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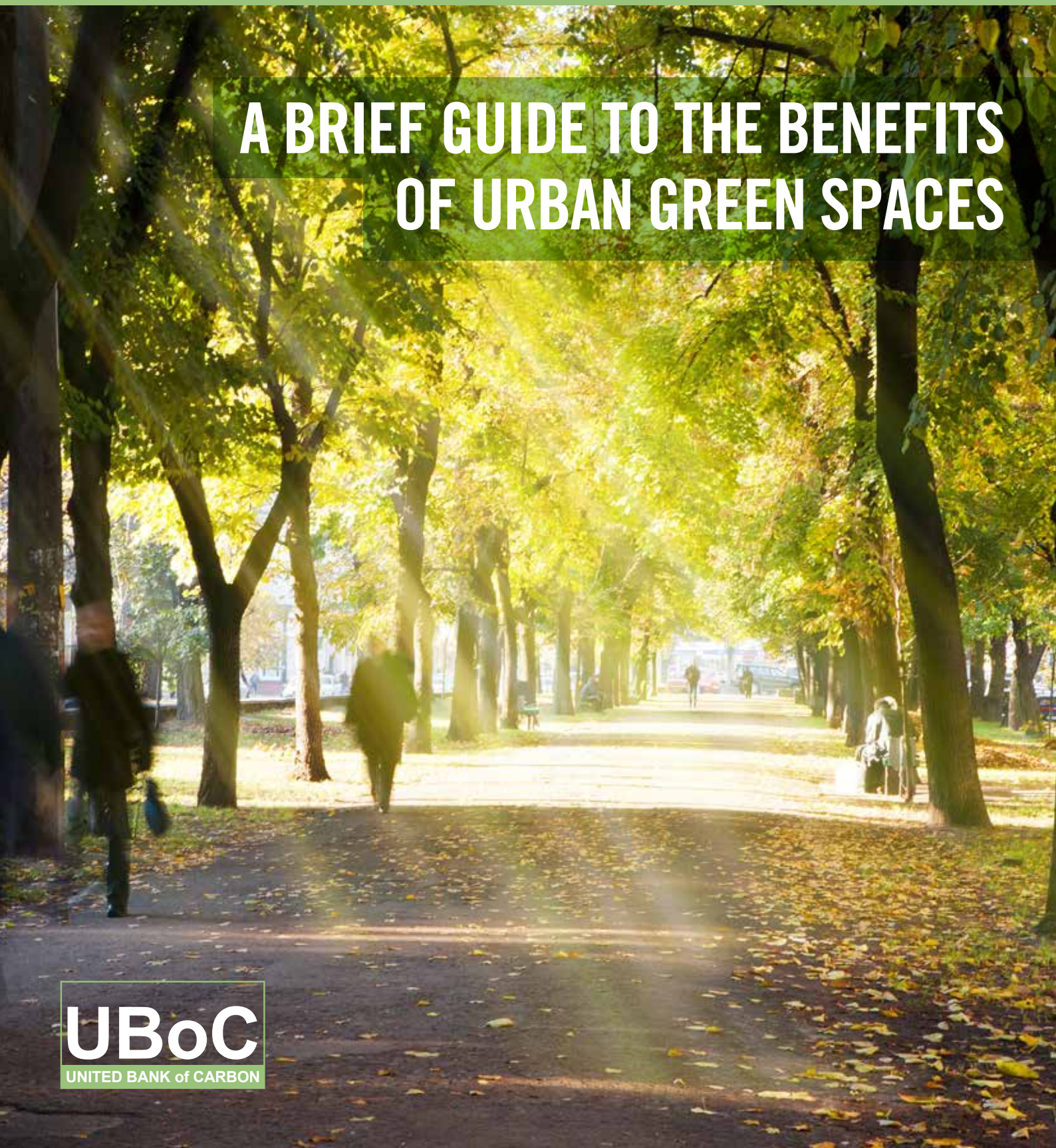
A BRIEF GUIDE TO THE BENEFITS OF URBAN GREEN SPACES



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This document, and further information, is available online at: **leaf.leeds.ac.uk/green-space**

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Introduction

In 2014, around 54% of the world's population were living in towns and cities, and this number is projected to increase to nearly 70% by the middle of the century[1]. Almost two thirds of the urban area that will exist by the year 2030 is yet to be built, so it is vital that we take the opportunity to create and maintain healthy and sustainable urban environments.

Urban green spaces such as domestic gardens, parks and woodlands provide a multitude of benefits to human urban populations, and a vital habitat for wildlife. By improving physical fitness and reducing depression, the presence of green spaces can enhance the health and wellbeing of people living and working in cities. Green spaces also indirectly impact our health by improving air quality and limiting the impact of heatwaves by reducing urban temperatures. In addition, urban vegetation stores carbon, helping to mitigate climate change, and reduces the likelihood of flooding by storing excess rain water.

This document presents a summary of the existing literature around the importance of urban green space; you can find further details online at: **leaf.leeds.ac.uk/green-space**

Health & Wellbeing

Access to green space improves our mental wellbeing[2], reducing the need to treat for anxiety and mental health conditions[3]. Depressive disorders are now the foremost cause of disability in middle- and high-income countries[4] and can be precursors for chronic physical health problems.

Spending time in green spaces has been shown to produce levels and patterns of chemicals in the brain associated with low stress[5] and positive impacts on blood pressure[6]. Positive links have also been demonstrated between how well people perform at attention-demanding tasks and time spent, either beforehand or during, in green space[6-9].

Across Europe, approximately 1 in every 15 deaths is associated with a lack of physical activity[10]. In the UK, only one third of the population achieves the recommended level of exercise[11] and the impact of this on our health is estimated to have a direct economic cost of £1 billion per year[12].

Green areas encourage physical activity by providing a pleasant environment in which to exercise[13]; linear woodland trails encourage walking and cycling, whilst large sport and community parks encourage more formal physical activity[14].

Where green space is available, the socioeconomic position of the local population does not affect how frequently it is used[15], implying that where accessible green space is provided it will be used and may help to reduce socioeconomic health inequalities[16,17].

Urban green spaces provide pleasant areas to relax and socialise, promoting greater levels of social activity and stronger neighbourhood relationships[18]. This can be particularly important in maintaining a high quality of life for elderly people[19-21].

GREEN SPACE SHOULD BE ACCESSIBLE TO AS MANY PEOPLE AS POSSIBLE- PEOPLE ARE MORE LIKELY TO VISIT GREEN SPACE IF THEY DO NOT HAVE TO TRAVEL FAR TO REACH IT, AND THE MOST FREQUENT VISITORS REPORT THE GREATEST BENEFITS TO THEIR MENTAL WELL-BEING[22]

Temperature & Climate Change

In the UK, urban temperatures are typically 1-2°C higher than the surrounding rural areas[23,24]. This urban heat island (UHI) effect occurs because the materials used to build towns and cities absorb more of the sun's energy than the natural surfaces they replaced.

The UHI effect makes people living in urban areas particularly vulnerable to heat waves, for example there was an estimated 42% increase in mortality in London during the heatwave that affected Europe in August 2003[25].

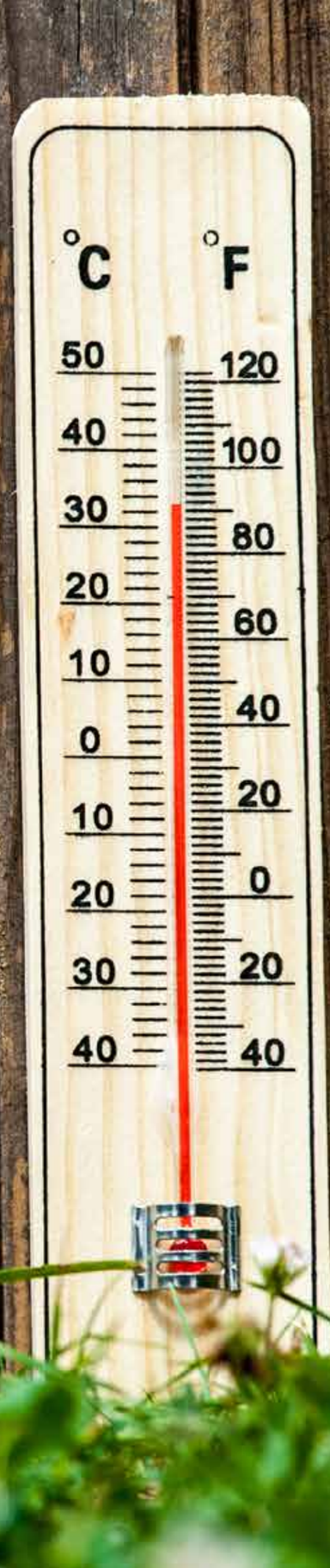
Urban green spaces reduce the UHI effect by providing shade and by cooling the air through the process of evapotranspiration. During evapotranspiration, the sun's energy is used to transfer water from the leaves of plants into the atmosphere[26].

Urban green spaces are on average around 1°C cooler, during both the day and night time, than built-up regions in the same town or city[27], and this cooling effect can extend beyond the green space itself, into the surrounding urban areas[28]. During the summer this may reduce the need for air conditioning, and associated energy use, in nearby buildings[29].

The amount of carbon dioxide in the atmosphere has increased by more than 40% since humans began industrialising, resulting in a gradual warming of the planet over the past century[30]. Trees and plants take carbon dioxide from the atmosphere and around half of it is stored in their branches and roots, with large amounts of carbon also stored by the surrounding soils.

This process is known as carbon sequestration and, as long as the vegetation is preserved, results in an overall reduction of atmospheric carbon dioxide concentrations. However, the decomposition of dead trees and plants returns carbon dioxide to the atmosphere. Understanding the carbon balance of any green space therefore requires an analysis of the relative amounts of sequestration and decomposition, in addition to any maintenance related greenhouse gas emissions (e.g., through mowing, irrigation and the use of fertiliser).

Overall, urban green spaces take in more carbon than they return to the atmosphere[31,32] but their design and maintenance play a crucial role in determining how much carbon they will store. For example, a "forest-like" green space with many trees and native vegetation ground cover maximises carbon sequestration over a "park-like" design with fewer trees and frequently mown grass[33]. As well as creating new green space, looking after existing mature trees is particularly important because they continue to sequester and store large amounts of carbon[34].



LARGE PARKS CONTAINING MANY TREES WITH WIDE CANOPIES, AND MINIMAL PAVING, REDUCE THE URBAN HEAT ISLAND EFFECT THE MOST[27,35-37]

WOODLAND AREAS THAT ARE MANAGED TO MINIMISE TREE MORTALITY, AND DO NOT REQUIRE INTENSIVE IRRIGATION OR FERTILISER USE, ARE THE BIGGEST SINKS OF CARBON[33,38]

Air Quality

Urban air pollution consists of tiny particles, known as particulate matter (PM), and gases such as ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). These pollutants are formed mainly as a result of vehicle and industrial emissions.

Poor air quality is a serious threat to human health, causing problems for the respiratory system and cardiovascular diseases[39,40]. In many UK cities, including Leeds, average levels of NO_2 in the air exceed the legally binding limits set by the European Union[41].

Worldwide it is estimated that approximately 3.7 million deaths per year are caused by exposure to poor ambient air quality[42]. At the local scale, exposure to particulate air pollution is estimated to cause 350 premature deaths annually in Leeds, and 29,000 across the whole UK[43].

Trees and shrubs have multiple impacts on air quality. They can improve air quality by removing both particles and gases from the air; particles stick to the surface of the leaves, and gases are taken up through pores on the leaf surface. Trees with complex, ridged or hairy leaves (such as pines) tend to capture more particles than trees with broader, smoother leaves[44-46].

However, plants also emit gases (volatile organic compounds; VOCs)[47] into the atmosphere that can result in the formation of O_3 and PM under certain conditions[48-51].

In places, trees may exacerbate local pollution by reducing the ventilation of air. The presence of large trees in narrow street canyons can obstruct wind flow and limit the ability of trees to remove pollutants[52,53]. As a result, planting hedges[54] or adding "green walls"[55] in polluted street canyons may be more beneficial.

Current understanding suggests that the presence of urban vegetation results in an overall reduction in air pollution[56,57]. For example, schools surrounded by green space have been shown to experience lower levels of traffic-related pollution in their classrooms[58]. However, more research is required to fully understand the multiple ways in which urban vegetation can affect air quality.

TREES ARE THE MOST EFFECTIVE TYPE OF VEGETATION FOR CAPTURING POLLUTANTS, BUT IN STREET CANYONS SHORTER VEGETATION OR "GREEN WALLS" ARE MORE BENEFICIAL FOR LOCAL AIR QUALITY

URBAN GREEN SPACES STORE AND FILTER WATER, REDUCING THE RISK OF FLOODING AND IMPROVING WATER QUALITY IN STREAMS, LAKES AND RIVERS

Flooding & Water Quality

In urban areas, the impermeable materials used for roads and pavements mean that rain is not absorbed and remains on the surface[59]. During periods of heavy rainfall this water accumulates and when the drainage capacity of the area is exceeded, flooding will occur.

In contrast, vegetated surfaces are able to intercept[60] and store water[61], reducing the volume of rainwater run-off. Benefits from individual trees are maximised if they are planted in tree pits containing permeable soils able to absorb additional water[62], or structural soils that facilitate the growth of tree roots beneath pavements and roads[63].

A further consequence of high levels of surface water run-off is that rainwater washes pollutants away from the surfaces it falls onto, transporting them into water courses[64]. This can be detrimental to water quality in streams, rivers and lakes and lead to high pollutant loading at water treatment facilities[65].

In the UK, climate change is likely to lead to wetter winters[66] which would exacerbate existing flooding and water quality issues. Including green spaces as part new urban developments, as well as integrating them within existing urban regions, could help to reduce these risks[67-69] and offers an alternative to other hard engineering flood control that can be disruptive and expensive to install.

Wildlife & Habitats

Our towns and cities are typically considered to host a less diverse range of plants, animals and birds than nearby rural areas[70]. However, green spaces within an urban area can be home to many of the same species that are more commonly associated with rural settings[71], including those that are rare or threatened[72,73]. For some species, urban areas can provide a more favourable habitat than intensively farmed countryside[72,74], suggesting that towns and cities could make an important contribution to national conservation efforts.

Large parks and woodland regions are able to support the widest range of species[71], but even small areas of vegetation such as roundabouts[75], roadside verges[76] and green roofs[77,78] can support a range of plants, insects and birds.

For many city dwellers, spending time in urban green spaces is their only regular opportunity to be surrounded by nature. Research suggests that people get more enjoyment from spending time in green space when they perceive there to be a high level of biodiversity[79] and that visitors to green spaces would be willing to pay to see an enhancement in the species richness of plants, birds and invertebrates[80].

Urban green spaces can act as "wildlife corridors", linking together larger parks, and providing links to rural areas on the outskirts of towns and cities. This facilitates the movement of animals, birds and insects between individual green spaces and prevents the fragmentation and isolation of wildlife[81,82].

In the UK, urban green spaces form an important habitat for pollinators, such as bees, butterflies and hoverflies[74]. Maintaining a healthy population of pollinators is vitally important as many flowers and crops (including tomatoes, apples and strawberries) depend upon them in order to reproduce. Pollinator populations are declining in the UK[83,84], so the provision of viable habitats in urban regions could form part of a broader strategy to combat this trend.

The more green space the better for urban wildlife, but strategies designed to enhance biodiversity will depend on the location, type of habitat and species present[85]. However, some general themes emerge, such as: less intensive management practices, e.g., infrequent mowing of grass; protecting some parts of the green space from human interference, e.g., routing paths away from the most suitable nesting locations to prevent adverse effects on the reproductive success of birds; and the introduction of locally native wildflowers[85].

INTERCONNECTED GREEN SPACES COMPOSED OF NATIVE TREE AND SHRUB SPECIES, WITH LESS INTENSIVE MANAGEMENT, OFFER THE GREATEST BENEFITS FOR WILDLIFE

Economic Impacts

The presence of green space affects an urban region in the many different ways described in this document; the economic impacts of which are not straightforward to quantify and estimates can vary widely[86]. In terms of direct financial impacts, case studies from around the UK suggest that proximity to green space is positively linked to both commercial and residential property prices, with properties overlooking a park being valued around 5-7% higher than equivalent properties elsewhere[87].

The creation, maintenance and management of green space also generates employment opportunities, and may have indirect benefits to local economies by encouraging further investment and property development in the area[86].

An assessment conducted for the Mersey Forest, a tree planting programme that now forms a 1300 km^2 network of woodlands and green spaces across Cheshire and Merseyside, concluded that every £1 invested in the programme was more than doubled[88]. This was due mostly to tourism expenditure, the creation of forestry related jobs, estimated social cost savings (such as the impact of reduced air pollution), and well-being benefits (such as people's perception of increased biodiversity and improved visual quality of the environment). The assessment concluded that the location of green space is key; to maximise the benefits, green space must be easily accessible to both local people and tourists, or at least viewable from their homes or while travelling.

However, it is not clear whether the assignment of monetary values can fully capture the importance of non-monetary effects, such as increased biodiversity or the cultural significance of woodland. Further research is required to develop approaches that can combine both monetary and non-monetary valuations in order to assess the true value of urban green spaces.

RESIDENTIAL AND COMMERCIAL PROPERTIES OVERLOOKING GREEN SPACES ARE VALUED AROUND 5-7% HIGHER THAN EQUIVALENT PROPERTIES ELSEWHERE

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