1 Green infrastructure and health
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INTRODUCTION

The World Health Organization (WHO) estimates that by 2030 60 per cent of the world's population will be living in an urban environment and this figure is likely to increase to approximately 70 per cent by 2050 (WHO, 2014). This rapid urban growth and migration to urban areas is accompanied by a complex pattern of change in the built environment, creating pressures on the landscape. Pressures such as urban sprawl (Bell et al., 2010), which is often associated with the loss of green and natural areas, may thereby impact on people's health.

The term 'green infrastructure' is often used as an overarching concept to describe an interconnected network of green spaces that incorporates a number of different types of spaces (natural, semi-natural, green corridors, urban green spaces and green roofs) and other natural elements such as street trees (see Chapter 12). In this chapter, such a broad definition of green infrastructure is considered in so far as it may have relevance for people's health and well-being.

As is explored elsewhere in this book, green infrastructure is recognised as potentially providing a number of complementary benefits from different spheres, namely, environmental, social and economic. Tzoulas et al. (2007) proposed a conceptual framework of associations between green infrastructures, ecosystem health[1] and human health. The authors highlighted the complex and dynamic nature of interactions that demand inter-disciplinary understanding, suggesting that aspects of public health are embedded in green infrastructure, in association with ecosystem functions and services, and ecosystem health. It is in this context that green infrastructures can be considered to provide health benefits to residents of the urban environment.

This chapter explores these links between green infrastructure and human health and well-being. Starting with a historical perspective, it considers the relationship between human health and nature, and the implications for green infrastructures. It concludes with an example considered a successful green infrastructure development for contemporary times.

HISTORICAL PERSPECTIVE

Although the term 'green infrastructure' is relatively new, its concept can be traced to the nineteenth century (Benedict and McMahon, 2002), in particular to the American landscape architect, Frederick Law Olmsted.

From the mid-nineteenth century, the growth of industry and the influx of people into the large cities of the American Northeast and Midwest produced a rapid reorganisation of the urban landscape in the United States. This unprecedented urbanisation led

to a deterioration in the quality of life and physical infrastructure of cities, with poor living conditions, poor sewerage systems, contaminated water, pollution and the ready spread of communicable diseases. Such problems had been recognised in Europe and led to social reforms alongside the promotion of public parks to enhance the health of the urban working classes (Ward Thompson, 2011). Development of individual parks open to the public, such as Victoria Park in the East End of London and Birkenhead Park, outside Liverpool, were early examples of 'green' interventions in the 1830s and 1840s in Britain. Such developments were influential in North America, where the improvement in human health and well-being through the amelioration of the urban fabric, especially through access to natural places, was defended by progressive thinkers of the time. The writings of John Muir (Muir 1901 [1981]) and Frederick Law Olmsted are early examples of the development of theory and practice based on the premise that visits to parks could promote better health, allowing for a restorative experience (Hartig, 2007). Olmsted officially entered the public health arena when he was appointed as general secretary of the Sanitary Commission during the American Civil War (Szczygiel and Hewitt, 2000). He had the opportunity to work with various experts in public health and develop his own planning and design theories, strengthening understanding of the links between health and well-being, and nature. He recognised that, in addition to the physical health risks associated with a highly industrialised urban society, mental health and social bonds were also at risk (Eisenman, 2013). He acknowledged that the effects of daily life in a crowded city, with its fast pace and distance from the countryside, could often result in 'mental disability, sometimes taking the severe forms of softening of the brain, paralysis, palsey, monomania, or insanity, but more frequently of mental and nervous excitability, moroseness, melancholy, or irascibility' (Olmsted, 1865, p. 18). He believed that achieving an improvement in the physical environment, through the interconnection of natural and green areas, was an important step towards gaining a better public health:

> That rural scenery has the effect alleged, of counteracting a certain oppression of town life, is too well established to need argument . . . the evil to be met is most apt to appear in excessive nervous tension, over-anxiety, hasteful disposition, impatience, irritability, and that the grateful effect of a contemplation of pleasing rural scenery is proverbially regarded as reverse of this. (Olmsted, 1886, p. 248)

The opportunity to get fresh air and exercise was defended by Olmsted and his partner Calvert Vaux as a way to gain ground against certain diseases 'the remedy and preventive can not be found in medicine or in athletic recreation, but only in sunlight and such forms of gentle exercise as are calculated to equalize the circulation and relieve the brain' (Olmsted and Vaux, 1868, p. 40). Although Olmsted never fully detailed the restorative mechanism of contact with nature, his work has been influential as a precursor to today's more empirically evidenced theories on restorative environments (Hartig, 2007).

In addition to his contribution to theorising links between nature and health, Olmsted made an important contribution to the practical planning of natural systems to deliver health benefits. His strategic vision acknowledged the importance of green infrastructure in the planning and development of cities. He recognised that contact with nature would be more beneficial if green spaces were connected, rather than individual parks: 'No single park, no matter how large and well designed, would provide the citizens with the beneficial influences of nature' (Olmsted, 1903, cited in Benedict and McMahon,

2002, p. 13). On the contrary, he suggested that parks should be 'linked to one another and to surrounding residential neighbourhoods' (Olmsted, 1903, cited in Benedict and McMahon, 2002, p. 13), creating a network of green spaces that provided opportunities to connect people from all backgrounds and allow easy contact with nature for all. Access to individual parks was seen as problematic for those living far from any such park, not only because of distance but also because of the poor state of the streets. Furthermore, Olmsted and Vaux were aware of how the expansion of cities was alienating city centre residents from contact with more expansive areas of nature (that is, the countryside), depriving them of having a restorative experience: 'a great body of the inhabitants cannot so easily as formerly stroll out into the country in search of fresh air, quietness, and recreation . . . makes tranquilizing recreation more essential to continued health' (Olmsted and Vaux, 1868, p. 40).

The Boston Park System, commonly described as the Emerald Necklace (1878–96), is one of the key examples of Olmsted's strategic planning and its influence cannot be overestimated in the context of current concerns over green infrastructure and health. Boston's Emerald Necklace, developed by Olmsted and Eliot, became the first metropolitan park system to be developed as such, and it still offers social, economic and ecological benefits to the residents of Boston's metropolitan area. Initially developed in response to flooding from the Charles River, it linked a series of public parks (Franklin Park through Arnold Arboretum and Jamaica Park to the Boston Garden and Common) with a series of parkways (Fábos, 2004; Benedict and McMahon, 2006). Smaller parks and playgrounds were also part of the parkway system (Carr et al., 2013). The network of green spaces offered: (1) ecological benefits (flood mitigation, management of sewage stormwater outflow in the context of a tidal river, and habitat protection); (2) social cohesion – a connection between the old and new sections of the town, which Olmsted had criticised as being 'distinct local communities . . . in a spirit of competition and jealousy towards the others' (Olmsted, 1882, p. 221); and (3) ready access from any part of the urban fabric to green spaces, which ultimately allowed for recreation and well-being: 'the contemplation of pleasing rural scenery . . . the enjoyment of this pleasure, and not simply of air and exercise' (Olmsted, 1886, p. 248). The possibility of offering seclusion from the harsh urban condition was also on Olmsted's agenda:

> We want a ground to which people may easily go after their day's work is done, and where they may stroll for an hour, seeing, hearing, and feeling nothing of the bustle and jar of the streets, where they shall, in effect, find the city put far away from them . . . We want, especially, the greatest possible contrast with the restraining and confining conditions of the town, those conditions which compel us to walk circumspectly, watchfully, jealously, which compel us to look closely upon others with sympathy. (Olmsted, Vaux and Company as cited in Taylor, 1999, p. 440)

This aim is very well articulated in the design of parkways, for example, the presence of trees (for example, elms) and other vegetation enhanced the sense of seclusion and connection with the natural environment for those residents adjacent to the parkways as well as for recreation and circulation (Eisenman, 2013).

Olmsted also noted how the health benefits offered by green spaces, in particular the construction of parkways, would have an economic value: 'a park-way would complete a pleasure-route from the heart of the city, a distance of six miles into its suburbs . . .

They would have a larger use, be more effective as appliances for public health, and every dollar expended for their maintenance would return a large dividend' (Olmsted, 1881, p. 233).

Among the many other great examples of the Olmsted firm's work is the Buffalo Park System, which he began to plan in 1868. This is another example of the integration of green spaces within the urban planning framework. The plan included three major parks: the Park, the Front and the Parade. To connect the parks to each other and to the city overall, Olmsted adopted the design of linear paths/parkways. Here again, Olmsted expressed his desire to create a park system that would be close to working-class neighbourhoods (Taylor, 1999). He argued: 'At no great distance from any point of the town, a pleasure ground will have been provided for, suitable for a short stroll, for a playground for children, and an airing ground for invalids, and a route of access to the large common park of the whole city' (Olmsted, Vaux and Company, cited in Taylor, 1999, p. 449). This quote demonstrates acknowledgement of the benefits of the parks for different types of users. Once again, the design was intended to create a different type of space within the urban structure, allowing for a contrast with the urban environment:

> Most of the steps on the way to it would be taken in the midst of a scene of sylvan beauty and with the sounds and sites of the ordinary town business, if not wholly shut out, removed to some distance and placed in obscurity. The way itself would thus be more park-like than town-like. (Olmsted, Vaux and Company as cited in Taylor, 1999, p. 449)

In Buffalo, Olmsted also focused on the physical exercise aspects of park provision. When he designed South Park, he argued that workers needed more than a serene landscape, and that parks should incorporate spaces for active recreation. As an example, the park system had a baseball lot (Taylor, 1999).

In both Boston and Buffalo, the common characteristic of the Olmsted firm's design is the balance between human users (recreation, health, and social cohesion) and nature (ecological functions). According to Eisenman (2013), these examples translate the origins of green infrastructure into practical plans, where Olmsted and his partners expressed for the first time the principles of a 'hubs and links' structure: 'hubs' can take various forms and include parks and other large natural areas, and 'links' are corridors with vegetation that connect the hubs.

While Olmsted and his partners developed landmark projects, similar work was being done in Europe. In the UK, Ebenezer Howard (1965), through the Garden Cities movement, proposed designing and building connected polycentric networks of small urban spaces. The creation of these networks of green spaces aimed to alleviate the effects of pollution and industrial growth, by supporting and promoting the development of more favourable living conditions (Mell, 2010).

At the beginning of the twentieth century, the biologist and city planner Patrick Geddes (1915) engaged in the green and sustainable development of cities, focusing on design with nature and a strong connection between people and place. In the second half of the twentieth century, Ian McHarg (1971) strengthened again the links between nature and human habitats, reinforcing the need to develop a strategic landscape planning to deliver multiple functions, 'putting nature first, not last, on the planning agenda' (Hough, 2007, p. 54). Building on these early ideas, in today's urbanised world it is important to

consider how urban parks can also be part of wider green infrastructures, and their links to human health.

EVIDENCE AVAILABLE ON THE IMPORTANCE OF GREEN INFRASTRUCTURE TO HEALTH

The World Health Organization has defined the term 'health' not only as the absence of illness, but also as a 'state of complete physical, mental and social wellbeing' (WHO, 1948). In the past, a large body of research in the field of health and the environment focused on the negative aspects of the environment and the hazards for public health (Frumkin, 2001), focusing for example on water-borne diseases or toxic chemicals and their relationship to cancer and other illnesses. This tendency has recently shifted and researchers are now studying the positive influence on human health of different aspects of the social and physical environment. This study of the salutogenic (or health-enhancing) aspects of the environment include issues such as land use, urban and rural patterns of settlement, air quality, public transportation systems and green space.

As a result of this renewed emphasis on the positive value of certain kinds of environment, twenty-first century access to, and the use of, good quality green space continues to be considered important, long after nineteenth-century exponents articulated their visions. This is especially true for those living in urban areas and it is particularly relevant to the study of green infrastructure and health. 'What is impressive about Frederick Law Olmsted's mid-nineteenth century assertions on the benefits of the "natural" park is the degree to which they are confirmed by research over the last few decades' (Ward Thompson, 2011, p. 192).

In recent years, a solid body of evidence has been established on the role of the physical environment, and especially green or natural environments such as parks and woodlands, as an important factor influencing health, both for the individual and at a population level (Tsunetsugu et al., 2010; Lee and Maheswaran, 2011; Mitchell et al., 2011; Ward Thompson et al., 2012). Research shows that access to local green space, alongside access to housing, health and education, is a basic requirement for a good quality of life (CABE, 2010). The associations between health and the environment seem to vary by socio-economic characteristics and levels of urbanity, with greater benefits from nearby green space for populations of a lower socio-economic class (Mitchell and Popham, 2008) and those in more urban areas (Maas et al., 2006; Mitchell and Popham, 2008). Furthermore, the percentage and abundance of green space available in someone's surrounding living environment has been linked in a positive association with perceived health (de Vries et al., 2003; Maas et al., 2006). Studies have shown a typical reduction in the risk of mortality from cardio-respiratory disease of 5–10 per cent in urban populations with good access to natural environments, compared with those with poor access (Mitchell and Popham, 2008; Richardson and Mitchell, 2010).

Types of Benefits

Although there is emerging evidence that contact with nature can be beneficial to health, one key question is, what is the pathway between health and nature? Four pathways have

been proposed as ways in which access to 'nature' may have beneficial health outcomes (Hartig et al., 2014):

- physical activity in the natural environment;
- the restorative effect of nature (reduction in stress, promotion of mental well-being);
- social cohesion through social contact enabled by the natural environment;
- air quality enhancement by plants in the natural environment.

Before detailing some of the benefits, it is important to recognise that the mechanisms by which nature might affect health are multiple, may well be synergistic and can be beneficial at various levels.

Physical activity

It is estimated that physical inactivity and its consequences for human health has cost the UK economy more than £8 billion a year (Bird, 2007). Physical activity has both preventative and curative impacts, and natural environments are recognised as being particularly good places to promote healthy activity (Ward Thompson, 2011). However, it is unclear whether access to natural environments, alone, is sufficient to encourage more physical activity in people who would otherwise be less active. Nonetheless, a growing number of epidemiological studies reveal that the presence and accessibility of green spaces can help support physical activity (Coombes et al., 2010; Sugiyama et al., 2013).

Visiting green or natural environments is usually associated with higher levels of physical activity, and walking in particular, compared with other urban environments, regardless of the primary purpose of the visit (Ward Thompson and Aspinall, 2011). Access to walkable green streets can reduce blood pressure (Orsega-Smith et al., 2004), while walking in forests may promote cardiovascular relaxation, and reduce negative physiological symptoms (Lee et al., 2014). Researchers in Australia have suggested that a green environment might not be enough of an incentive for people to start walking, but it can help them to maintain their levels of activity (walking) over time (Sugiyama et al., 2013). Lower levels of obesity have also been associated with access to green spaces, through the promotion of physical activity (Coombes et al., 2010).

Although findings are mixed, the role of the environment in levels of physical activity is also suggested as positive in subgroups of the population, such as children and older people. Children and adolescents with better access to parks are less likely to have higher Body Mass Index (BMI) levels (Wolch et al., 2011) and the level of children's physical activity seems to be influenced by access to parks and vegetation (Ding et al., 2011). A review of various studies revealed that there was a significant association between a green environment and levels of physical activity for those aged over 60 years (Broekhuizen et al., 2013).

One way in which physical activity and green environments may be linked to health is through the indirect benefits of physical activity in green or natural places, as opposed to other contexts. 'Green exercise', defined as physical activities while being directly exposed to nature (Pretty et al., 2005), has been suggested as being more restorative than other types of exercise (Mitchell, 2013). For example, running in the park is often associated with a more restorative experience when compared with the same exercise in an urban environment (Bodin and Hartig, 2003).

Stress reduction

Overall, contact with nature can be restorative (Hartig et al., 1991) and evidence of mental health benefits from having contact with nature and green spaces is well documented. There are two main theories that attempt to explain this: (1) Psycho-evolutionary theory proposes that contact with nature (for example, views of natural settings) can have a positive effect for those with high levels of stress, by shifting them to a more positive emotional state (Ulrich et al., 1991); (2) Attention restoration theory suggests that involuntary attention given to interesting and rich stimuli in natural settings helps to restore a sense of well-being in those who are suffering mental fatigue (Kaplan and Kaplan, 1989).

Living in areas with a high percentage of green spaces appears to have a positive impact on lowering levels of stress (Grahn and Stigsdotter, 2003; Ward Thompson et al., 2012). The distance to a green space is also linked to levels of stress: those living further away from a green space (> 1 km) are more likely to experience higher levels of stress than those with green space nearby (Stigsdotter et al., 2010). Although the presence of green space seems to be beneficial for both men and women, recent research has suggested that the relationship may be different for women. For example, in a study of women in deprived communities and not in work, higher levels of stress were associated with a lower percentage of green space in the neighbourhood (Roe et al., 2013).

However, simply having natural and/or green spaces in the surrounding living environment might not be sufficient to have a positive health outcome. More recently, studies have focused on the quality of parks and suggest that quality might be more important than the quantity of public open spaces in the neighbourhood, in terms of impact on mental health (Francis et al., 2012). The presence of nearby trees and grass visible from apartment buildings has been shown to lower residents' levels of aggression and mental fatigue in comparison with those living in buildings overlooking barren vistas (Kuo and Sullivan, 2001). Also, the absence of green elements near to housing has been shown to impact negatively on the management of major life issues (Kuo, 2001). However, the quality of green spaces (overgrown or unmanaged) may increase levels of anxiety owing to fear of crime, resulting in a negative impact on people's well-being (Kuo et al., 1998).

The presence of water in the environment (lakes, rivers and coasts) has long been recognised as an attraction for people, is consistently associated with landscape preference in aesthetic terms (Nasar and Li, 2004) and is experienced as being particularly relaxing and peaceful (Ulrich, 1993). This has led to recognition of the importance of the role of water in green infrastructure, often described as the sub-category 'blue-green' or 'turquoise' infrastructure (Mell, 2008). However, water can bring negative as well as positive consequences, particularly where flooding is a potential hazard, and can have negative mental health consequences as a result (Miller et al., 2012). Given recent concerns over climate change, there is an increasing awareness of sustainable design, urban drainage systems, and green walls and roofs, all of which have implications for how water is managed in the landscape (see Chapter 3). While blue spaces, often in association with green spaces, may have a positive impact on health, research into the links between water and health are still being developed. Recent findings on 'blue spaces' have shown positive associations between water in the landscape and human health, mainly postulated as relating to the restorative benefits of such landscapes (White et al., 2010; Volker and

Kistemann, 2011, 2013). White et al. (2013) indicated that blue spaces and coastal regions were perceived as particularly restorative, more so than primarily green nature scenes. However, the robustness of the cognitive restoration of blue spaces remains unanswered (Emfield and Neider, 2014).

Social cohesion

The benefits of green infrastructure exist not only at an individual, but also at a community level. Research has explored the positive association between social relationships, and health and well-being (Nieminen et al., 2010), and a positive relationship between local green space availability and health has been established (de Vries et al., 2013). Green spaces have been recognised as playing an important role in the interaction between residents, fostering social interaction and promoting a sense of community (Kim and Kaplan, 2004). Conversely, when there is a shortage of green space in the environment, this appears to be associated with feelings of loneliness and lack of social support (Maas et al., 2009).

As for other social well-being benefits, the role of green spaces appears to be important for social cohesion across different sectors of society. According to research in Switzerland, public urban green spaces play an important role in children's and young people's social networks, including friends across cultures, promoting social inclusion (Seeland et al., 2009). Older adults living in inner-city neighbourhoods also benefit from the presence and use of green spaces, which appears to promote social ties and a sense of community (Kweon et al., 1998).

Air quality

Vegetation (trees, shrubs, herbs and grass) affects air quality and, consequently, human health. Although trees are often associated with allergies through the release of pollen, their role in health can also be positive. Trees and other vegetation can reduce levels of air pollutants (gases and particulate matter) and subsequently improve urban air quality (Nowak et al., 2006). Living in greener areas can support a lowering of exposure to air pollution (Dadvand et al., 2012). However, the interaction between trees, airflow and pollution is complex and in some cases tree extent may not have a positive association with human health, for example when a closed canopy over a road impedes the localised dispersion of vehicle emission pollutants, or when trees contribute to allergens such as pollen (Hartig et al., 2014).

Apart from the removal of pollutants, trees can have an indirect impact on air quality. Excessive heat can have damaging consequences for human health. During warmer weather, trees can provide shade and reduce the demand for air conditioning and, especially in warmer countries, they can provide comfortable outdoor settings and allow people to avoid heat stress (Lafortezza et al., 2009). Trees can also provide shelter from wind and thereby reduce heating demand in cooler climates. More information on the relationships between green infrastructure and air quality and temperature is available in Chapter 2.

IMPLICATIONS FOR PLANNING AND DESIGN: HOW CAN HEALTH AND WELL-BEING BE PROMOTED THROUGH GREEN INFRASTRUCTURES?

Healthy and sustainable cities require policy-making that connects across public health and the physical environment. Urban planning and design can play a key role here. There is an increased awareness that the environment, particularly green and natural environments, might not only play a significant role in enhancing human health, but also in preventing illness (Ward Thompson, 2011). Recognition that there may be a reduction in medical costs attributable to the provision of green spaces has been slow to influence government policy and spending, although there are signs that this may slowly be changing (Bird, 2007; Marmot, 2010). In most cases, the literature focuses on the positive relationships that exist between the environment and health but understanding what attracts or deters people from using green and natural environments may be as important as understanding the mechanisms that lie behind any environment–health relationship.

Green infrastructures can play a pivotal role in urban development, providing a matrix of green spaces that can vary in attractiveness to different groups or segments of the population. As suggested by Maas et al. (2006), green space should occupy a more pre-eminent position in planning, since evidence suggests it is more than just a 'luxury'. Green infrastructures can be incorporated in cities via future planning strategies for new developments but, crucially, can also be retrofitted into the existing urban fabric and be part of urban renewal processes; there may be particularly good opportunities for this in shrinking cities (Haase, 2008). The creation of greenery within the abandoned urban fabric may help to reduce crime and promote health (Branas et al., 2011). Programmes to rehabilitate existing green infrastructures by improving accessibility (paths, signage and tree management) and involving the community can have a positive impact on the use of green spaces and, ultimately, support increased activity levels and quality of life (Ward Thompson et al., 2013). The creation and management of green infrastructures in connection with other areas of planning (for example, housing and transportation) can enhance landscape connectivity and provide places for exercise, restoration and social connections, offering benefits for the population at various different levels. Indeed, people's choice of residential location often reflects their desire to have good access to restorative places (green and blue spaces) and decreased exposure to stress (Hartig et al., 2003b).

As indicated previously, the type of environment in which the activity takes place seems to affect the health outcome. For example, there is evidence that suggests walking in built urban environments is associated with higher mental or cognitive engagement, while walking in green spaces appears to promote higher meditation and lower frustration (Aspinall et al., 2013). Good access to large, attractive public open spaces seems to contribute to maintaining higher levels of walking (Giles-Corti et al., 2005), while walking or running in an urban environment might have reduced benefits (Hartig et al., 2003a). Therefore, the integration of green into the grey/urban structure can provide opportunities for a variety of positive health outcomes, both physical and mental.

However, getting the planning, design and management of green infrastructure right,

so as to maximise the health of all species, including humans, is complex. Academics, practitioners, and policy-makers need to collaborate to explore and evaluate alternative and innovative urban designs, planning and zoning approaches in order to correctly size, and maximise access to, green areas, enhance the quality of new and existing green spaces and guarantee a green continuum in the landscape. The particular characteristics of the green environment, especially the quality of the parks and boulevards, may make an important difference to how well they support more active lifestyles (Giles-Corti et al., 2003; Oewn et al., 2004; Sugiyama et al., 2008); and the quality of green spaces is also important in relation to increasing perceived social cohesion (de Vries et al., 2013). A careful selection of urban vegetation, its design configuration and maintenance, may have positive impacts on air quality, and consequently may be beneficial for human health, but poor design may actually result in harm to human health. In a similar vein, the presence of trees in the public realm has been associated with low levels of crime (Kuo and Sullivan, 2001). However, in other studies, small trees obstructing the views in private lots have been linked with higher rates of crime, perhaps since they might imply a house is less cared for than those with large, mature trees (Donovan and Prestemon, 2010). The design and management of vegetation in public green space can also enhance people's feelings of safety or contribute to their sense of insecurity. Good, open views along pedestrian routes and informal oversight from passers-by or surrounding buildings can enhance perceived safety in many cases, particularly for women (Krenichyn, 2004). This can impact indirectly on health since levels of physical activity in green spaces, for example, are associated with perceived safety (Jansson et al., 2013). By contrast, a common image of green space in deprived neighbourhoods – bare, mown grass, devoid of shelter, seating or more varied and attractive vegetation such as trees – may equally be a deterrent to use, attracting only dog walkers at best.

In order to take advantage of the different range of possibilities offered by green infrastructure, it may be necessary to strengthen the links between different stakeholders; for example, creating partnerships between health and planning authorities or organisations. Since various groups of society will benefit differently throughout their life from green infrastructures, it is important to involve diverse groups of users in planning green infrastructure, including potentially more vulnerable groups such as older people, children and minority ethnic groups. Further, since the presence of good quality green space seems to offer greater benefits for those living in more deprived communities, the planning process should ensure that green spaces in these areas are designed carefully and are linked to the rest of the green infrastructure in order to avoid segregation, promote health and reduce inequalities.

EXAMPLE: THE GREENLINK, SCOTLAND

This project is an example of ways in which links between development of a green infrastructure and opportunities to enhance community health have been promoted. The green infrastructure in a deprived urban area of Central Scotland resulted from the rehabilitation of the existing natural environment and the creation of new green links through paths and a cycle track. This was achieved via the concerted effort of various stakeholders and the strong engagement of the local community.

Location: Motherwell, North Lanarkshire, Scotland

Description: The Greenlink was established in 2005 and developed over a period of eight years. The Greenlink Project is managed and delivered by Central Scotland Green Network Trust on behalf of project partners and funders.

It links Motherwell city centre to Strathclyde Country Park, through a main cycle track (Figure 1.1). It is complemented by a series of paths, linking and offering a range of additional local routes to the adjacent communities of North Motherwell, Orbiston, Forgewood and Calder Valley. The path is a means for all of the community to access businesses, shops and recreation by bike or on foot, through green spaces.

The Greenlink has benefited from a range of physical interventions:

- 7 km of cycle track;
- 3 km of connecting footpaths, connecting urban areas, green spaces and woodlands;
- the rehabilitation and opening up of woodland to public access (Forestry Commission Scotland's WIAT – Woods In and Around Towns – programme) (43 hectares of adjacent woodlands);
- the creation of new woodlands;
- management of green spaces (20 hectares);
- waste removal;
- allotments;
- a mountain bike 'skill area'.

Alongside the physical changes in the environment there has been strong community engagement.

Communities: 10 000 residents in the local area benefit from this project (Figure 1.2). Historically, Motherwell was a primary location in Scotland for steel production. After production ceased in the 1990s, unemployment and socio-economic deprivation rose in the area. At the beginning of the project, many of the communities in this locality were, according to the Scottish Index of Multiple Deprivation, in the most deprived 15 per cent of those in Scotland. Many residents had a low life expectancy owing to their poor health and lack of well-being: coronary heart disease, poor mental health and child obesity were common, and 10 per cent of the population were prescribed drugs to combat anxiety, depression or psychosis.

Landscape prior to the intervention: The existing green spaces and woodlands had deteriorated (that is, were poorly maintained or not maintained at all), with blocked paths, abandoned cars, litter and tipping, graffiti and high levels of antisocial behaviour. Community perception of the local natural environment was that it was poor, and there was little engagement with it.

Investment: £1.64 million over eight years

Aims:

- to enhance the network of green space and woodland for local communities and wildlife;
- to improve the mental health and well-being of North Lanarkshire residents;
- to encourage all age groups to be more physically active in the outdoors;
- to encourage cohesion, capacity building and healthy lifestyles.

Figure 1.1   Images of the cycletrack and paths from the Greenlink

Figure 1.2 *Map of the Greenlink's route linking suburban communities on the*
north-eastern edge of Motherwell with the town centre (centre bottom of the
map) and with Strathclyde Country Park to the north and west of the town

Activities promoted:

- walking – involving a wide range of the community; buggy walks (for mothers); Granny, Grandfather and Grand Weans' (grandchildren's) Walk; family walks; bi-weekly health walks;
- cycling;
- volunteer activities – including becoming a health walk leader, working with school groups, helping to organise events; involvement in the allotment project;
- regular conservation activities;
- events on sites (example: Greenlink Rounders Tournament; Hallowe'en walks; Father's Day Family Cycle Run);
- activities with local schools, including a dedicated school programme 'Seed to Greenlink'.

Outcomes: There are no available data on measurable and robust health outcomes for this project. However, a study developed by Greenspace Scotland (O'Neill, 2009) revealed:

- increased use – 92 per cent of residents reported using the space more often (n = 38);
- community improvements – 97 per cent of respondents felt the Greenlink was making a positive difference to the community (n = 38);
- according to Motherwell Police, antisocial behaviour improved. There were 32 per cent fewer incidents reported of disturbance, in comparison to the year 2007–08. The project promoted health walks, and by 2012, there were over 4000 attendances at health walks organised by the Greenlink project. Currently, health walks are run in partnership with NHS Lanarkshire Greenspace Health and Wellbeing Partnership. 'Having recently moved to the area, I have met some very nice people by participating in the health walks and also, after being ill, I am getting fitter' (local resident – Greenlink, 2009);
- encouragement to people from different age groups to mix and work together in community and volunteer activities;
- community engagement – more than 5000 people were involved in conservation activities;
- enhanced quality of the physical environment;
- contact with nature and opportunities to do gardening in the allotments: 'This has been the best thing ever for me, I needed something to do with my time. I have been trusted with my own allotment key, so I can come and go as it suits. This has been better than a holiday for me because I come down to the allotment to potter about and relax' (local male resident, age 52 – Central Scotland Green Network Trust, 2014, p. 1);
- new planting, a greener environment and expansion of natural areas.

Social return:[2] £7.63 for every £1 invested (O'Neill, 2009).
Previous and current partners: Central Scotland Forest Trust, Scottish Natural Heritage, North Lanarkshire Council, Forestry Commission Scotland, Central Scotland Green Network, NHS Lanarkshire, Asda Foundation, Viridor.

CONCLUSION

The causal relationship between health and environment is difficult to establish (Tzoulas et al., 2007). However, in light of all the evidence indicated above, it appears that green infrastructure has great potential to offer support for better health in urban citizens, for the following reasons:

- Access to local green spaces or natural environments can offer potential benefits to all individuals across their life span, starting in childhood.
- Contact with nature offers restoration and mental well-being.
- Access to nature can support physical activity and enhance its benefits.
- Green settings can foster social cohesion.

Linking natural areas and green spaces appears to be important, providing a green infrastructure that offers all urban dwellers good and easy access to attractive, green and hydrologically sustainable landscapes. However, in order to maximise the potential benefits of green infrastructures for health, it is crucial to understand better the relationship between nature and health, and so further collaboration between researchers, policy-makers and practitioners is needed.

NOTES

1. Ecosystem health is a transdisciplinary concept that links the natural, social, and health sciences (Muñoz-Erickson et al., 2007). An ecosystem is considered healthy when it is free from stress and degradation and maintains it functionality over time (Tzoulas et al., 2007).
2. Expressed as a ratio of return, this value is a result of dividing the impact by the investment.

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