology – patterns, processes and applications. Oxford University Press. Pp. 159–166.
- Kundzewicz ZW, Menzel L 2005. Natural flood reduction strategies – a

- challenge. *International Journal of River Basin Management* 3: 125–131.
- Kuo FE 2010. *Parks and Other Green Environments: Essential Components of a Healthy Human Habitat*. Ashburn, VA: National Recreation and Park Association.
- Lindsay H, Wild C, Byers S 2009. *Auckland Protection Strategy: A report to the Nature Heritage Fund Committee*. Wellington, Nature Heritage Fund.
- Louv, R 2005. *Last child in the woods: saving our children from nature-deficit disorder*. Chapel Hill, NC, Algonquin Books.
- Mace GM, Bateman I et al. 2011. Conceptual framework and methodology. Chapter 2 in *UK National Ecosystem Assessment Technical Report*. Cambridge, UNEP-WCMC.
- Macleod A, Wratten SD, Sotherton NW, Thomas MB 2004. 'Beetle banks' as refuges for beneficial arthropods in farmland: long-term changes in predator communities and habitat. *Agricultural and Forest Entomology* 6: 147–154.
- Maller C, Townsend M, Leger LS, Henderson-Wilson C, Pryor A, Prosser L 2008. Healthy parks, healthy people: The health benefits of contact with nature in a park context. Melbourne, Deakin University and Parks Victoria.
- Mark AF, Dickinson KJM 2008. Maximizing water yield with indigenous non-forest vegetation: a NZ perspective. *Frontiers in Ecology and Environment* 6: 25–34.
- Mathieu C, Freeman C, Aryal J 2007. Mapping private gardens in urban areas using object oriented techniques and very high resolution imagery. *Landscape and Urban Planning* 81: 179–192.
- McConchie J 1980. Implication of landslide activity for urban drainage. *New Zealand Journal of Hydrology* 19: 27–34.
- McConchie J 2000. From floods to forecasts: the hydrology of Wellington. In: McConchie J, Winchester D, Willis R eds. *Dynamic Wellington: a contemporary synthesis and exploration of Wellington*. Institute of Geography, Victoria University of Wellington. Pp. 35–74.
- McGowan R 2000. Plants for rongoā: traditional Māori medicine. In: Clarkson BD, McGowan R, Downs TM eds. *Hamilton Gullies — a workshop hosted by The University of Waikato and sponsored by the Hamilton City Council*, 29–30 April 2000. Hamilton, The University of Waikato. Pp. 27–29.
- MEA 2005. *Ecosystems and human well-being: current state and trends*. Findings of the condition and trends working group. Millennium Ecosystem Assessment Series. Island Press. 984 p.
- Meurk CD 2003. Cities are cultural and ecological keys to biodiversity futures – The 2003 Banks Memorial Lecture. *New Zealand Garden Journal* 6: 3–9.
- Meurk C 2004. Beyond the forest: restoring the 'herbs'. In: Spellerberg I, Given D. eds. *Going native*. Christchurch, Canterbury University Press. Pp. 134–150.
- Meurk CD 2005. Cities are cultural and ecological keys to biodiverse futures. In: Dawson MI ed. *Greening the city: bringing biodiversity back into the urban environment*. Proceedings of a conference held by the Royal New Zealand Institute of Horticulture in Christchurch, 21–24 October 2003. Royal New Zealand Institute of Horticulture, Lincoln University. Pp. 301–310.
- Meurk, CD 2011. Recombinant Ecology of Urban areas – characterisation, context and creativity. Pp 198–220 in Douglas, L., Goode, D., Houck, M.C., Wang, R. (editors), *The Routledge Handbook of Urban Ecology*. Routledge, London.
- Meurk CD, Hall GMJ 2006. Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. *New Zealand Journal of Ecology* 30: 131–146.
- Meurk CD, Swaffield SR 2000. A landscape ecological framework for indigenous regeneration in rural New Zealand-Aotearoa. *Landscape and Urban Planning* 50: 129–144.
- Meurk CD, Swaffield SR 2007. Cities as complex landscapes: biodiversity opportunities, landscape configurations and design directions. *New Zealand Garden Journal* 10: 10–20.
- Meurk CD, Zvyagana N, Gardner RO, Forrester G, Wilcox M, Hall G, North H, Belliss S, Whaley K, Sykes B, Cooper J, O'Halloran K 2009. Chapter 18: Environmental, social and spatial determinants of urban arboreal character in Auckland, New Zealand. In McDonnell MJ, Hahs AK, Breuste JH eds. *Ecology of cities and towns: a comparative approach*. Cambridge University Press. Pp. 287–307.
- Meurk CD, Watts RH, Swaffield SR, Awatere S 2012. A natural environment cultural asset management system for New Zealand's state highway network: towards a practical concept and application. NZ Transport Agency research report 503. 77 p.
- Miller JR 2005. Biodiversity conservation and the extinction of experience. *Trends in Ecology and Evolution* 20: 430–434.
- Ministry for the Environment 2007. *Environment New Zealand 2007*. Wellington, Ministry for the Environment.
- Ministry for the Environment 2010. *Preparing for future flooding: A guide for local government in New Zealand*. Report ME1012. Wellington, Ministry for the Environment.
- Ministry of Health 2005. *Drinking water standards for NZ 2005*. Wellington, Ministry of Health.
- Mitchell R, Popham F 2008. Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet* 72: 1655–1660.
- Mithraratne N, Vale R 2007. Conventional and alternative water supply systems: a life cycle study. *International Journal of Environmental and Sustainable Development* 6:136–146.
- Morgan K 2010. Feeding the city: the challenge of urban food planning. *International Planning Studies* 14:341–348.
- Morris P 2000. Restoring gullies: reflecting on experience. In: Clarkson BD, McGowan R, Downs TM eds. *Hamilton Gullies — a workshop hosted by The University of Waikato and sponsored by the Hamilton City Council*, 29–30 April 2000. Hamilton, The University of Waikato. Pp. 30–41.
- Mulet-Marquis S, Fairweather JR 2008. Rural population and farm labour change. Research Report No. 300. Lincoln, Lincoln University.
- Nagels P 2005. Raintanks in an urban setting – radical, real or revolution? Proceedings of the 4th South Pacific Conference on Stormwater and Aquatic Resource Protection, 4–6 May 2005, Auckland, NZ.
- Ninan KN ed 2008. *Conserving and valuing ecosystem services and biodiversity: economic, institutional and social challenges*. London, Earthscan Publications.
- Patterson MG, McDonald GW, Smith NJ 2011. Ecosystem service appropriation in the Auckland region economy: an input-output analysis. *Regional Studies* 45: 333–350.
- Pearce J, Kingham S 2008. Environmental inequalities in New Zealand: a national study of air pollution and environmental justice. *Geoforum* 39: 980–993.
- Pearce J, Kingham S and Zawar-Reka P 2006. Every breath you take: Environmental justice and air pollution in Christchurch. *Environment and Planning A* 38: 919–938.
- Pedersen Zari M 2012. *Ecosystem services analysis for the design of regenerative urban built environments*. Doctor of Philosophy thesis, Victoria University of Wellington, New Zealand.
- Peters S, Burns B 2013. Urban forest of residential Auckland: composition, structure and resilience. Presentation to Southern Connections Conference, Dunedin, February 2013.
- Renard, T. and Meurk, C.D. 2004. Land, habitat and resource planning and mapping in southwest Christchurch. Unpublished report to Christchurch City Council.
- Richardson E, Pearce J, Mitchell R, Day P, 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: 240.
- Richardson EA, Pearce J, Mitchell R, Kingham S 2013. Role of physical activity in the relationship between urban green space and health. *Public Health*: doi: 10.1016/j.puhe.2013.01.004
- Rydin Y, Bleahu A, Davies M, Dávila JD, Friel S et al. 2012. Shaping cities for health: complexity and the planning of urban environments in the 21st century. *The Lancet* 379: 2079–2108.
- Sadler JP, Bates AJ, Hale J 2010. Bringing cities alive: the importance of urban greenspaces for people and biodiversity. In: Gaston KJ ed. *Urban Ecology*. Cambridge, Cambridge University Press.
- Sanderson S, Redford K 2003. Contested relationship between biodiversity conservation and poverty alleviation. *Oryx* 1: 1–2.
- Sauerwein M 2011. Urban soils – characterisation, pollution and relevance in urban ecosystems. In: Niemälä J ed. *Urban Ecology – patterns, processes and applications*. Oxford University Press. Pp. 45–58.
- Sawyer J 2005. Saving threatened native plant species in cities – from traffic islands to real islands. In: *Greening the City*. Proc. RNZIH conference. Pp. 111–117.
- Statistics New Zealand 2004. *New Zealand: an urban/rural profile*. http://www.stats.govt.nz/browse_for_stats/people_and_communities/Geographic-areas/urban-rural-profile.aspx.
- Stevenson A, Pearce J, Blakely T, Ivory V, Witten K 2009. *Neighbourhoods and health: a review of the New Zealand literature*. New Zealand Geographer 65: 211–221.
- Stewart G, Ignatieva M, Meurk C 2007. *Designing with nature – an*

- interdisciplinary approach. *New Zealand Institute of Surveyors Quarterly* 50: 19–22.
- Stewart GH, Meurk CD, Ignatieva ME 2009. Nature conservation strategies: urban design with ecological priorities. *Landscape Architecture Design* 3: 44–47.
- St Hilaire, R., Arnold, M.A., et al. 2008. Efficient water use in residential urban landscapes. *Hortscience* 43: 2081–2092.
- St Hilaire, R., VanLeeuwen, D.M., Torres, P. 2010. Landscape preferences and water conservation choices of residents in a high desert environment. *HortTechnology* 20: 308–314.
- Suren A, Elliot S 2004. Effects of urbanisation on streams. In Harding J, Mosley P, Pearson C, Sorrell B eds. *Freshwaters of New Zealand*. Christchurch, NZ Hydrological Society.
- Townsend M, Thrush S 2010. Ecosystem functioning, goods and services in the coastal environment. Auckland Regional Council Technical Report 2010/033.
- UK National Ecosystem Assessment 2011. The UK National Ecosystem Assessment Technical Report. Cambridge, UNEP-WCMC.
- Van Heezik YM, Dickinson KJM, Freeman C 2012. Closing the gap: communicating to change gardening practices in support of native biodiversity in urban private gardens. *Ecology and Society* 17: 34–43.
- Vejre H, Jensen FS, Thorsen BJ 2010. Demonstrating the importance of intangible ecosystem services from peri-urban landscapes. *Ecological Complexity* 7: 338–348.
- Vesely E-T 2007. Green for green: the perceived value of a quantitative change in the urban tree estate of New Zealand. *Ecological Economics* 63: 605–615.
- Vesely E-T, Heijs J, Stumbles C, Kettle D 2005. The economic side of low impact stormwater management in practice. 4th South Pacific Conference on Stormwater and Aquatic Resource Protection. Auckland, New Zealand Water & Wastes Association.
- Vitiello D 2008. Growing Edible Cities. In: Birch EL, Wachter SM eds. *Growing greener cities: urban sustainability in the twenty-first century*. University of Pennsylvania Press. Pp. 259–280.
- Voyde E, Fassman E, Simcock R 2010. Hydrology of an extensive living roof under sub-tropical climate conditions in Auckland. *Journal of Hydrology (NZ)* 394: 384–395.
- Waitangi Tribunal 2011. *Ko Aotearoa Tēnei: a report into claims concerning New Zealand law and policy affecting Māori culture and identity* (WAI 262 report). Wellington, Waitangi Tribunal.
- Wald C 2013. City of heat. *New Scientist* 13 April: 30–34.
- Whaley PT, Clarkson BD, Smale MC 1997. Claudelands Bush: ecology of an urban kahikatea (*Dacrycarpus dacrydioides*) forest remnant in Hamilton, New Zealand. *Tane* 36: 131–155.
- Wilcox MD 2012. Auckland's remarkable urban forest. Auckland Botanical Society.
- Williams PA, Karl BJ 1996. Fleshy fruits of indigenous and adventive plants in the diet of birds in forest remnants, Nelson, New Zealand. *NZ Journal of Ecology* 20: 177–145.
- Witten K, Hiscock R, Pearce J, Blakely T 2008. Neighbourhood access to open spaces and the physical activity of residents: a national study. *Preventative Medicine* 47: 299–303.
- Wunder S 2008. Payments for environmental services and the poor: concepts and preliminary evidence. *Environment and Development Economics* 13: 279–297.

ENDNOTES

- 1 http://www.fh-erfurt.de/urbio/httpdocs/content/ErfurtDeclaration_Eng.php; http://www.fh-erfurt.de/urbio/httpdocs/content/documents/mumbai_declaration_urbio_2012.pdf
- 2 http://www.michigan.gov/documents/dnr/22_benefits_208084_7.pdf
- 3 <http://www.stuff.co.nz/national/health/8529835/Loaf-of-bread-sunny-breeze-and-sanity>
- 4 <http://www.enviroschools.org.nz> <http://www.aucklandcouncil.govt.nz/EN/environmentwaste/sustainabilityconservation/environmentalprogrammes/learningthroughexperience/Pages/home.aspx>
- 5 http://en.wikipedia.org/wiki/Urban_wild; <http://www.urbanwilddesign.com/>
- 6 <http://www.bbc.com/future/story/20120503-sustainable-cities-on-the-rise/>
- 7 http://www.mwpress.co.nz/store/downloads/LRSS35_nature_neighbourhoods.pdf <http://www.wold.landcareresearch.co.nz/services/greentoolbox/gtbweb/default.asp>; and <http://www.landcareresearch.co.nz/science/living/cities-settlements-and-communities/rebuilding-christchurch/ellerslie>.

Online submission

This is a submission that was made online via the Council's website.

Submitter No.	S624
Submitter Name	Bridget Dadds
Submitter first name	Bridget
Submitter middle name	Diana
Submitter surname	Dadds
Submitter is contact	Yes
Email	bridget_dadds@hotmail.com
Wish to be heard	Yes
Joint presentation	Yes
Trade competition	I could not gain an advantage in trade competition through this submission.
Directly affected	N/A
Withhold contact details?	No

Submission points

Plan section	Provision	Support/oppose	Reasons	Decision sought
Inner City and City Fringe Zones	Inner City Zone	Support in part		

High Density / Medium Density Zone

To allow 3 to 6 storey units to be built without any consultation to neighbours or the immediate neighbourhood is unfair, unjust and offers a poorly planned option for the residents of Nelson to respond to.

Our homes are our castle. They're not a commodity or investment. They are the product of a lifetime of financial and emotional investment. To allow one's enjoyment of that to be affected without consultation is unfair and if allowed to proceed will have a tremendous social cost.

Daylight sunshine. We are very good at measuring the measurable. Angles, percentages. But how to you measure the feeling of joy from the warmth of sun on your face, or conversely the feeling of anger at no longer being able to enjoy a view you once had, because of a building that's now blocking your line of sight?

Following the earthquake rebuild in the hill regions of Christchurch where consents were loosened to speed up the repair and rebuild of houses there, many residents with views they had paid a great deal of money for, found themselves looking at the southern wall of their neighbour rather than their view over the city.

It created a great deal of anger and despair. It destroyed people's lives and torn once friendly neighborhoods apart. Making it legal doesn't make it moral. Allowing this to happen legally would divide the community and pit neighbour against neighbour.

You cannot measure the stress that this plan change would create, or the toll on people's mental health.

The Plan allows the developer too much control.

Leaving design decisions up to the developer, because by nature of business, will mean that the success is measured by profit rather than positive housing betterment. Developers are not known for their sympathetic views of neighbouring property owners. Whatever form this Plan takes should ensure robust design that includes neighbourhood input.

I would support multiple storey units to be built in the **central business area** of Nelson.

Apartments on commercial buildings, or similar to the units near FreshChoice. Take advantage of commercial areas that are vacant and can be rezoned to accommodate residential units

I also support the building of 3 storey (not 6) in ALL areas of Nelson where there is no **loss of light or view** to neighbouring properties, and it is suitable from a geographical and infrastructural aspect. Any disruption to light or access or view should initiate (at the developers cost, a meeting between parties for resolution.

There has to be a pathway for affected neighbours to be heard and compensated (if chosen), again at the developers cost, NOT the Councils.

The argument for intensive housing development for affordable housing is flawed.

How will allowing developers to build multiple story units, help the less advantaged people of Nelson? Developers don't build \$600k units for a reason. There's less profit in it. Developers will build units worth \$1.2m which will be unobtainable to most other than overseas buyers who will soon have access to New Zealand's housing stock, or people moving to Nelson from out of town.

Sewerage plant under pressure during climate related weather events

Bell Island is designed to serve up to 133,000 population and yet it is already under pressure during storms and sea surges. This is not going to go away, it will only get worse. Who is going to pay for this to be upgraded to meet the additional population? The ratepayers?

<https://www.rnz.co.nz/news/ldr/497332/climate-change-challenges-wastewater-treatment-plant>

The effects of climate change are now impacting on Nelson-Tasman's wastewater treatment facility on Bell Island, with new land needing to be found for its long-term viability.

One of the immediate concerns for the facility - which serves Nelson City and Tasman communities as far as Wakefield and Māpua - is it being inundated with excess wastewater during major rainfall events.

Climate change increases the frequency and intensity of extreme weather events.

There were two periods during the 2022/23 financial year when inflows exceeded the treatment plant's discharge capacity and extensions to its discharge duration were requested until the wastewater level was reduced to a manageable level

The sewerage system can only process a limited amount. That amount has been reached. It doesn't matter what time of the day it is processed, it still needs to be processed.

Roading and parking

Roads are at capacity now. You cannot say no cars to apartment owners. Many will have a car and will simply park it on the street. We are not Melbourne with a hub of bankers and city workers who eat out every day.

Areas that are appropriate with Nelson for 3 storey buildings:-

The corner of Nile Street and Dommet Sts. This large parcel of building and land which one assumes is for development would suit 3 story townhouses.

Perhaps areas of the Port could be developed for housing?

Developer funds a planning review panel.

Heritage	Richmond Avenue	Oppose	Resource consent fees There are a number of costs and regulation surrounding Heritage Precincts and the onus is on the property owner to foot the bill. The benefit to keeping heritage precincts is to the city of Nelson, so why must the home owner bare the costs? We are expected to pay for resource consents that previously would not have had to, but the Council advise that it is not their problem. "Applying for a resource consent does involve additional costs. Currently a \$1500 deposit is required for an application and the total cost depends on the time taken to process it. .." Insurance implications As a home owner whose house falls within the Richmond Heritage Precinct I feel that the Heritage 'powers that be' have little understanding and do not apply any credence to the insurance implications of owning a house in these areas. Insurance companies in Christchurch lost many millions of dollars in repair costs following the earthquake, having to rebuild heritage house. Lessons were learnt and changes to policies followed to ensure that the insurance companies mitigated that exposure. Insurance companies factor in the additional costs of having to repair or replace plaster work, weatherboards, wooden detailing etc. It is unfair that the increased costs and compliance is born by the property owner, when it is a demand placed on us by the Council. In response to my question regarding increasing premiums, the Council stated: "Ultimately it is up to homeowners to discuss their options with insurers and to shop around for the policy that best suits their needs and circumstances". In other words, the Council couldn't care less. I do not believe they understand the issue. With regards to the insurance implication for those whose properties are included in this Richmond Ave Precinct: https://hdp-au-prod-app-nels-shape-files.s3.amazonaws.com/3616/9025/4978/Appendix_M_-_Final_Memorandum_-_Proposed_Heritage_Ave_Precinct_-_2022.pdf	We wish our property at 30 Bronte St, Nelson to be removed from the Richmond Avenue Heritage Precinct. Our house is not spectacular in its historic appearance and the land it sits on (the only reason for its inclusion in the Heritage Precinct) has little relevance in the eyes of anyone other than Dr McEwar If the Council object to this then we seek support in being able to rebuild to our design should our house be deemed uneconomic to repair following an event, without the additional resource conservation fees being placed on us.
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This appendix states with regard to insurance implications, that if a house within this Precinct were to be damaged to the point of being 'uneconomic to repair', the house must be rebuilt to fit the dwelling style of the era.

This is saying that if a natural event or fire deems our house non repairable (uneconomic to repair) in the eyes of an insurance company, we cannot rebuild what we want. We will have to rebuild in the style of 1920s era using sympathetic building materials, paint colours etc.

I strongly disagree with this.

'Uneconomic to repair' is a term insurance companies use when it deems the cost of repair of a property to be greater than the cost to rebuild, something as a property owner I have no control over. It is a decision made by the insurance company alone.

Your house doesn't need to be a burnt out wreck, it only has to be out by 10cm (not difficult in an earthquake situation), for an insurance company to deem it uneconomic.

New insurance systems demand that the homeowner determine the value of the cost of rebuilding. If I don't know what building materials to use (based on Heritage Precinct requirements), then how can know what figure this will be?

If my house is deemed 'uneconomic to repair' we wish to be free to rebuild to our choice of design. For example 2 townhouses to allow a greater housing offering. There were no townhouses in 1920 so we would have no chance of having this approved by the Council.

I believe the costs and limitations of insurance and compliance far outweigh any benefit to us as the property owner.

Obscure wording open to interpretation

The wording of the document is obscure and open to interpretation. When in discussion with the Council, having regulations open to interpretation

can easily mean an additional 3 months of discussions with people in fluorescent holding clipboards having back and forward email

conversations with multiple other people earning \$200 an hour. As well as tens of thousands of dollars in additional resource consent fees.

We wish to have clarification around wording must be given by the Council regarding the ambiguous meaning of some words used in the document. Namely 'street' – is that Richmond Ave or any street? The latest update we have is:

These changes will be notified as part of the Housing Plan Change. They include specifying that a consent is required for Memorandum on Proposed Richmond Avenue Heritage Precinct_Final 12 Issue Raised Reasons Response to interpretation". additions and alterations that are "visible from a road within the precinct", rather than also from "a road or public place adjoining the precinct" as currently worded.

Does this mean that the rules only apply if the changes can be seen from Richmond Ave?

If a house within a Heritage Precinct is deemed uneconomic to repair then there should be a provision for that house to be rebuilt in the style the owner chooses not one that the Council determines.

Heritage value going forward

The owners of properties with heritage value should be approached individually and not blanketed into a heritage heading when many of the buildings are not of heritage value.

There are many houses in Nelson that deserve heritage status, far more than many of the properties on Richmond Ave. And those properties that are should be supported by the Council, not billed by them.

RMA Submission Form for Publicly Notified Plan Change 29



Return your submission by 4pm on
Tuesday 31 October 2023 to:

Senior Planning Administrator
RMA Plan Submissions
Nelson City Council
PO Box 645
Nelson 7040

(Hand delivery or courier to: Ground Floor, Civic House, 110 Trafalgar Street,
Nelson 7010 or email to: environmental.planning@ncc.govt.nz with plan
change no.29 in the subject line)

*Required

Submitter Details

Full Name*	LINDSAY WOOD		
Organisation	RESILIENZ LTD		
Contact Person	LINDSAY WOOD		
Postal address*			
Telephone*		Email*	lindsay@resilienz.co.nz

OFFICE USE
Submission No: S625
Date Received Stamp: 31/10/23
NDOCs No: 539570224+17973

Trade Competition*

If you are a person who could gain an advantage in trade competition through the submission your right to make a submission may be limited by clause 6 (4) of part 1 of Schedule 1 of the Resource Management Act 1991.

- ☒ I/we could not gain an advantage in trade competition through this submission.
- ☒ I/we could gain an advantage in trade competition through this submission. *if yes, please complete the following:*
- ☐ I/we are directly affected by an effect of the subject matter of this submission that: (a) adversely affects the environment; and (b) does not relate to trade competition or the effects of trade competition.
- ☐ I/we are not directly affected by an effect of the subject matter of this submission that: (a) adversely affects the environment; and (b) does not relate to trade competition or the effects of trade competition.

Council Hearing*

- ☒ I/we do not wish to be heard in support of my/our submission.
- ☐ I/we wish to be heard in support of my/our submission. If yes:
- ☐ I/we would be prepared to consider presenting my/our submission in a joint case with others making a similar submission at any hearings.

Public information

Please note that your name and address is required to be made publicly available under the Resource Management Act 1991, as any further submission supporting or opposing this submission is required to be forwarded to you as well as council.

Signature of Submitter*

(or person authorised to sign on behalf of submitter - a signature is not required if you make your submission by electronic means)

Date*

2023 10 31

RMA Submission Form for Publicly Notified Plan Change 29

The specific provisions of the Proposed Plan Change that my submission relates to are as follows:

- | | |
|--|--|
| ☒ Entire Plan Change | ☐ Papakāinga |
| ☒ Residential | ☒ Transport |
| ☒ Inner City and City Fringe | ☐ Mapping |
| ☐ Industrial | ☐ Infrastructure |
| ☐ Suburban Commercial | ☐ Area outside of Plan Change |
| ☒ Natural Hazards/Climate Change | ☐ Subdivision |
| ☐ Heritage | ☒ Other |

- I/we*: ☒ Oppose the Plan Change in part
☒ Support the Plan change in part
☐ Are Neutral about the Plan Change
- ☒ Oppose the Plan Change
☐ Support the Plan Change
☒ Request amendments to the Plan Change

My submission is*:

(include whether you support or oppose the specific provisions or wish to have them amended, and reasons for your views)

AS ATTACHED

RMA Submission Form for Publicly Notified Plan Change 29

I seek the following decision from the Council*:

(Give precise details, where amendments are sought, provide details below of what changes you would like to see).

AS ATTACHED.

Note:

- 1) This form is only for the purpose of making a submission on Proposed Plan Change 29 to the Nelson Resource Management Plan. It is NOT for making a further submission (i.e., in support or opposition to an original submission) or for making a submission on a resource consent or on Council's Annual Plan.
- 2) It is not mandatory to use either the cover or content sheet of this form, however your submission must be in writing and provide the necessary information as indicated on the form, e.g., what is supported or opposed, the reason why and the decision sought, full contact details, etc.
- 3) Council cannot accept a submission that does not clearly indicate what a submitter wishes Council to do (i.e., Council to make a decision to refuse, amend or accept the Plan Change). Please indicate specific recommendations if amendments are sought. Council also cannot accept a submission that does not relate specifically to the Plan Change. In these cases, the submission may be considered 'Out of Scope' and may not be considered further.
- 4) Please note that your submission (or part of your submission) may be struck out if the authority is satisfied that at least 1 of the following applies to the submission (or part of the submission):
 - a. is frivolous or vexatious.
 - b. discloses no reasonable or relevant case.
 - c. would be an abuse of the hearing process to allow the submission (or the part) to be taken further.
 - d. contains offensive language.
 - e. is supported only by material that purports to be independent expert evidence but has been prepared by a person who is not independent or who does not have sufficient specialised knowledge or skill to give expert advice on the matter.



**SUBMISSION TO NELSON CITY COUNCIL
ON PROPOSED PLAN CHANGE 29 2023 10 30**

LINDSAY WOOD, DIRECTOR, RESILIENZ LTD.

WE WISH TO BE HEARD.

Note: Page and clause references in the text are to the PC 29 s32 evaluation report unless stated otherwise.

HAIKU by way of a KARAKIA

May you show wisdom
and courage, stepping well back
to rethink this plan.

INTRODUCTION

We are broadly very supportive of the concept of substantial intensification of existing urban areas as part of an integrated suite of strategies to address all the critical and escalating social and environmental issues we are confronting in the region and beyond.

We acknowledge the enormous amount of work invested in developing Plan Change 29 (PC29) and the related consultation documents, and recognise that aspects are likely to be contentious. We do, however, highlight that this is an era that demands very different ways of doing things almost across the board, in terms of reviewing, changing and moderating our existing activities, and bringing serious innovation to both traditional and emerging ones.

As a result we applaud PC29 as being a significant and courageous step into “different ways of doing things”. Having said that, and while we see it as a promising start, we consider PC29 is still a very long way short of an acceptable finish, and has various fundamental flaws.

For the strategic reasons outlined in items 1,2, and 3 of this submission we object to Plan Change 29 in its entirety.

Our objection would be addressed by a deeply considered strategic review of the entire plan change, capturing all of the issues that have been inadequately addressed and integrating them into a cohesive plan.

We like to think that PC29 can ultimately be developed into the major change that the people of Nelson need and deserve, and we urge Council to commit to that process.

We are also of the view that the development and consultation process of PC 29 has been seriously wanting, with regard to:

- The large scale of the plan change and the complexity of the issues it seeks to address.
- The overclaimed levels of parity with the region’s Future Development Strategy.
- The (subsequently largely rectified) paucity of public engagement which, none the less, set a mistrustful and adversarial tone to the consultation.
- Strategic shortcomings in the S32 report that impede proper public appreciation of the PC29 proposal.
- The relative inaccessibility of key documents (e.g. through their online portal and PDF formats, even with contents pages which offer no means of locating the often-referenced “Part 2” and “Part 3” sources of information, and no hyperlinks to clauses.)

For the foregoing reasons we express deep concern about the development and consultation processes adopted for PC29, regardless of whether they technically comply with minimum legal requirements.

Our concern would be addressed by a substantial and wide-ranging public engagement process such as the participatory democracy processes that the June 2023 review of local government encouraged councils to trial.

1. A SKEWED PORTRAYAL OF THE THRUST OF THE RMA.

The section 32 evaluation report has misrepresented a critically important dimension of the RMA. Section 5 of the S32 report opens with a seeming portrayal of the purpose of the RMA, but in doing so completely bypasses two of the three core principles underpinning the RMA in its cl 5 (2) definition of the central concept of “sustainable management” Specifically, it completely omits reference to :

- (b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems;
- and
- (c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

In so doing the S32 report portrays to the citizens of Nelson a skewed perception of issues fundamental to consideration of PC29, an omission and distortion that it is quite unreasonable to expect the citizens to be alert to in themselves while considering the S32 report.

This is compounded by the fact the S32 report itself fails to address those issues in anything like sufficient detail to enable readers alert to the relevant issues to reach a suitably informed view of PC29. These matters are expanded on below.

2. RMA CLAUSE 5(2) (b) INADEQUATELY CONSIDERED

Clause 5 (1) of the RMA describes the Act’s purpose as to “promote the sustainable management of natural and physical resources.” The immediately-following definition of “sustainable management” identifies three key objectives, of which 5 (2) (b) is “safeguarding the life-supporting capacity of air, water, soil, and ecosystems.”

One of the greatest threats, if not the greatest threat, to the life-supporting capacity of air, water, soil, and ecosystems is climate change, and major causes of climate change are the emission of greenhouse gases from the burning of fossil fuels (especially, in New Zealand, from road transport), and from the construction of buildings and physical infrastructure.

The S 32 report provides no reliable basis for evaluating the impact of PC29 in these regards. While the report makes numerous references to notional ways that PC29 will “support” the reduction of greenhouse gas emissions (e.g. pp 29 and 33) there is no analysis or quantitative evidence whatsoever put forward to validate such claims – an especially conspicuous omission when seen in contrast to the substantial analysis of, say, future population or levels of housing construction.

For example, emissions associated with buildings are generally considered to represent around 15-20% of New Zealand’s GHG emissions profile. However, the construction systems associated with the higher rise buildings PC29 promulgates are, unless very carefully controlled throughout the design, construction, and operational processes, likely to be significantly more carbon-intensive than stand-alone timber-framed dwellings.

Similarly, while intensification would be expected to reduce travel emissions for various reasons (e.g. through lower vehicle kilometres travelled and greater viability of active and public transport) there is no evidence to indicate whether or on what scale that might happen.

Depending on the balance of the foregoing issues, it is possible that on balance the effect of PC29 might be to *increase* overall emissions, which would then be in serious conflict with clause 5 (2) (b).

Indeed, there is a potent argument that “safeguarding the life-supporting capacity of air, water, soil, and ecosystems” must in fact ensure that emissions actually *reduce* at a rate commensurate with, at least¹, the IPCC 2023 Synthesis Report and New Zealand’s “Zero Carbon Act”.

Work carried out by the Nelson Tasman Climate Forum shows that the annual rate of decarbonisation for the Nelson region would need to be a challenging 8.05% per annum, year on year, plus a further allowance commensurate with the further impact of population growth.

The S32 report gives no evidence of considering these matters, and thus its suggestion that PC29 is supporting the reduction of greenhouse gas emissions is at best conjectural and quite possibly seriously mistaken. In addition, it seems predicated on the false notion that “safeguarding the life-supporting capacity of air, water, soil, and ecosystems” is achieved by any level of emissions reduction, while a very substantial level is in fact needed to offer even a modest chance of achieving that in a climate sense.

3. OTHER STRATEGIC SHORTCOMINGS OF THE S32 REOPORT

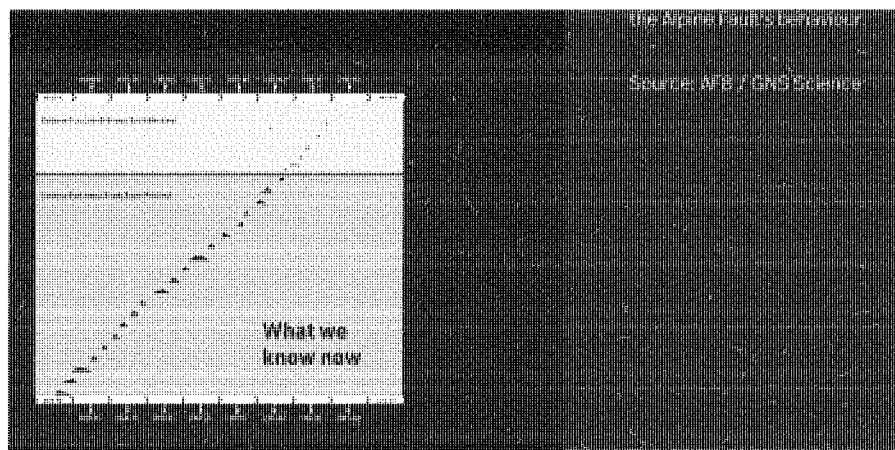
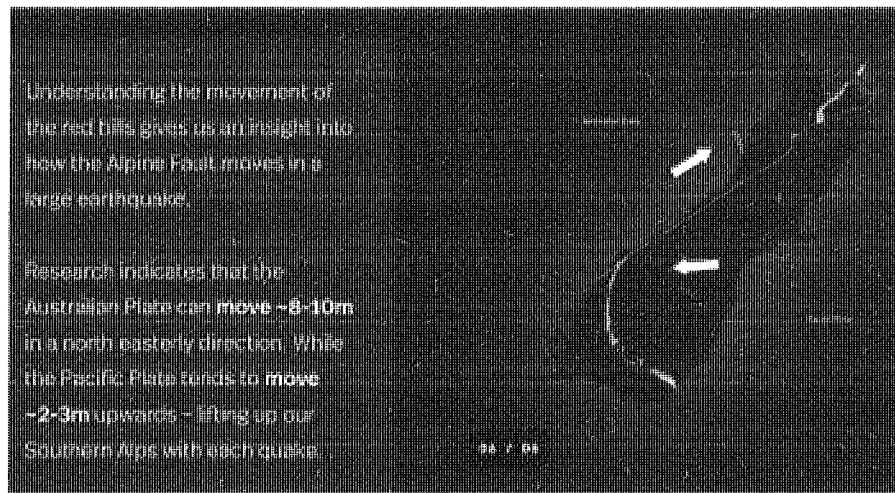
- We find it seriously remiss (as with the FDS) that PC29 deliberately chooses not to consider renewable energy (top of p 25) when the RMA specifically states that it should². Energy drives every economy, renewable energy must be the primary driver of our future economy, and needs to be a key part of our future planning. The implications of this omission are intensified by the failure of PC29 to consider the impacts of an Alpine Fault earthquake (e.g. “AF8”) and its potential to disable the national electricity grid for an extended period.
- The climate change strategies of PC29 (as far as they go) come ahead of, and so can only be poorly informed by, the Dynamic Adaptive Pathways Planning and the climate change risk and vulnerability assessments, which are currently termed as Council “currently developing” and “underway” respectively (p39). These are critical futureproofing studies and PC29 is far too substantial to proceed without such considerations.
- PC29 is silent in reference to perhaps the greatest medium-term natural hazard we face, an “AF8” rupture of the Alpine Fault (silence in spite of “faults” being an issue it is charged with considering, and being topical as recent geological reports have brought forward the likelihood of an “AF8” earthquake). Given that such an event will put our national grid electricity security at serious risk, the failure to consider renewable electricity becomes an even graver omission, and even more so with the potential geometry of structures associated with the proposed intensification, which may well compromise the viability of some rooftop generated solar power.

Please refer <https://storymaps.arcgis.com/stories/424c14ec8d5a4c32829d21fde9244818> which contains GNS information from which the following two images were taken.

¹ “At least” because the IPCC report is predicated on only “better than a 50% probability” of keeping global warming under recommended limits.

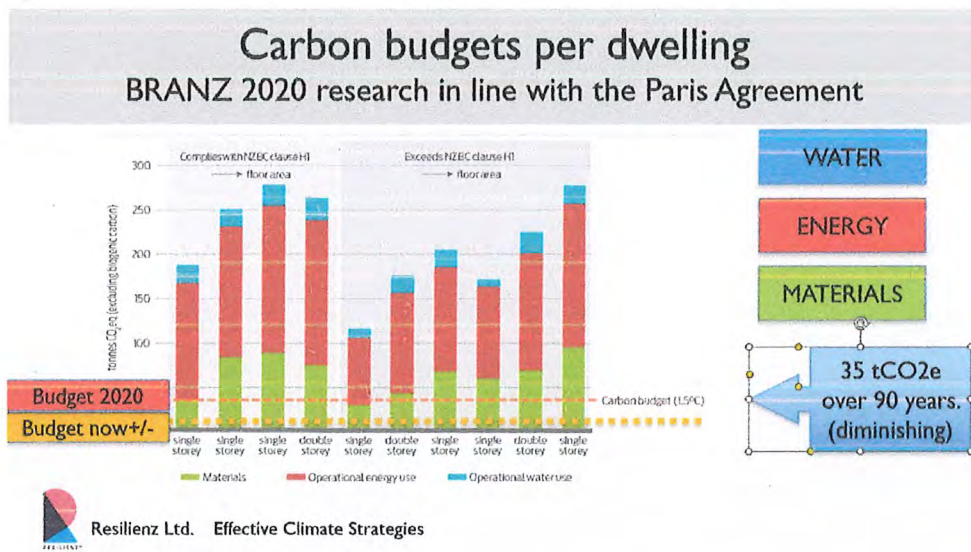
² Section 7 of the RMA (“Other matters”) requires such processes as the development of PC29 to “have particular regard to” various matters, including “the benefits to be derived from the use and development of renewable energy.”

The first image indicates the likely direction and magnitude of movement, and the second, based on recent research, shows the remarkable regularity of Alpine Fault movements, and this underpins the increased focus on a potential AF8 event in the near future.



- PC29 has almost nothing to say about the decarbonisation challenges of our region or of the enormous carbon footprint of our building stock – embodied and operational carbon, in both existing and proposed buildings – when in fact we are almost bereft of ideas how to build such intensification at remotely close to aligning with our Zero Carbon Act.

The image below is from a Resilienz slide based on world-acclaimed research by New Zealand's Building Research Association (BRANZ). The discrepancy between the dotted budget lines near the bottom and the heights of the columns for various dwelling types illustrates just how huge is the challenge of decarbonising our building practices.



BUILT FORM

Timber floor construction:

There are numerous and considerable advantages to maximising the use of timber in lieu of concrete or steel in the construction of buildings. These include use of renewable and local resources, greatly reduced carbon footprints, generally speedier and less disruptive construction, greater potential for subsequent relocation or reuse of entire buildings or their components, and lower impact on the global resource depletion crisis.

However, a modest downside is that timber ground floors generally need to be constructed some 600 mm higher off the ground, to enable appropriate moisture control measures and inspection access. (Although this comes with the benefits of improved freeboard and resilience in the event of inundation, and of simplified maintenance or alteration to building services).

It is thus proposed that in view of the wide-ranging benefits of encouraging the use of timber construction, the maximum height controls in all zones factor in the extra overall height for such timber construction, but require buildings with concrete ground floor construction to work within a 600 mm lower height limit. An exemption would be made for floor construction to an excavated basement (on average, say, at least 1.2 m below surrounding ground).

Benefits of half-basement construction.

There are numerous benefits to developing medium-density residential developments with a utility basement excavated half a storey into the ground. This solution is used widely in Europe and its benefits include:

- Additional useful utility space with modest retaining construction and modest extra building height;
- Improved privacy, security and outlook for dwellings on occupying the ground floor;
- Improved inundation resilience of the lowest apartment level.
- Good and relatively convenient location for a range of utility activities – personal general storage areas; storage of bicycles and the like; housing of heating and related plant; ready access to building g services near their point of entry into the building;
- Potential vehicle parking.



It is proposed that the maximum height rules for MRZ and HRZ are based on a ground floor a maximum of 1.5 m above ground level so as to accommodate an excavated minimum stud basement, and 2.4 m stud dwellings on upper floors.

Height limits generally

We consider the height allowances per storey are too great for general application. For example a three storey building in the MRZ could reasonably be 3 storeys with 2.4 m studs and 0.6 m floor construction thickness which, with a ground floor clearance of 500 mm and an allowance for a 1m low-pitched roof, is only 10.5 m, compared to the 12 m proposed. (see also comments on half basements and individual zone heights). giving the MRZ as proposed in essence

We are opposed to the concept of a 6m height as of right even within the central business district. We consider buildings of such heights come with considerably more downsides than upsides for provincial towns, and that there are other ways of achieving their perceived benefits.

Downsides include:

Increased overshadowing

Dominance of important natural features of trees.

Loss of human scale with regard to prevailing street widths etc.

Greater wind funneling and microclimate issues.

Necessity to use lifts in buildings.

Greater obstruction of viewshafts.

Possible additional burden on fire and emergency services and equipment requirements.

The primary upside is greater plot ratio, plus marginal increase in efficiency of urban servicing. There is also a theoretical advantage of more rapid intensification if one lot proceeds notably ahead of its neighbours.

Given that such high levels of intensification are not required to accommodate the forecast population growth we consider a lower maximum height should be adopted for the HRZ, and advocate that as.

We consider that the maximum height as of right in the HRZ should be 15m with a timber lower floor, being a ground floor at 1.5 m above ground level, 4 floors at 3 m floor to floor, and an additional 1.5 m for roof construction.

This is a versatile height that allows five storeys including a half-basement, is not necessarily serviced by a lift, and is in greater keeping with streetscapes, treescapes and the like .

The corresponding height limit for a building with concrete ground floor construction should be 14.4 m.

We are opposed to the notion implicit in the proposed zone rules that an owner could develop up to the maximum height even with just a single dwelling. This is contrary to the intention of urban intensification and contrary to the spirit of an effects based approach to planning.

As it stands under the PC20 proposal an owner of an HRZ site could building a single dwelling 19.5m high

We consider there should be constraints that relate the maximum height of a building in regard to the number of dwellings that it contains and the size of the site being developed. We are not conversant with rules to that effect and consider council should develop suitable mechanisms.

Height limits in individual zones

We support the proposed 8m height limit in the GRZ zone for buildings with timber ground floor construction, and a 7.4m limit for those with concrete ground floor construction.

We support the proposed MRZ height with slight adjustments: we consider it should be 11.5m for a building with a timber ground floor and 10.9 m for one with a concrete ground floor. The timber floor option would accommodate a ground floor at 1.5 m above ground level, three floors at 3m floor to floor, and a further 1 m for roof construction.

We do not agree with the proposed HRZ height for th4e reasons outlined above. We consider that the maximum height as of right in the HRZ should be 15m with a timber lower floor, (made up of a ground floor at 1.5 m above ground level, 4 floors at 3 m floor to floor, and an additional 1.5 m for roof construction). The corresponding height limit for a building with concrete ground floor construction should be 14.4 m.

Online submission

This is a submission that was made online via the Council's website.

Submitter No.	S626
Submitter Name	Raine Estate Oaklands Ltd
Submitter Company/Group Name	Raine Estate Oaklands Ltd
Submitter is contact	No
Contact company	Planscapes
Attention:	Natasha Wilson
Email	natasha@planscapes.co.nz
Wish to be heard	Yes
Joint presentation	Yes
Trade competition	I could not gain an advantage in trade competition through this submission.
Directly affected	N/A
Withhold contact details?	No

Submission points

Plan section	Provision	Support/oppose	Reasons	Decision sought
Entire Plan Change	General support	Amend	Refer to attached submission for reasons for the decisions sought.	Refer to attached submission for decisions sought.

Documents included with submission

Document name	Raine Estate Oaklands Submission
File	raineestateoaklandsltdsubmissionpc29oct2023.pdf
Description	

RMA Submission on Publicly Notified Plan Change 29 to the Nelson Resource Management Plan

To: Nelson City Council

Name of Submitter: Raine Estate Oaklands Limited

Address for Service: c/- Planscapes NZ Ltd (Attn: Natasha Wilson), PO Box 99, Nelson 7040

Trade Competition: We **could not** gain an advantage in trade competition through this submission.

Council Hearing: We wish to be heard in support of our submission.
We are prepared to consider presenting our submission in a joint case with others making a similar submission at any hearings.

Introduction

1. This submission is on Proposed Plan Change 29 to the Nelson Resource Management Plan and relates to the **entire Plan Change**.
2. Raine Estate Oaklands Limited **supports in part** and request **amendments** to the Plan Change.

Background

3. The objective of Plan Change 29 is to implement the National Policy Statement on Urban Development 2020 (NPS-UD) by supporting housing delivery and the provision of well-functioning urban environments within Nelson while ensuring that natural hazard risks are appropriately managed and historic heritage is protected. This is proposed to be achieved through enabling intensification of development in the urban areas of Nelson where not affected by significant natural hazards, being on land currently zoned for residential and commercial uses. Residential intensification is proposed to be enabled through the introduction of three new residential zone areas: General Residential zone, Medium Density Residential zone and High Density Residential zone. Changes are also proposed to provisions for natural hazards, heritage and papakāinga housing.
4. The scope of the Plan Change does not include new growth areas located outside the existing Residential or Commercial zones (i.e on land currently zoned Rural).
5. In identifying areas suitable for intensification through Plan Change 29 the Council considered a range of matters, including the Nelson Tasman Future Development Strategy 2021-2052 (FDS). The FDS is a relevant document to the Plan Change as it has been recently adopted and aligns with the NPS-UD. The growth strategy identified within the FDS includes consolidated growth focused largely along State Highway 6. This includes prioritising intensification of housing development in the Nelson areas of Stoke, Tāhunanui, Marsden Valley, Maitai Valley, and the Nelson City Centre, and providing for managed greenfield expansion around the urban edges of Nelson and Stoke.
6. Raine Estate Oaklands Limited are the landowners of the Oaklands Farm, situated behind Saxton Field in Stoke. Eight generations of the Saxton and Raine family have lived on and farmed the land for 182 years. Under the Nelson Resource Management Plan the farm is currently zoned Rural. Through the FDS process parts of the Oaklands Farm were identified as Growth areas – N-11 Saxton and N-115 Saxton Extension.
7. While the Oaklands Farm property falls outside the scope of Plan Change 29, consideration of the Plan Change is relevant to Raine Estate Oaklands Limited in the context of realising the Saxton growth areas identified in the FDS. Raine Estate Oaklands Limited have completed a scoping and feasibility exercise to initiate the implementation and rezoning of these growth areas, with a Development Vision document created to capture the findings of this exercise. As a summary, a total of 60ha of development potential has been identified, with integrated ecology and open

space areas, mobile connectivity and provision for a community hub. Residential living is envisaged to include terraced homes, standalone dwellings, and retirement living. Commercial areas are proposed to encompass a medical hub, food and beverage, retail spaces, farmers market and local business spaces. This submission therefore specifically relates to the amendments proposed for the Residential and Suburban Commercial zones.

8. For the Residential zones, residential activity and development is permitted where standards are met. Generally, the following bulk and location standards are proposed through the Plan Change:
 - a. With minimal change from the Nelson Resource Management Plan (NRMP):
 - Front yards requirements
 - Corner sites controls
 - Fences standards
 - b. Existing NRMP rules with modification:
 - Outdoor living court requirements
 - Other yards setbacks
 - Subdivision rules and minimum net site area
 - c. Existing NRMP rules that have been aligned with the Medium Density Residential Zone Standards (MDRS) for Tier 1 Councils as per the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021:
 - Maximum site coverage
 - Maximum building height
 - Daylight admission controls
 - d. New rules proposed for the NRMP:
 - Glazing controls to the street (based on MDRS)
 - Outlook and privacy controls (based on MDRS)
 - Minimum permeable landscaped area requirements
 - Maximum building length
 - Minimum unit size
 - Cycling parking requirements

Reasons for Submission

9. Raine Estate Oaklands Limited supports, in part, Plan Change 29 to the extent that:
 - a. in principle, it provides for residential and commercial growth in the Nelson region, specifically in and around Stoke; and
 - b. it supports the direction set out in the Nelson Tasman Future Development Strategy.
10. Raine Estate Oaklands Limited does not support, in part, Plan Change 29 and seeks amendment to the Plan Change to the extent that:
 - a. it introduces numerous bulk and location standards for the residential zones, which together create greater need for compliance in development proposals and in turn can impede innovative design; and
 - b. as a result of the package of bulk and location standards, in reality it will limit opportunities for residential growth and housing choice in Nelson; and
 - c. the limitations in (b) above will be exacerbated without opportunity for greenfield development on appropriate sites, such as the Oaklands Farm land.
11. The specific reasons for the Raine Estate Oaklands Limited submission are:
 - a. The greater level of control over residential development can result in less flexibility in quality design and site specific outcomes. This in turn can impact diversity in character and amenity

outcomes and can limit housing choice. More controls can also have the effect of resulting in greater costs to the development process, which in turn impacts affordability.

- b. Bulk and location controls within a residential zone should work together as a package. Each standard has multiple benefits and overlap in what they achieve. As a result not all bulk and location standards available are necessarily required to attain the desired level of amenity. For example height in relation controls by default manage building/yard setbacks. As such in determining the correct mix of bulk and location controls, they need to be considered as a package rather than on their individual merit.
- c. It is agreed that it is important to ensure neighbouring residential amenity is protected, particularly with regard to sunlight and daylight access, however there are some aspects of planning control that can be effectively left to the market to dictate, such as parking related controls.

Relief Sought

12. Raine Estate Oaklands Limited seeks the following decision from the Council:

- a. That the Plan Change be reviewed and amended to ensure that the following rules of each residential zone are individually workable, practical, effective and allow for good design outcomes to be achieved:
 - i. Site coverage;
 - ii. Front yards;
 - iii. Other yards;
 - iv. Maximum building height;
 - v. Daylight admission;
 - vi. Glazing to the street;
 - vii. Outlook and privacy;
 - viii. Permeable landscaped area;
 - ix. Maximum building length;
 - x. Cycling parking; and
 - xi. Subdivision – General.
- b. That all of the bulk and location rules of residential zones be reviewed and considered as a package of controls for each zone, and that amendments are made, including deleting unnecessary or excessive rules, to ensure the methods of the residential zones achieve the outcomes sought for the zone.



.....
(Signed by the Authorised Agent)

Dated this 31st day of October 2023

Online submission

This is a submission that was made online via the Council's website.

Submitter No.	S627
Submitter Name	Philip Guy
Submitter first name	Philip
Submitter middle name	Colin
Submitter surname	Guy
Submitter is contact	Yes
Email	guyarch@xtra.co.nz
Wish to be heard	No
Joint presentation	Yes
Trade competition	I could not gain an advantage in trade competition through this submission.
Directly affected	N/A
Withhold contact details?	No

Submission points

Plan section	Provision	Support/oppose	Reasons	Decision sought
Entire Plan Change	General support	Oppose in part		Our submission is: (Include whether you support or oppose the specific provisions or wish to have them amended, and reasons for your views) In general we support the intent of the proposed plan change as we recognise that Nelson is a growing city and that some intensification is required in order to cater for a growing population which would provide more varied housing options and allow people to live closer to where they work. This also gives opportunity to regenerate the town centre with more people able to socialise within the urban area and support the local retailers. However we believe that the plan as it stands is not suitable to deliver the promised gains because it lacks an overall strategy to control development in a way that ensures that the existing high quality environment is retained. We have looked at the plan and imagined that if every site was fully developed as is planned then the city of Nelson would be changed completely through over-development, the environmental costs would be extreme. Nelson is a green attractive city with many wonderful gardens with established trees and open spaces and it seems that no safeguards exist in the plan to acknowledge and value these.

We ask council to consider the following:

To recognise that Nelson encompasses many different built environments and communities and the proposed broad brush approach does not in any meaningful way address this.

Each neighbourhood should have it's own spatial plan with identified outcomes as a way of planning future developments to build on existing attributes and enhance areas that require improvements.

As an example the proposed High Density and Medium Density Zoning around Tamaki Street, Chamberlain Street and Tosswill Road in Tahunanui completely ignores the challenging geotechnical conditions in this area. From a traffic point of view there is no existing connection between Tamaki Street and Tahunanui Drive and the existing steepness of the land we would say precludes this. At present the roads in this area have traffic calming measures in place and parking is already a problem. We note that the development plans do not require on-site parking. Stormwater infrastructure is already inadequate in this area and will be further compromised by the reduction of green space.

Further such intensive development in this neighbourhood would completely change the character of the existing area. We strongly object to this re-zoning and request that the High Density and Medium Density Zoning is removed from the Tahunanui Hills area.

We would request the council consider the undertaking of a spatial plan for each Nelson neighbourhood which records the existing buildings, topography and open / public spaces and identifies areas for improvement and intensification which can be undertaken without compromising existing amenities.

Documents included with submission

Document name	Guy Submission PC29
File	guysubmissionpc29.pdf
Description	Philip Guy Ella Evans PC29 Submission

Following this Development Guidelines should be established to encourage quality design and development that is sympathetic to the existing environment. These guidelines can be incorporated as part of permitted site development controls broadened to provide better outcomes. As part of these guidelines consideration should be given to dwelling standards such as distance between dwellings, private open space, outlook, accessibility, size of dwelling, ventilation, parking and adequate storage etc, to ensure that developments are suitable and provide healthy accommodation.

We believe that with consideration of the points listed above and greater council and community involvement in broadening the scope of the plan for the future development of Nelson, that greater intensification can be achieved but it must not be at the cost of the existing quality environment and living standards.

We think a new vision is required for the future of Nelson and this plan with enhancements can be part of that.

We thank you for the opportunity to make our submission..

Regards

Philip Guy and Ella Evans-Guy

Received: 30/10/23
Submission: S628

SUBMISSION FORM FOR NELSON CITY COUNCIL NOTIFIED PLAN CHANGE 29

SUBMITTER DETAILS

Janet Ruth Whittington [individual]

whittington99@xtra.co.nz

I wish to speak to my submission.

I could NOT gain an advantage in trade competition through this submission.

Thank you for receiving and reading this submission.

I have been involved in future planning, for, myself, the companies I have worked for, economic interest and gain for myself for most of my life. Launched by the acquisition of a B.Com [Commerce Degree] in the 1980's when women only constituted 22% of all commerce graduates. I filled roles in marketing, researching and planning for the future, with multi-national corporations such as Canon and Motorola amongst others. From there I re-trained and diverged into housing and interior design. I have also been following international politics, economics and stocks and futures markets. I submitted an energy descent action plan to the NCC Long Term Plan in 2006[?], that covered all these topics then.

Given all the information this past has provided me, I think we need to provide ourselves with **as happy a life as possible**. Keep the quality humane aspects of our city and look for other ways to accommodate the human quantity, by following our already chosen path of NCC plans and futures. The pressures from overseas are enormous for us to do otherwise, but we don't have become a **tier one**. Otherwise, the international population will be forced on us until our lives become as unliveable as theirs. Our best chance of a happy future that the council can directly govern is our living spaces with peoples happiness in mind.

As tier 2, we don't need to reduce the quality of our way of life at all.

Furthermore, if we only used approx. half of the infill space in Nelson, we might be able to accommodate every type of family size, into a 1-storey home and affordably priced. Refer Mark Fielding's [#343] point # 20, submission.

It is significant to me as a resident that **the process be improved**. The process that has been undertaken is very difficult to follow and respond to. The one-on-one council staff sessions are popular for the staff and utterly inadequate for the residents. I learned so much more from the public than the council at the meetings I attended it undermined my faith in the integrity of all council people involved. Furthermore, I request that the **commissioning committee be made up of unbiased councillors** me, not those that have publicly already made up their mind, e.g. Rohan O'Neill-Stevens.

"I REJECT EVERYTHING ABOUT PC29 100% IN ITS ENTIRETY. However, if the RMA does go ahead with this plan I would like to submit the following points..."

Part A: THE CITY

1. **The Inner City**. HDZ in the inner city seems less intrusive on the public's personal lives. So I would only accept the new rules if the following were implemented.

NDocs: 539570224-16987-

a. That the city is for people not buildings and egos. In the 19thC, the English left England to put the 'Coronation St' style housing rows behind. In the 20thC, worldwide, **Nelson is in the top 10 places** for the northern hemisphere to migrate to [without assistance], partly due to weather [sun], lifestyle and benign politics. I request that NCC maintain NZ's unique low rise lifestyle and identity, so attractive to the world wide population and tourists in particular.

b. **Retain as much of our planting as possible.** The trees bordering our inner city streets and rivers in particular. I request that this will need to be written into PC29 for future people to rely on the long term, given our lack of accurate information on sea level impacts and the suddenness of the PC29 proposal.

c. **All the buildings on the north and west side of Trafalgar St and inner city CBD and fringe streets.** I request that they be held at no more than 2 stories. The sunlight [far more than 2hours/day] makes the cafes, outdoor seating and chance encounters of the local kind a significant benefit for locals and tourism alike. I contrast this to Queen St Auckland. I walked Queen St street for 30 years [not professionally]. What was once a sunny pleasant outing for all sorts of reasons, is now literally overshadowed by permanent deep cold shade, albeit readable by as well. Queen St Auckland, is unfriendly, windy, and dedicated to buildings, not people. People's happiness is not a word used to describe that street now. Please don't legislate to make the same mistake here in Nelson

2. **Fill the existing empty city buildings first and now.** a. The CBD has run-down top story spaces now. These are held back by current restrictions, uninterested or obstructive landlords, and other issues. I request these rulings that allow this situation to continue be lifted in the PC29. Address this behaviour in the plan change29? What have other cities done to mitigate landlord involvement?

b. What %age of housing would be solved by encouraging upgraded premises without higher 3-6 storey rises?

3. **Maintain our livelihoods where they rely on tourism.**

Relying on tourism relates all of us, as the tourist ticket price is converted into the purchase of Nelson goods and services by the Nelson staff and manager, which keeps local commerce afloat. Unlike bank loans where the principal and interest goes to Australia.

The affluent 20thC, Christchurch public have been coming here for their Christmas holidays, and settling here for retirement. This century, internationally as well, we are a tourist destination. This isn't changing anytime soon, if we keep the Nelson we all love. Tourism is one of the main income arms for the Nelson/Tasman area. Unlike forestry, where the money flows out of the region in the hands of a very few, the tourism is attracted here by dozens of small operators, each mostly spending their profit in the region. I would like the ruling to refuse consideration for these and similar businesses to be lifted in the PC29. **Tourism is a crucial financial artery.** You think there are empty shops now? It will be much worse if our attractive unique identity is turned into banality, like all the other modern cities in the world. How do we keep our charming mix of Victorian/bungalow elegance, green landscape, humane building proportions? By building low level 1 storey infill. Please refer to Mark Fielding's submission [# S343] for residential changes to include more infill without building up.

5. Build instead, on top of industrial areas close to suburbs. E.g. The new Briscoe's building in the Warehouse/Countdown area of the city could have been 3- 6 stories and not affected other residential housing. Build above Vanguard St, against the hills this doesn't contribute any more shade than the hill itself.

a. **We are sunny Nelson not daylight Nelson.** High density in the city means 2 hours/day of direct sunlight in the roads and car parks in the city. This goes against who we are as a province and a city. Trafalgar and Hardy Sts, the most popular streets in the city, should be left as sunny as they are now.

b. **Keep the facades of the Victorian architecture in Trafalgar, Bridge & Hardy Streets.** In the 1980s, the BNZ building in Queen St, Auckland, retained its wide stone steps, its Palladian columns and charming windows intact for the first 2 floors. A modern glass high rise went up behind this fabulous facade. The street level charm was maintained while the business of the city carried on, [albeit without a scrap of sunshine from the high rise]. <https://nzhistory.govt.nz/media/photo/bnz-facade> .

6. **Add in infrastructure carrying capacity - water and roading.** There is no assessment in the plan for carrying capacity. The plan needs more detailed assurance that this is completely covered. Currently the council say - "it's the builders problem to resolve". We need a transport, and water plan in details to assess this properly.

7. Address the anathema between **greenfield's** and buildings. I request climate change issues be addressed. The flood level overlay shows Nelson city under water in floods, so building in the flood zones doesn't make sense. Existing and heritage trees should be retained. We need frequent green spaces in the CBD too.

8. Changing **the building act** changes our ability to react on climate change reactions. How does this affect the city? We need more time to learn more about this. Information from NCC is requested for public digestion before the PC29 is passed.

Part B: CITY FRINGE

Each site should be considered on its merits. E.g. This category includes Selwyn place, 1903 Square and the Church steps. A key site in our town. Not leaving this out from 'the rules' is an example of a special site which should have been excluded. Sunlight reaches most points of this area for much longer than 2 hours because of the 2 storey buildings on the west side of Trafalgar Street. Retain this and specify in the plan in case of future assaults on changes.

Retain the Church Hill View Shaft as per council specifications.

PART C: THE SUBURB

1. Have a neighbourhood plan change before government imposed plan change. MP Rachel Boyack mentioned this at the Trafalgar Park meeting 7th Sept. Please make information on this public. Discussions are great for neighbourhood bonding as well. Bonding is essential for us to help ourselves in climate crises.

Parks/Greenspace

I request all the following to be included in the plan.

Parks are needed, I was told, every 200m[ideally] from dwellings, especially where only 20% of property land use is free for growing food, flowers and lawns etc on sections, as is the current plan.

- a. Parks and green space prevents flooding. We will need more of this everywhere with the increase in flooding everywhere throughout the CBD and suburbs.
- b. Privately owned tanks could take roof-rain-water, rather than forced into stormwater, which takes unwanted harmful toxins into the harbour. I request this in the plan.
- c. Stop developers from levelling the site, and selling the topsoil. Clay movement is increased when topsoil is not there to take up the stormwaters.
- d. The public should be notified if a green space/park/playground is sold into private hands. I have been told that a [Nelson local] construction company bought a park from the Auckland City Council to fill with houses, rather than get consent. The council chose to sell it to the company. Rather than consume time and wages for each park, we can request that this one event be legislated against in the plan for Nelson.

3. Low rise answers to intensification. Architects have been designing a range of low rise intensification housing for years here. E.g. If they were built on only half the number of potential infill housing available, they would completely cater to Nelson's needs for the next 10-15 years. This would give us time to develop an excellent future for the whole city.

4. **Build higher where vertical hills** are the neighbouring property on the west or south side of the building, where this would shade only the hill and not residential housing.

5. **Affordable housing.** A Secondary Minor Dwelling (SMD), would not only cater for an increasing population, regardless of whether such statistical predictions are accurate, but primarily will provide **truly affordable housing**, especially for young growing families that otherwise find it impossible to get on the house ownership ladder. Refer to Mark Fielding's submission. I request that truly affordable housing be included in the PC29. Affordable housing is noticeably absent from the plan. Please add into the plan the number and dollar value of affordable housing.

PART D: 35 Brougham St. Nelson South

1. **Solar power requires sunlight,** not daylight. I am planning to put PV panels on my roof this year. Even at 3 stories, this plan change gives me no certainty of long term use of solar. Retain the existing regulations for those adversely affected by neighbouring building height.

2. **Slope sunlight angles.** Visit the Saturday market. Notice the BNZ building backing onto the market is 3 stories high and look at the shade it casts. This would completely cover my property in autumn winter and spring. The hotel beside the BNZ where the alley connects Trafalgar with Montgomery Square is even higher. Please retain current 'daylight' and sunlight angles in residential properties and surrounding buildings.

3. **Sunlight versus daylight.** Sunlight streaming through our windows is passive solar heating and makes me a happy soul. Without it, we pay for electric heating, and have a depressed soul. Even Rohan O'Neill-Stevens sat in the sunlight outside Fairfield house when he came to listen to the architects meeting held there on Sunday afternoon 1st October 2023 - to discuss daylight angles.

Refer to the research article called **Valuing sunshine pdf**. <https://www.motu.nz/assets/Documents/our-work/urban-and-regional/housing/Valuing-Sunshine-Executive-Summary.pdf>.

Summary: This is how lucrative it is for us: 2.4%/hour of sunlight on a \$1m property with 8 hours of sunlight is worth:

$$2.4 \times \$1,000,000 \times 8 = \$192,000.$$

With 2 hours of sunlight: \$48,000. The difference is enough for a frugal person to retire on.

I think letting those with profitable interests take that money off the residential public by depriving them of sunlight, is worth publicly discussing, and worth council consideration. Money is like energy. It doesn't appear and disappear. It transfers from one medium to another or one pocket to another. This money is about winning and losing. I would like the rules around this strengthened to provide further protection for the residential public. Support mutual transfer amongst the residents.

4. Heritage status in the Nelson South area

The historic rules changes are of concern to me:

- The loss of the non-renewable heritage resources can't be reversed.
- PC29 will have negative economic, social and environmental consequences to Nelson.
- There has been no take a precautionary approach of incremental and considered change.
- A significant number of listed heritage properties, the Inner City Heritage Precinct and the Wakefield Quay Heritage/Character Precinct are deleted from the current register in the Nelson Resource Management Plan as part of PC29. I would like these reinstated.
- Nelson has a high proportion of heritage and character buildings, clusters of which merit further investigation for precinct listing and specific rules and policies e.g. height controls on adjacent buildings

The areas I disagree with are:

- It does not address thematic gaps in the historic built environment that should be identified and be part of any heritage assessment, see Thematic Historic Overview of Nelson City 2011 – Dr. John Wilson
- Does not use best practice criteria
- It has been undertaken by one person rather than a multidisciplinary team
- The Plan Change does not include conservation plans
- Listings do not include all Heritage New Zealand (HNZ) listed place.

I request:

Before any Plan Change is finalised, Nelson City Council:

- Takes a precautionary sustainable approach to non-renewable heritage resources and the effect of the proposed changes to heritage policies and rules and the wider proposal for intensification
- Undertakes a comprehensive, independent, updated assessment of Nelson's heritage following best industry practice based on John Wilson's Thematic Overview
- Undertakes a comprehensive, independent review of all listings proposed to be deleted.
- Retains the Inner-City Heritage Precinct, updates the design guide.
- Retain the Wakefield Quay Heritage/Character Precinct, updates design guide.
- Reassesses the Fairfield/Nelson South area as a character precinct with additional protections (addressing requests in submissions to the Draft Nelson Plan 2020)
- Ensure policies and rules protect heritage values.

5. **Existing houses around 35 Brougham St.** I am surrounded by 6 two-storey homes built between the 1860s and 1980s. I know this is already high enough. Trees and a victorian 2 storey home already block sunlight until midday during autumn, winter and spring. Two others in front of me [north side] will block the afternoon sun if raised to 3 stories. I request that 2 stories limit remain in residential suburbs, regardless of proximity to the CBD. This need to utilise property around a residential building has not been specified as exclusionary to properties yet. I would like them to be included in the plan. Under the PC29, I cannot **use my own land to feed myself**, which is why I do grow vegetables. I have poison [roundup] allergies that preclude my eating commercial food.

6. **Climate Change emergency and Greenfield solutions.** I have an un-recognised [and therefore council-unaware] stream running on one side of my property. It is soggy or a puddle at ground level all winter. The house in front of me is the same. If that house was expanded or a new house built over that metre wide channel, it would stop natural water distribution so vital to climate change mitigation. I would like our conversion of swamp to residential land stopped and reversed. Then roof-guttering, channeled into stormwater drains, is another climate change mitigator we can employ safely on land and **reduce pollution in our harbour**, so more sea life can thrive, which makes fishing and eating fish, another happy part of our lives.

7. **Our views and house values.** This will lower our property values. Look at the difference in price and construction of houses either side of a hill. The houses without sun are worth less than those facing north, in the sun. Currently the council do not consider these issues valid for us either. I would like them included the plan.

8. **Contradicts existing NCC plans**

In 2006, before I bought in this area I was told 35 Brougham St was to remain as part of a low density area. The Long Term Plan is supposed to be 60 years. Others PC29 is not in alignment with:

- Te Ara Whakatū, Council's Spatial Plan

- Future Development Strategy
- Taonga Tuku Iho Strategy Retain this part of the long term plan in the PC29.

9. **Ability to utilise the garden for food**, is one of the reasons I bought in Nelson South. I specifically asked the council what the long term plans for the area was. Is this abrupt drastic change legal? If so, I would like to change the rules so we can **rely on our council to honour their commitments**.

I support Shelagh Noble's submission.

I support Geoffrey Hayes submission.

I support Mark Fielding's submission.

Online submission

This is a submission that was made online via the Council's website.

Submitter No.	S629
Submitter Name	Samuel Nevin
Submitter first name	Samuel
Submitter surname	Nevin
Submitter is contact	Yes
Email	scnevin@gmail.com
Wish to be heard	Yes
Joint presentation	Yes
Trade competition	I could not gain an advantage in trade competition through this submission.
Directly affected	N/A
Withhold contact details?	No

Submission points

Plan section	Provision	Support/oppose	Reasons	Decision sought
Entire Plan Change	General support	Support	Enabling intensification will promote a well-functioning and more vibrant urban environment, with better social, economic, climate and environmental outcomes. This will reduce urban sprawl and the associated adverse outcomes of that type of development, including higher costs (transport, infrastructure, climate), less social cohesion and less vibrant urban places.	I support the objectives and overall intention of the proposed plan change in principle. This includes support for the provisions enabling urban intensification, the differing residential zones and associated standards (and the implied outcome of less urban sprawl type development), as well as the avoidance of risk in relation to natural hazards. I seek that the Council consider some minor changes raised in my other submission points.

Residential Zones	High Density Residential Zone	Amend	It is unclear to me why there is a restriction of 3 unit in the high density zone. Given a new development is permitted to be up to 6 storeys high, it is reasonable to anticipate that many such developments will provide more than 3 units. The only mention or rationale I could find for this from a quick skim of the s32 report was on page 143 that four or more units would "enable a qualitative design assessment for a multi unit development". If that's the case, then the basis to trigger a qualitative assessment (via consent) should be based on building size/bulk, not the number of units. Otherwise, there would be a situation, for example, where one 6 storey building with 3 units does not require consent whilst another 6 storey building with 4 plus units does. Space will need to be provided for bike parking, rubbish storage and loading zone for larger multi unit developments - all of which can have specified standards.	I seek that the Council amend the restrictive standard that there can only be up to 3 residential units on a high density residential zone. I seek that the limit be raised to a high number as considered appropriate by the Council (perhaps 9).
Residential Zones	High Density Residential Zone	Amend	The standard 19F that requires all units in a new development to have some form of outdoor space is perhaps too onerous given the likely form and nature of the developments in the high density zone. These may be apartments on the city centre fringe or other built up areas, and the provision of balconies etc is not always necessary for those wanting a 'city centre' urban life. Suggest this requirement is removed. Nearby green spaces can provide sufficient outdoor space for people inhabiting these apartments.	New residential units on the first floor and higher should not require any outdoor space provided they are within approximately 500 metres of green space/parks etc.
Residential Zones	Other	Amend	Side facing windows may invade privacy. Requiring them to be obscure glazed and non opening below approx. 1.8m will maintain neighbour privacy. I may have missed some provision along these lines in the plan.	Side facing windows at the first floor and above should be obscure glazed and non-opening up to at least 1.8m above finished floor level.

Residential Zones	Other	Neutral	Minimum unit sizes for all units with a greater number of bedrooms will maintain minimum quality standards for habitable units.	Suggest that minimum sizes be added for 2, 3 and 4 bedrooms too. Currently only for 1 bedroom/studio units (eg, 19U).
Residential Zones	Other	Neutral	If the Council was minded to reduce the scope and spread of the proposed plan change due to various potential concerns that could be raised through submissions, then some form of intensification could and should still be enabled.	Only if there is to be a significant reduction in the scope and spread of enabled development as the plan change progresses, then Council should look to still enable proportionately larger development on properties to the south of sites/streets and proportionately smaller for those to the north.
Documents included with submission				
None				

Online submission

This is a submission that was made online via the Council's website.

Submitter No.	S630
Submitter Name	Ruby Hall
Submitter first name	Ruby
Submitter middle name	Lee
Submitter surname	Hall
Submitter is contact	Yes
Email	rubyhall12345@gmail.com
Wish to be heard	No
Joint presentation	No
Trade competition	I could not gain an advantage in trade competition through this submission.
Directly affected	N/A
Withhold contact details?	No

Submission points

Plan section	Provision	Support/oppose	Reasons	Decision sought
Entire Plan Change	General support	Oppose		Firstly, I reject PC 29 in its entirety, but if it is not rejected then these are my points...

The Plan Change 29 Process. I want to acknowledge...

That I have found it difficult to digest the total effect of the proposed PC 29 and its supporting documentation due to its size and complexity.

That access to a paper copy of PC 29 and the Section 32 reports has not been made available for residents who do not have access to, or the ability to use a computer.

That I have found PC 29 lack of early public engagement and consultation by Council, with its severe implications towards the well-being of existing rate paying residents enjoyment of their properties, extremely stressful, very time consuming and unnecessary.

That I have been put in a position of hoping more qualified citizens than I, will make more comprehensive submissions covering my concerns as to the future of Nelson and its ratepaying residents.

That Council Planning Staff have stated at numerous meetings "This is a 'Broad Brush approach' that requires public submissions to refine the plan". Such a statement implies PC 29 has been prematurely put out for public submissions in an incomplete and inaccurate state that requires the public to learn and understand in its entirety, so they can formulate and articulate a suitable response.

The severe lack of Trust between residents and Council has become significant given the following:-

The PC29 submission timeframe was only extended from 27 to 56 working days because of public pressure at 7th Sept public meeting. PC29 media engagement was only increased because of public pressure at 7th Sept public meeting.

Information regarding the negative impacts on existing residents' enjoyment of their properties is not forthcoming in every interaction with NCC members and staff. It is 'Deceit by Omission' and has required individuals to research PC 29 to find out these aspects and share them with the wider public. Eg. Loss of winter sunlight with new recession planes.

Loss of on street car parking with increased intensification due to no requirement for on-site car parking.

Loss of privacy with bigger buildings that are closer to boundaries.

Loss of property value with loss of views, sunlight, and privacy.

Increased levels of noise with increased residential dwellings around a boundary.

Residential unit numbers per building can be increased on a 'restricted discretionary' basis without notification or written approval.

Exaggerated population forecasts.

Council voted NOT to withdraw PC 29 on Sept 14th Meeting.

Predetermined biased Councillors on the hearing panel.

I am asking Council to immediately withdraw PC 29 and get Council Planning staff to refine the plan design and then put it back out for public consultation.

Hearing Panel

I strongly disagree with the make-up of the hearing panel, because of its 'biased' public perception following the vote on Councillor Courtneys proposal to withdraw PC29 at the 14th September Council meeting.

I ask the Council to appoint Councillors from either side of the Sept 14th vote.

If i) is not followed then I ask that all Councillors are replaced with independent Commissioners.

NCC's Population forecasts

These are a pivotal aspect for the scale of which Nelson needs to enable intensification and growth. The forecasts used by NCC are not Statistics NZ medium projections, but are over inflated 'home grown' projections that require the scale of intensification to be greater than those of Statistics NZ. I refer to the submission by Demographer, Dr Geoffrey Hayes.

When challenged, NCC staff and the Mayor, always refer to the wider Nelson-Tasman regional growth, which is beyond the scope of PC29.

I ask the Council to use Statistics NZ medium projection forecasts for Nelson, as recommended by the NPSUD Capacity: Guide on Evidence and Monitoring, para 2.1.1 and amend its intensification requirements accordingly.

Design Lead and Not Developer Lead Growth. Nelson is a very special and unique place that needs to be protected with care. It is unlike any other district in NZ It includes a 'Low Rise'

any other district in NZ. It includes a Low Rise City with a collection of heritage and non-heritage character buildings that have attracted people for generations and been a cherished holiday destination for many New Zealanders. Residential Neighbourhoods should be protected for future generations to enjoy and new developments thoughtfully designed and planned on a neighbourhood, by neighbourhood basis to maintain the essence of their character.

We need to protect and retain CBD historic facades as an essential part of the character of the Inner City.

Contemporary Black Iron Clad Boxes, built only a few metres from 120-year-old Historic Homes is completely out of character and lacks a long-term vision for maintaining the attraction of Nelson for all the future residents and visitors.

Green Spaces, Trees and Landscaping are essential for the look and feel of some of our older neighbourhoods. They help considerably with the wellbeing of the residents and help to provide an essential part of the attraction of Nelson, which must all be considered during developing the growth of Nelson.

I ask the Council to create a broader level of protection for neighbourhoods beyond the heritage buildings and precincts to that of areas of historic character value from the early settlement years of Nelson and stop future 'out of character' developments.

I ask the Council to appoint an Urban Development Agency (UDA), as per the Nelson Tasman 2050 proposal, (attached) to carefully guide growth and actively facilitate the emergence of cohesive urban neighbourhoods with a variety of high-quality housing choices.

Sunlight Recession Planes and Shading Effects

Sunlight is a CRITICAL part of living in Nelson. It is not called the 'Sunshine Capital of NZ' for no reason. It is well documented that people relocate to Nelson because of the Sun and accept reduced wages called 'Sunshine Wages' for that privilege.

TDC even 'Encourage the Sun into your home'. See <https://www.tasman.govt.nz/my-property/building-and-alteration/heating-and-insulation/energy-efficiency-and-heating-your-home/>

I am unable to find a section 32 report

regarding the winter sunlight shading effects on neighbouring properties. The daylight admission testing in the B&A memorandum dated 15/3/23 are only about maximising building bulk and height to enable increased floor plates at upper levels on a typical size section, rather than any loss of sunlight and the shading effects of a neighbour.

Shape Nelson Website provides misleading information on 'How PC29 could affect you' with no mention of completely losing sunlight amenity with possible total shading over the winter months. Quote:- "Daylight admission - the maximum allowable building height decreases as the building gets closer to the side and rear boundaries, so that taller buildings leave space for daylight to get to the neighbouring properties".

All existing houses built prior to and under the current daylight admission rules will be subjected to the loss of sunlight amenity under PC29 with the following effects: -

Increased levels of mental health illness, anxiety and stress.

Increased levels of damp homes with associated mould and mildew and respiratory illnesses.

Shadowing of 'Green Energy' Solar Arrays and Passive Solar Energy Heating.

Increased heating costs, air pollution, carbon foot print, are all exasperated due to a large portion of Nelson housing is old, with un-insulated walls and single glazing and open fires were legislated out of use many years ago.

Reduction in property values and increased financial stress, because the house would be less desirable to live in.

Residents, struggling with the cost-of-living crisis may not afford to heat their home.

Property owners will be reluctant to invest in making additional new (low rise) infill improvements on their section, with affordable additional units that COULD be over shadowed and devalued by a wealthier developer who could afford to build a multi-storey development next door at any time in the future.

NCC & TDC 'Housing We'd Choose' report dated June 2021 by M.e Consulting ranks 'Sunny' as the highest preference for housing choice in Nelson and yet PC29 will remove that amenity from its exiting residents, without warning or compensation.

I ask the Council to maintain the AP15 Daylight Admission protection rules to all pre-existing properties, unless the owner gives written approval to the contrary.

I strongly support the inclusion of Daylight and Sunlight policy statement Para RE2.3.i: The reception of daylight and sunlight to each household unit is a critical component of residential amenity that provides warmth and energy efficiency, and is vital for outdoor activities such as gardening and recreation. To ensure shading effects are minimised, and to ensure there is sufficient space around buildings to allow the admission of daylight to the site, this Plan has provided for daylight controls on all side and rear boundaries. The policy also applies to larger non-residential buildings such as schools or halls. The basic premise is that the daylight and sunlight received on a residential site should be no different whether or not the neighbour is residential. This philosophy applies whether the building is on an adjoining site or across a street.

Privacy and Outlook

Privacy is a critical part of enjoying a property. I support the inclusion of RE2.4.iii, but ask Council to add the following [bracketed] words. 'The building Act controls windows in walls of buildings on or close to boundaries and the outlook rules ensure that residential units [and their neighbours] have a reasonable degree of privacy as well as encourage residential units to be orientated towards the street or public open space'.

Intensification

I strongly oppose the High-Density Residential Zone. It is by no way in character or in keeping with any existing 'Low Rise' Nelson residential suburb and beyond the MDS legal mandate. I ask Council to remove HDRZ from the plan completely.

I ask Council to apply no greater than new General Residential Zone equally across the entire Nelson district on the introduction of PC29, on the basis that AP15 Daylight Admission protection rules will apply to all pre-existing properties, unless the owner gives written approval to the contrary.

I strongly oppose the Medium and High Density intensification in the Tahunanui Hills

area (Tosswill, Tamaki, Chamberlian, etc)

I am strongly opposed to all new 'Green Field' developments being used for only single storey dwellings as it is a complete underutilisation of land that can accommodate increased intensification.

I ask Council to ensure a minimum of two storey dwellings be built on all new green field developments. Eg Golden Elms in Toi Toi, Ngawhatu Valley and Marsden Valley.

Building holiday apartments that sit empty for long periods, does not solve our intensification, growth and affordability dilemma, and yet it locks up a valuable housing resource. Eg Rocks & Haven Road has many empty apartments.

I ask Council to consider solutions to mitigate against new-build empty holiday apartments.

I oppose the increase of residential units beyond 4, as a restricted discretionary activity that does NOT require notification and written approval from neighbours.

I ask Council to ensure that more than 4 units requires notification, to restrict large 'out of character' accommodation blocks spanning multiple sections, and taking up lots of on street car parking spaces, popping up in a residential street, without warning.

Bigger older properties, could be better utilised and help with our growth if they were more easily allowed to be divided into multi-dwellings.

Building inner city apartments that offer an alternative solution to 'retirement villages', can free up the bigger homes for new families to occupy. The 'retired' occupants may also be less likely to be reliant on a vehicle, which may more closely suit the growth model desired.

Designing Inner-City roof gardens and balconies with green spaces for commercial hospitality use or places for apartment living residents to relax and enjoy the Nelson Sun. Incentivise rate paying residents to demolish or relocate their house in favour of replacing more units on the same section providing they comply with the suitable character or heritage of the neighbourhood.

Progressively Phased Intensification

Firstly, Inner City should be the starting place to have the most significant intensification, before forcing it onto the residential neighbourhoods this can give more time to

complete a better design vision for our residential neighbourhoods.

I ask Council to make better utilization of Car Only spaces, by developing them into shared spaces, with Accommodation overhead.

'Nelsust' highlights 44% of the Inner City as Car only spaces. See attached photo (city area taken up by cars).

I ask Council to retain para ICd.11 'The zone enables and encourages an increase in the density and diversity of quality housing in the City Centre by enabling residential activity above ground floor level. It is expected that over time, more people will choose to live in the City Centre because of its easy access to offices, shops, entertainment and varied open spaces and experiences'.

Secondly, City Fringe would be the next zone to phase in for intensification.

I ask Council to negotiate and/or incentivise Industry and car yards to relocate, to less essential land that can be better used for accommodation.

Finally, the Residential Zones would be the last area to be phased in, by working out from the City Fringe Zone (and Central Stoke).

I would support Medium Density Residential Zones (3 storey 11m high) progressively expanding from the CBD (and Central Stoke) if required and over time, providing AP15 Daylight Admission Protection rules remain in force for existing properties.

Intensification in hazard zones

I ask Council to apply no greater than General Residential Zoning rules in all Hazard overlays, because these areas have been assessed as vulnerable and given that we are in a climate crisis, with increasing record-breaking weather events, affecting increasing areas of Nelson in ways not seen before then, I believe those areas should be treated with caution.

On-street carparking

Increased intensification without providing off street carparking will result in significant hazards to pedestrians and road users in some areas of Nelson where roads are extremely narrow, with little or no footpaths, no berms, high retaining walls, steep drop offs and no turning spaces. Some of these roads are all much narrower than would be expected under

modern standards with some being barely a single vehicle wide.

On street parked cars, have also narrowed two-way roads down to single lane for two-way access and forced parking on footpaths to become the 'norm'.

Drivers must carefully share the roads with each other, cyclists and pedestrians, frequently having to pause where there is available space to allow vehicles to pass. Sometimes this requires driving over the kerb and onto footpaths.

In places trucks, including the weekly waste collection vehicles have to reverse quite long stretches because of the lack of anywhere to turn.

In places, visibility of oncoming vehicles is also very poor and dangerous.

Driving up and reversing out of very steep driveways is challenging at best and potentially unsafe.

Access for pedestrians, mobility scooters, cyclists, refuse collection and Emergency Service vehicles is difficult and unsafe.

Intensification, without providing on-site car-parking in these narrow road access areas will cause fracturing of neighbourly relations and communities who live in these areas.

I strongly recommend that the Hearings Panel conduct a thorough site inspection of the narrow streets of Nelson including, (but not limited to) Locking St, Mount St & Konini St, Tosswill Rd, Tamaki St, Chamberlian St etc. including on foot.

I ask Council to provide a 'Comprehensive car parking management plan' as strongly encouraged by Policy 11 of the NPSUD 2020, to mitigate against the issues of on-street parking.

I ask Council to use traffic calming solutions that do not lose on-street car parking spaces. Eg. Speed Humps, instead of Choke Points.

I ask council to restrict more intensification in the neighbourhoods with narrow and hazardous road access to Standard Residential zoning for road user safety reasons. Eg (But not limited to:-) Mount St, Konini St, Locking St, Locking Tce, Northesk St (East), Renwick Place, Tosswill Rd, Tamaki St, Chamberlian St etc.

Social Housing

Significant care and attention must be considered with all social housing because

there are too many examples across the country where this has resulted in disharmony in communities.

High density living for the homeless and vulnerable will not result in healthy outcomes for all concerned.

Careful design controls from the concept stage onwards, will be rewarded in the long run, with less support required by Mental Health Services, Charity Services, Police and Social Services.

I would like to see Council working closely with Kainga Ora, to provide a 'transparent' way of creating new Social Housing Developments that 'Fit' with the long-term design vision of Nelson.

I would like to see Council have more fit for purpose controls for antisocial behaviour that affects the existing neighbour's enjoyment of their property.

Infrastructure

I ask the Council to include a plan to mitigate against future drought situations with a greater demand on the same amount of water from the Maitai Dam, for a greater population.

I ask the Council to include a plan to mitigate against the increased capacity requirements for our waste water systems.

I ask the Council to include a plan to mitigate against the increased capacity requirements for storm water.