Nature's contribution to health and well-being in the city

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Abstract

Biodiverse, vegetation-rich, green-spaces are important in the context of public health in urban environments. Links between residential proximity and equitable access to natural environments have been made with cardiometabolic disorders and emotional well-being. Also, there is evidence to support the notion that spending time in nature improves cognitive restoration, decreases oxidative stress and lowers markers of stress physiology and low-grade inflammation. Emerging from the discussion in this chapter is the view that if the health benefits attributable to contact with nature are to be realised, there needs to be a change in the framing of nature within urban environments.

Introduction

Biodiverse, vegetation-rich, green-spaces are important in the context of public health in urban environments. Links between residential proximity and equitable access to natural environments have been made with cardiometabolic disorders and emotional wellbeing. Also, there is evidence to support the notion that spending time in nature improves cognitive restoration, decreases oxidative stress and lowers markers of stress physiology and low-grade inflammation.

While the main focus of this chapter will be on the outdoor environment, it must not be overlooked that contact with nature indoors also influences human health. Today, some

architects and designers include spaces for luxuriant indoor planting schemes as part of the facilities provided for those who work in or are visiting a building.

Many of the ills affecting urbanites in the beginning of the twenty-first century —cancer, diabetes, obesity, and depression —may be explained by an emergent central theory. This theory posits that chronic, low-level inflammation is at the root of the problem and is, in part, a direct consequence of the environment in which people live. This raises the important question of what could be done to improve urban environments.

Emerging from the discussion in this chapter is the view that if the health benefits attributable to contact with nature are to be realized, there needs to be a change in the framing of nature within urban environments. The incorporation of green spaces for urban environments needs to be repositioned in policy and practice. In this chapter, the discourse around that challenge and a suggested reframing are set out.

Nature

Nature, a noun, is defined as ‘the phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, as opposed to humans and human creations’ (OED, 1998; p. 1235). This definition might appear to present a problem when considering nature in cities; cities are human creations and, by the definition stated here, not included within nature. Such a view is overly simplistic. Nature is to be found between, on and within the buildings and infrastructure that human create and which form cities. Nature is all pervasive within cities. For example, plants and animals can be found in areas that are remnants of the landscape before the city was constructed; alongside public

parks and domestic gardens; growing and living on roofs and walls, and under buildings; and in abandoned, derelict areas.

Long term modification of nature involves replacing one ecosystem with another (e.g. from wetlands to suburbs; Beichler et al., 2017). Short-term human inputs to nature refer to regular maintenance activities (e.g. pesticides, planting; Beichler et al., 2017). Based on the amounts of human input and modification, nature in cities could be understood as natural (i.e. least human input and modification), managed (e.g. parks, gardens), overbuilt (e.g. grass pavers), or constructed (e.g. green roofs, canals; Beichler et al., 2017).

Health and well-being

Today, health is frequently defined in three ways: the absence of any disease or impairment; a state that allows the individual to adequately cope with all the demands of daily life; and as a state of equilibrium that individuals have established within themselves and with their social and physical environment (Satorius, 2006). The consequences of adopting each definition are considerable. The first definition implies that the medical profession is the only one that can declare an individual free from disease or impairment and, hence, healthy. How an individual feels about his or her state – feeling unwell as a result of an un-diagnosed illness, for example – does not feature in this medical model of health. In the second definition the concept of coping is introduced and with that, one must recognise that there is a wide range regarding coping: some individuals cope with a disease of infirmity very well; others, with no discernible symptoms, cope very poorly. The third definition is focussed on the individual

and their internal equilibrium that allows them to get the most from life despite the presence of an illness or infirmity (Satorius, 2006).

The concept of well-being is central in concepts of health. Well-being can be defined by social, economic or psychological factors, or any combination of such factors (Rioux, 2005). Connectedness to nature is also considered an aspect of well-being (Mayer & McPherson-Frantz, 2004). The Millennium Ecosystem Assessment defined well-being as the outcome of five interrelated factors:

1) Security – personal safety, secure access to resources, and security from disasters;
2) Basic material for a good life – adequate livelihoods, sufficient nutritious food, shelter, access to goods;
3) Health – strength, feeling well, access to clean air and water;
4) Good social relationships – social cohesion, mutual respect, ability to help others;
5) Freedom of choice and action – opportunity to be able to achieve what an individual values doing and being (Millennium Ecosystem Assessment, 2003).

This multi-faceted definition illustrates the range of issues that are brought together within the concept of well-being and indicate that many factors need to be addressed in order to promote well-being within cities.

Linking Nature with Health and Well-being

So far we have examined the concepts of nature, health and well-being separately. It is time now to draw these together and explore how nature affects the health and well-being of those living and working in cities (Sandifer, Sutton-Grier & Ward, 2015). Rather than seeing these as two separate systems, with nature set apart from human health and well-being, it is

possible to conceptualise the two elements together as part of a social-ecological system (McGinnis & Ostrom, 2014). Within such a system, ecosystems provide services and dis-services which benefit or are detrimental to humans (Döhren and Haase, 2015). According to this conceptualisation the concept of ecosystem services become central to integrating the social and ecological aspects of human health and well-being.

Within the Millennium Ecosystem Assessment (2003) a clear link is established between ecosystem services and constituents of well-being. Within that report, for example, it is pointed out how flood regulation (an ecosystem service) affects security, basic materials for a good life and health (three constituents of well-being). Similarly, the provision of fresh water affects security and basic material for a good life. Many other examples could be given of these links, examples which would serve to indicate the integration of social-ecological systems whereby ecosystem (dis-)services affect humans who, in turn, affect the ecosystem services.

Ecosystem services can be delivered by passive, or indirect, and active, or direct routes (Berman, Jonides & Kaplan, 2008; Bolund & Hunhammer, 1999; Bowler, Buyung-Ali, Knight & Pullin, 2010; Dallimer et al., 2012; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007; Larson, Whiting, Green, & Bowker, 2014; McPherson, 1994; Mitchell, 2013; Shanahan, Lin, Gaston, Bush, & Fuller, 2015) (Table 6.1).

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Greenspace within cities is an example of an ecosystem service that ca be delivered, and benefits humans, in different ways. First, it improves individuals' short-term psychological health, cognitive functioning, and stress levels. Over a longer-term, these beneficial health impacts may translate to greenspace reducing chronic disease and illness. Empirical, theoretical and anecdotal evidence demonstrates positive impacts on blood pressure, cholesterol, outlook on life and stress-reduction (Hartig, Mang & Evans, 1991; Kaplan, 1992; Kaplan & Kaplan, 1989; Leather, Pyrgas, Beale, & Lawrence, 1998; Lewis, 1996; Moore, 1981; Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998; Rohde & Kendle, 1994; Ulrich, Dimberg, & Driver, 1991; Ulrich et al., 1991). Second, the reduced crime, promotion of social cohesion, and regeneration of local economies that is associated with greenspace revitalises communities. Third, greenspace, directly and indirectly, supports healthy ecosystem functioning, and in turn, human and societal health and wellbeing. Finally, both the presence, and lack of, greenspace can encourage pro-environmental behaviour and stewardship from local communities, which often increases the ecosystem functioning and, in turn, ecosystem services provided back to communities (Dennis, Armitage & James, 2016; James, 2018).

Cites are not isolated from their surrounds in terms of ecosystem services. This applies equally to the way that people use both urban and non-urban environments; for example, people may take day-trips or long excursions into the countryside to go walking. There is also a movement of waste products – waste energy as heat, the products of combustion of carbon-based products, including fuel, solid waste, chemicals and particles in water and air – out of urban environments (Figure 6.1). Hence, some ecosystem services are derived from areas outside the urban boundary while others come from both the surroundings and the urban area. Yet others come from just the urban area (Sadler et al., 2018).

<FIGURE 6.1 HERE>

Despite the theoretical attractiveness of the notion of ecosystem services, the very broad and fundamental way in which nature supports conditions vital to human health is reflected in the equally broad attempts to describe the influence of ecosystem services on health. It is largely agreed that the degradation of global ecosystems has led to a reduction in ecological functioning, which affects human well-being through a range of natural, economic and political processes (Millennium Ecosystem Assessment, 2003; Watts et al., 2012). Described at these scales of operation (i.e., from regional to global), the processes that lead to a worsening in human well-being are complex and mediated by coupled socio-economic and environmental inequalities. This renders the establishing of clear associations between ecosystem functions and individual health outcomes particularly challenging. In order to facilitate a clearer view of how ecological conditions affect processes that directly influence human well-being, models have been developed that attempt to offer intermediary stages in the pathway, leading from biophysical features or processes to end-point benefits to humans. Examples of such models that have received much attention, and subsequent development, are the notions of ecosystem service "cascades" and service providing units (SPUs).

The cascade model and service providing units

The ecosystem services cascade model (Haines-Young and Potschin, 2010) appeared several years following the largest global assessment of the condition and use of natural systems, the Millennium Ecosystem Assessment. Within that time, the notion of ecosystem services and an acknowledgement of the theoretical advantages of adopting a utilitarian approach to

ecosystem management and nature conservation had gained political and academic support within the field of ecological economics (e.g. Costanza et al., 1997; Fisher et al., 2008; UK NEA, 2011). However, despite the increasing popularity of ecosystem services as the environmental unit of measurement *de rigeur*, confusion over exactly how to quantify the end-usage of such services, trace them to their ecological functions of origin and distinguish between them has remained a challenge for the scientific community. This has resulted in the wide, but inconsistent, use of terminology on the topic of ecosystem services (Jax, 2007); the ecosystem services cascade model was developed in an attempt to remediate such inconsistency. The principal tenet of the cascade model is one of a production chain-like flow of energy. The chain charts the journey made by any given, nature-derived benefit to human well-being. This originates with the living organisms that comprise natural habitats (e.g., woodlands), proceeds to the capacity of such habitats to carry out important ecological functions (e.g., slowing and filtration of water), then to individual services relevant to human health (e.g., flood prevention) and finally to the benefits as perceived by humans (e.g., willingness to pay for forest management and protection). Note that the benefit described, as has often been the case in the literature on ecosystem services, takes on an economic mode of expression – the result of attempts to make natural habitats more visible in market-based transactions that so often lead to environmental degradation. Therefore, although the cascade model has contributed to an understanding of the relationships, and distinctions, between ecosystems, their functions and related services, such models still stop short of providing clear links between those services and human health outcomes.

The idea of service-providing units (SPUs) has similarly emerged from a utilitarian approach to nature conservation, grouping individual or groups of organisms according to the benefits (ecosystem services) that their unique or collective functional traits provide. This has allowed

for the development of pragmatic approaches to ecosystem management and allowed for the reduction of much ecological complexity through an anthropocentric rendering of ecological groups and their interactions (Andersson et al., 2015). Again, however, in the case of SPUs, emphasis has been placed on the links between organisms and the services they provide, rather than on clarification of the subsequent pathways linking individual services and human health.

Two reasons why evidence on the links between ecosystem services and human health has not been forthcoming relate to the scale at which the ecological processes determining ecosystem service production have been considered and the spatial distribution of the recipients of such services. Ecosystems (and their functional components) operate and interact across scales. In addition, end users and beneficiaries are often located at large, spatial and temporal distances from those ecosystems. As a result, benefits to humans derived from large-scale natural processes, such as carbon sequestration, water regulation, provision of food and medicines, and pollination, are difficult to quantify at the local spatial and temporal scales at which benefits to well-being are experienced. The situation becomes even more complex in light of the increasingly urban nature of today's global population, which sees highly dense populations relying on spatially and culturally distant regional-to-global ecological functions.

However, as we have observed earlier in this chapter, the increasing rural-to-urban migration and the parallel rise in chronic health conditions affecting urban populations has led to increasing interest in the role of the natural environment on the health of urbanites (i.e., the majority of humans today). Much of the evidence on this relationship stems from the public health disciplines, and the mechanisms already discussed have been offered as potential

causal pathways. Notably, very little research within public health, and none of the mechanisms identified in this chapter, take recourse to the notion of ecosystem services. Rather, the presence of nature and biodiversity itself is often treated as a fundamental component directly influencing human health. In contrast, biodiversity is presented in ecosystem services models as generating and supporting (cascading) ecological functions, via service-providing units, and subsequent benefits to human well-being. In this way, these two modes of describing the health benefits to humans stemming from the natural environment (one, from a public health and the other, from an ecological perspective) are characterised by their contrasting emphasis on biodiversity. That is to say, public health researchers tend to view biodiversity as something that may directly affect the biological, social and emotional mechanisms that regulate human health, regardless of intermediate functions, products, goods or services which may be involved. Conversely, ecologists – at least those promoting a utilitarian approach to nature conservation – tend to see biodiversity as that which allows the existence of ecosystems and their various functions to be beneficial to human well-being.

However, these two perspective need not be irreconcilable and, especially in an urban context, there exists both the need and the opportunity to explore links between ecosystem services and health. As we have seen, the urban environment has received much attention as a context for public health research, but has equally been the focus of much work within the ecological sciences. The latter has sought to better understand this unique environment and its implications for land-use change, nature conservation and human well-being. One of the key concepts to emerge from research on urban ecosystems is that of urban green infrastructure (UGI). The use of UGI – ‘an interconnected network of greenspaces that conserves natural ecosystem values and functions and provides associated benefits to human populations’ (Benedict & McMahon, 2002), stems back to the 1980s. More recently, it has been used to

denote the biophysical features within the urban environment from which ecosystem services are derived at the city-scale (Hansen & Pauleit, 2014). An important premise in the promotion of an urban green infrastructure approach is that, although fundamental benefits to human livelihoods are derived from distant ecosystems, important ecosystem services are delivered within urban environments at the neighbourhood-to-city scale by the presence of natural surface cover. Subsequently, evidence is forthcoming at increasingly local scales on the influence of local urban nature on topics relevant to health, such as access to green space (Benedict & McMahon, 2002), air quality (Pugh et al., 2012), neighbourhood walkability (Wolch, Byrne, & Newell, 2014), crime levels and social inclusion (Kuo & Sullivan, 2001). Many of these characteristics are critical to quality of life in urban areas, and their related well-being outcomes can be described through recourse to mechanisms identified in the public health literature. Therefore, given the current body of evidence, there is scope to integrate knowledge from research into urban green infrastructure and public health. Table 6.2 presents an example of how, drawing on the relevant literature, health outcomes for urban residents can be charted from types of urban green infrastructure to the ecosystem services they provide to the health benefits received by humans via relevant pathways.

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Although such an undertaking may provide some conceptual clarity, the assigning of unique health outcomes to individual green infrastructure types is not without its problems. For example, much of the evidence linking green spaces to health comes from cross-sectional studies and causality cannot be established through such methods where latent variables may be at work. Moreover, many of the outcomes described in Table 6.2 could be linked to an increase or decrease in the experience of stress. This suggests that, although types of urban

green infrastructure may be more or less closely linked to certain ecosystem services and related health mechanisms, the regulation of stress within may comprise a central pathway through which urban ecosystems influence human health.

Contact with Nature in Cities

Contact with nature has been tied to health and well-being in many studies. Links, through correlational studies, have been made to measurable human positive benefits in terms of physical health, psychological well-being, and social cohesion. The modernisation theory posits that social-economic development expands the resource base and is the driving force of political mobilisation. This is often used to explain the emergence of the environmental movement in advanced industrial societies.

The hygiene hypothesis postulates that a reduced exposure to environmental microbes and harmless infections, which is linked to increased economic wealth, leads to an increased prevalence of allergic reactions. Reduced exposure to environmental bacteria in early life, growing up in an urban environment, and less contact with people and animals are associated with an increased risk of developing allergies and asthma in later life (Jatzlauk, Bartel, Heine, Schloter & Krauss-Etschmann, 2017). Exposure to the microbiota associated with pets alters the gut microbial composition of infants, a putative pathway by which exposure to pets can reduce these health risks. The absence of pets, for example, from homes reduces the early-life exposure to microorganisms and contributes to the increased prevalence of allergies and asthma (Tun et al., 2017). These authors reported that following exposure to pets, there was increased abundance of two bacteria in the gut flora (*Ruminococcus* and *Oscillospira*). Both of these bacteria have been negatively associated with childhood atopy (a predisposition to

developing certain hypersensitivity reactions) and obesity. The range of specific health outcomes linked to contact with nature is wide and includes diabetes mellitus, various infectious diseases, cancer, obesity, birth outcomes, cardiovascular disease, musculoskeletal complaints, migraines and respiratory disease.

Theoretical frameworks linking nature and human health and well-being

There are a variety of disciplinary traditions in understanding the contributions of nature to health and well-being. These include the main disciplines in health and well-being, such as medicine, public health, epidemiology, environmental sciences, geography, sociology and environmental psychology. Furthermore, research in biology, physical activity, ecology, urban planning, economics, leisure and recreation also contribute to knowledge in the area of health and well-being. This variety of disciplinary traditions has resulted in a range of theoretical frameworks for explaining the contributions of nature to health and well-being. Frameworks explain the contributions of nature to health and well-being by emphasising different biological, social, economic, ecological or environmental factors or mechanisms that link environmental influence, internal processes and health and well-being outcomes.

Nine mechanisms, five starting intrinsic and four extrinsic, emerge that underpin the theoretical frameworks. These mechanisms are outlined below.

Mechanisms starting with internal intrinsic processes

The stress reduction mechanism is based on the emotional functioning of the brain. This mechanism asserts that contact with nature stimulates psyco-evolutionary emotions, which, in turn, reduce or increase stress. This mechanism starts in the emotional part of the brain. For example, Kellert (1996) reported that citizens of suburban and urban areas tend to place a much higher value on species conservation than those living in rural areas. Kellert suggested that this was because those living in urban and suburban areas perceive biodiversity as a cultural ecosystem service, one that links them to the natural world, and provides an aesthetic and stress-reducing function rather than a provisioning service. The latter, particularly the provision of food, may be a more prevalent view in rural areas where natural resources are more closely associated with provisioning ecosystem services.

The attention restoration mechanism is based on the cognitive functioning of the brain. This mechanism asserts that contact with nature restores involuntary attention, which, in turn, restores voluntary attention. This mechanism starts in the cognitive part of the brain. The cultivation of local biodiversity, which brings with it a need to focus on certain activities and, hence, is a cognitive activity, has been shown to provide psychological benefits for people (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007).

The built environment mechanism is based on sensory arousal. The assertion here is that increasing complexity of the environment is the cause of over-stimulated brain functions, which, in turn, causes stress. This mechanism starts in the cognitive part of the brain. The ‘extinction of experience’ to use a phrase coined by Miller (2005) that comes about as a result of the disconnection from nature, felt by many people living in urban environments, can have a negative impact on humans as well-being.

The physical activity mechanisms are based on the biophysical functioning of the body. The assertion is that infections, disease, injury, pollution or inactivity produce hormones, which, in turn, affect the immune and other systems. These mechanisms start in the endocrine system. Physical activity has been shown to be a major contributor to health. Intuitively, green space is associated with physical activity; however, this relationship is empirically inconsistent and may hold only under certain conditions and for certain populations. While greener residential areas do not consistently predict physical activity, they do consistently predict lower rates of obesity. This suggests the pathway between nature and obesity may depend less on nature's effects on physical activity and more on its effects on adiponectin, stress and impulse control.

The self-perception mechanism is based on the concept of actualisation. This mechanism asserts that progressively fulfilling physiological, safety, and psychological needs underpins the actualisation of self-potential, that is to say, that one fulfils one's potential. This mechanism starts in the physiological needs: the need for food, clean drinking water, and shelter (appropriate housing). Then, it moves to the need to feel safe from natural disasters and from attack by animals or other humans. The third step is for meaningful relationships with others who are part of the community. This hypothesis states that it is only when one's needs at all three of these levels are met that one can move on to develop one's full potential: learning new skills and achieving something above meeting one's basic requirements for life.

Mechanisms starting with extrinsic processes

The place identity mechanism is based on cultural conditions and norms. Here, the assertion is that culture preconditions people for what parts of nature are liked or disliked, or seen as good, bad, moral, immoral, healthy or unhealthy. This mechanism starts in cultural norms. Citizens of urban areas may support innovative initiatives that are framed as addressing the needs of people as much as the needs of wildlife such as landscaping green roofs, and the cultivation of native plants. People assign, and express diverse values and meanings to nature and their experience of it based on individual experiences and cultural backgrounds; hence, perceptions, context, and culture determine the number and types of cultural ecosystem services experienced that are shaped by difference in attitude and belief (Bertram & Rehdanz, 2015; Buchel & Frantzeskaki, 2015; Camps-Calvet, Langemeyer, Calvet-Mir & Gómez-Baggethun, 2016; Voigt & Wurster, 2015). The link to health is that if one assigns negative values to the place in which one lives and/or works, that will have a detrimental effect on one's health. As these values are based on individual and cultural norms, it means that two people with different life experiences and different cultural norms will assign different values to the same place. In the extreme, while one person may be unhappy and possibly depressed due to the negative values they assign to a particular place, to another person, this same place may be one in which they feel comfortable due to the positive values they assign to the community of that place or as a result of a life time of memories built up in that place.

The community mechanism is based on social interactions. This mechanism asserts that social isolation, exclusion and disadvantage cause ill health and poor well-being because humans need social ties and other group dynamics. This mechanism starts in social interactions between individuals. A well-educated public, alignment with voluntary organisations, leisure time to devote to political activism and attention to post-material goods also have been related to high levels of activism (Dalton, 2005). Opportunities for

community-based, environmental protesters to translate concerns into activism are facilitated by social interactions characterised by dense communication structures, mass education, urbanisation and high degrees of social mobility that characterise advanced industrial societies.

The care provision mechanisms are based on institutional settings. These mechanisms assert that health and well-being are the outcome of appropriate institutions providing prevention, treatment, care and management of disease. These mechanisms start in institutional settings.

Finally, the ecological mechanisms are based on interdependencies between factors. The assertion is that air, land, water, biodiversity, social and economic determinants affect personal, physical and psychological determinants of health. These mechanisms start in the broad environment. Long-term, positive health and well-being outcomes have been linked with time spent in and around urban green space – tree-lined streets, gardens, parks, and forested and agricultural lands. The greener a person's surroundings, the lower is the risk of morbidity and mortality, even after accounting for confounding variables.

A central mechanism linking nature to health and well-being

Stress has significant effects on human biology and appears to be a central factor in the external and internal mechanisms of health and well-being. There are two major hormonal stress systems. First, the autonomic nervous system controls the release of noradrenaline and adrenaline. These hormones are released within milliseconds and prepare the body to 'fight or flight' in response to a perceived threat (Adli, 2011). Second, the hypothalamus-pituitary-

adrenocortical system releases hormones that control digestion, the immune system, mood and emotions, sexuality, and energy storage and expenditure (Spencer and Hutchison 1999). Under chronic stress, this system continuously produces cortisol (the stress hormone). Too much cortisol antagonizes insulin and other hormones, leading to suppressed immune system, inhibited physiological and psychological functions, and toxic effects on neurons in certain brain regions.

The effects of low-level chronic stress can be seen physiologically at the cellular level. Under low-level chronic stress, cells are damaged by free radicals, lose their regeneration capacity and ultimately die. The result is premature ageing (Adli 2011). As cells die, they release chemicals that cause inflammation. In order to deal with the inflammation, the body's immune system is switched on and remains so until the cause of the stress is addressed. Inflammation caused in this way is recognised as 'the cause of causes' leading to arthritis, cancers, cardiovascular disease, diabetes, anxiety and depression, obesity and the decline of the brain and its abilities that collectively are described as dementia (Epel, Daubenmier, Moskowitz, Folkman & Blackburn, 2009; Hazel, Bardeesy, & Maser, 2005; Kuo, 2015; Manoli et al., 2007).

Drawing all the mechanisms together this theory posits that chronic, low-level inflammation is at the root of ill health and is, in large part, a direct consequence of the environment in which people live. Many current urban settings cause low-level stress. Low-level stress causes physiological and psychological changes. Physiological and psychological changes are manifested as ill health and poor well-being (Figure 6.2).

<FIGURE 6.2 HERE>

Conclusion

Nature within cities forms part of a complex social-ecological system. The ecological components of the system produce ecosystem services and disservices that influence the health and well-being of people living and working in cities. Both health and well-being are complex, multi-faceted concepts that have been studied by many and diverse disciplines. With an accompanying diversity of approaches there are a wide range of models explaining different aspects of the links between nature in cities and health and well-being. The unifying feature of all these models is that there is a tangible link and that people benefit from there being nature in cities. If these benefits are to be exploited in order to address the health concerns of the early 21st century, then four areas need further development. First, the theoretical gaps need addressing, for example there is much to be done to determine the potential health and well-being benefits that arise from contact with nature for a range of populations groups (e.g. for an ageing population and those with dementia). Second, preventative or therapeutic outcomes need clarity, for example clear links established with, for example, reductions in the rates of obesity, cardiovascular disease, Type II diabetes, certain cancers, and mental ill health (e.g. depression and anxiety). Third, passive and active contact with nature needs promoting so that preventive 'upstream' health interventions are developed and delivered. This will require changes in the way in which health and well-being are managed by the health professions and by individuals. In turn this will necessitate the design and delivery of health and well-being interventions that are based on contact with nature. Fourth, appropriate architectural and urban designs need implementing. In order to achieve the maximum benefits, it will be necessary to design towns and cities in such a way that contact with nature is both possible and encouraged as part of everyday living. The

challenge for the designer is to set aside ideas that see nature apart from people in cities but which integrates nature in to all elements of the fabric of cities. Ideally, from the moment someone opens their bedroom curtains in the morning to drawing them in the evening, they should be able to see some form of greenery – a park, a green façade on the building opposite, or a green roof visible to those living in high rise buildings – at all times of the day.

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Table 6.1: Passive/direct and active/indirect ecosystem services associated with domestic green space. (Based on McPherson, 1994; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007; Berman, Jonides & Kaplan, 2008; Bowler, Buyung-Ali, Knight & Pullin, 2010; Dallimer et al., 2012; Mitchell, 2013; Larson, Whiting, Green, & Bowker, 2014; Shanahan, Lin, Gaston, Bush, & Fuller, 2015)

	Description	Examples
Passive or indirect ecosystem services	Can be delivered via pathways which do not require people to engage actively with the natural environment – services provided even when a person is not in the greenspace.	Climate regulation Privacy Noise reduction Screening from unwanted views Flood mitigation
Active or direct ecosystem services	Delivered via pathways requiring people to actively engage with the natural environment. This requires people to spend time in the greenspace, and experiences and benefits derived are dependent on the behavioural patterns of a person and the characteristics of the vegetation.	Gardening activities Sitting in the greenspace Play activities

Table 6.2. Urban green infrastructure, ecosystem services and potential mechanisms affecting human health

UGI	Ecosystem Service Category (MEA)	Ecosystem Service	Benefit	Mechanism
Protected areas	Supporting	Habitat for wildlife	Sense of place/heritage	Connectedness with nature
Urban wetlands	Provisioning	Water filtration/purification	Clean water	Alleviate stress caused by pollutants
Street trees	Regulating	Capture of ultra-fine particles from traffic	Reduced cardio-vascular disorders	Alleviate oxidative stress
Riparian habitat		Flood prevention/management	Lower risk to people and property associated with extreme weather events	Hydrological filtration

Urban parks		Evapotranspiration and shading	Reduction of heat stress	Physical/physiological
Playing fields/recreational grounds	Cultural	Recreation/exercise	Lower obesity levels	Physical activity
Neighbourhood greenery		Amenity/aesthetic	Hedonic uplift	Increased life satisfaction
Community gardens		Social interactions	Improved social ties	Participation

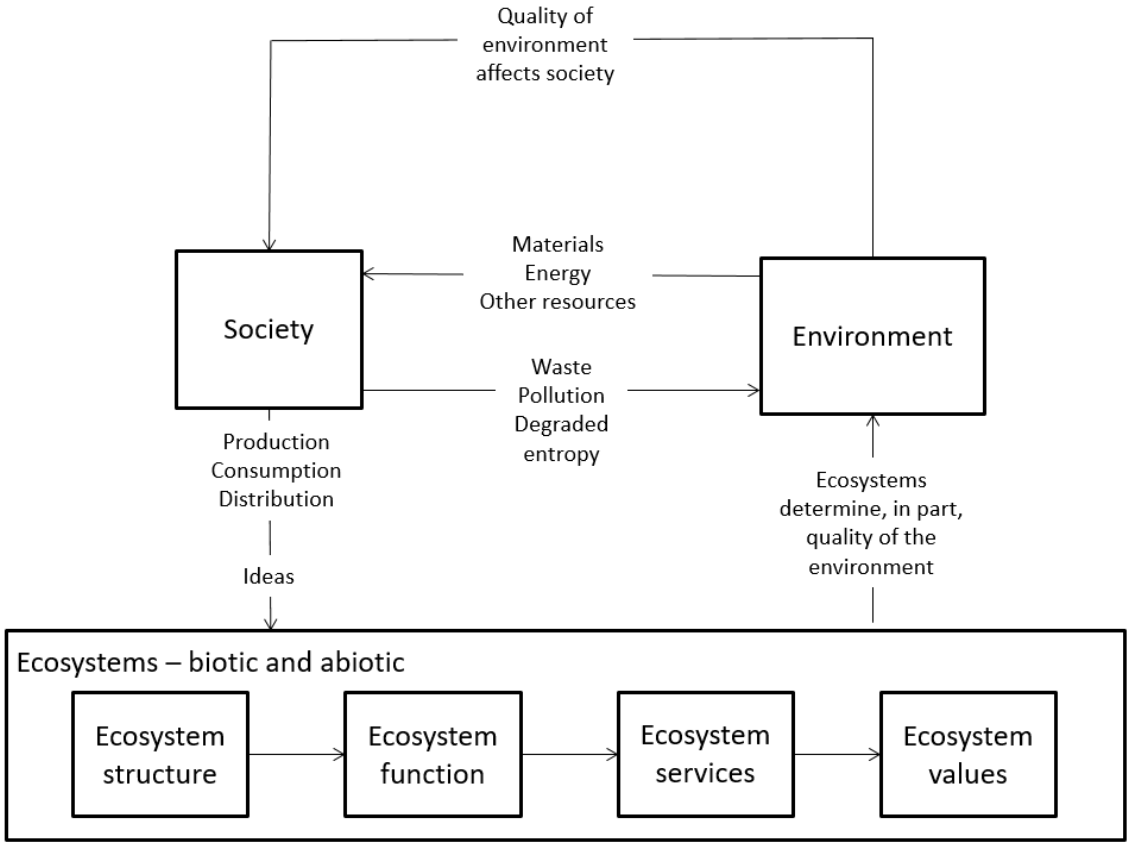

Figure 6.1 Conceptual diagram of a social-ecological system in cities

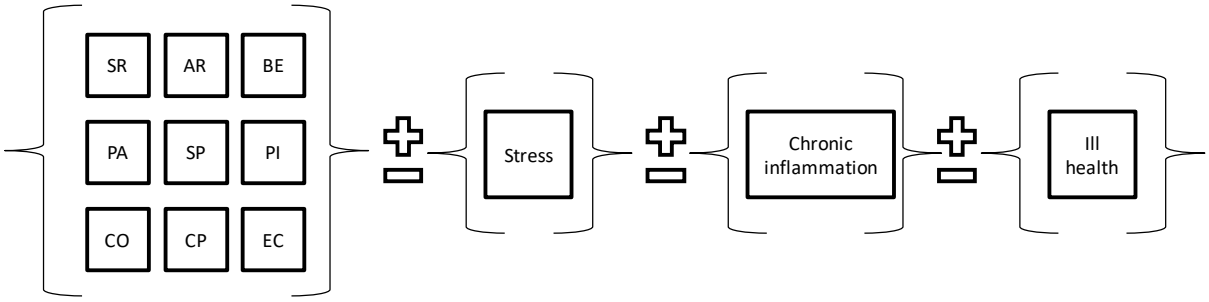

Figure 5.2 Links between mechanisms determining health and well-being and ill health.

Square brackets indicate multiple factors, aspects, symptoms; **Positive and negative signs** indicate increasing or decreasing determinants of health; **Mechanisms:**

SR: stress reduction i.e. contact with nature tunes into positive or negative psyco-evolutionary emotions, which in turn reduce or increase stress;

AR: attention restoration i.e. contact with nature restores involuntary attention, which in turns restores voluntary attention, and consequently reduces stress;

BE: built environment i.e. increasing complexity of the built environment over stimulates the brain and causes stress;

PA: physical activity i.e. infections, disease, injury, pollution, lack of physical activity all have consequences on the immune, digestive, hormonal and circulatory systems and affect stress

SP: self-perception i.e. not being able to fulfil Maslow's hierarchy of needs causes stress;

PI: place identity i.e. culture preconditions people for what is liked and disliked, good, bad, moral, immoral, healthy, unhealthy and consequently what is perceived as stressful;

CO: community i.e. isolation, exclusion, disadvantage, lack of social ties, family, friends, or other group dynamics cause stress

CP: care provision i.e. lack of medical treatment, care, and management of disease through institutional support cause stress;

EC: ecological i.e. air, land, water, biodiversity, social, economic determinants affect personal physical and psychological determinants of health and consequently affect stress;

Stress from multiple mechanisms causes chronic inflammation; **Chronic inflammation** affects health.