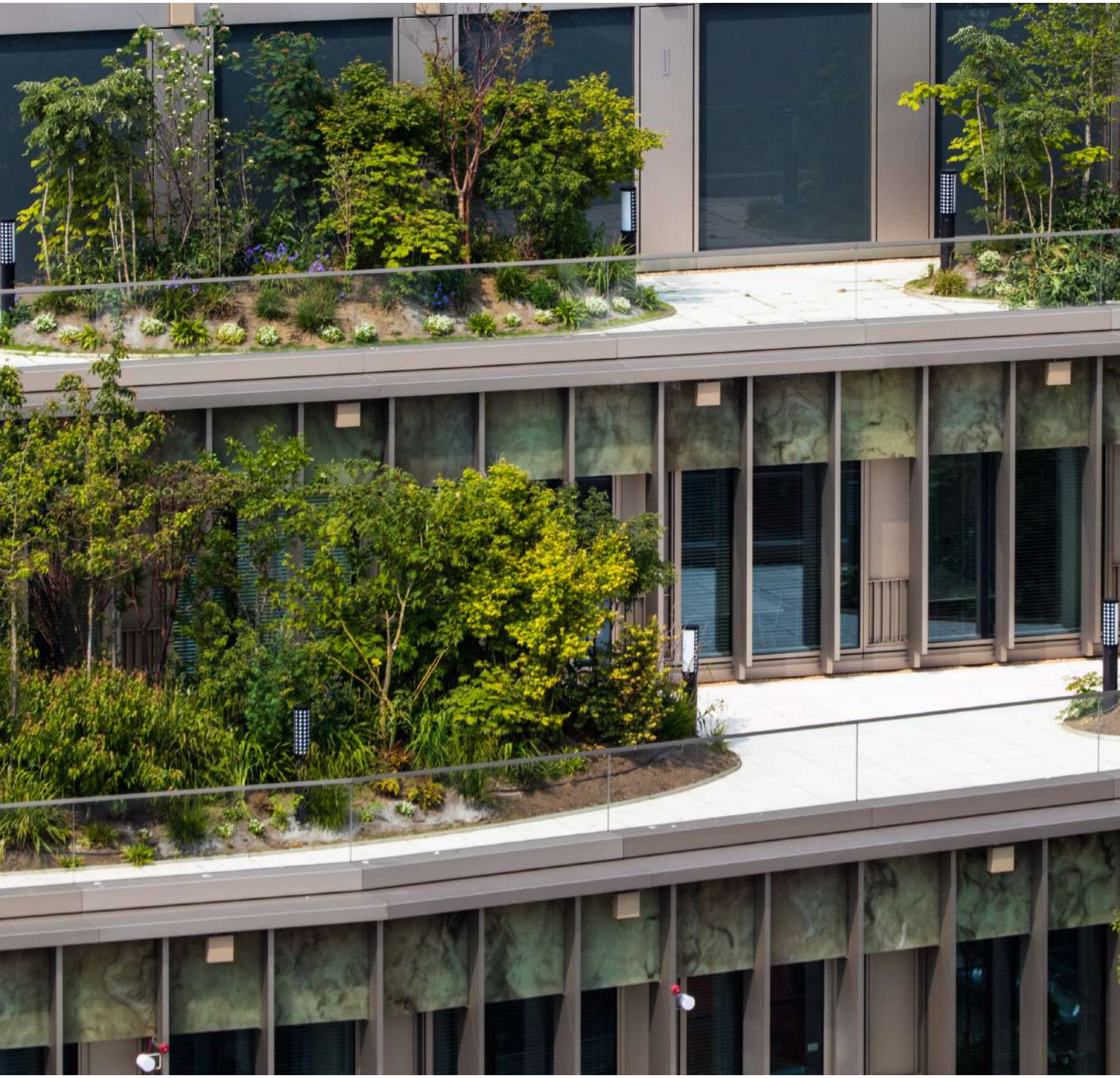
"GREENING OUT THE GREY":
The value of Green Infrastructure for People and Places

August 2021



CROSS RIVER PARTNERSHIP
HEALTHY STREETS EVERYDAY

SUPPORTED BY
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Department for Environment Food & Rural Affairs

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01 Introduction

The climate is changing. London's physical environment is becoming more extreme, with warmer weather, more frequencies of extreme heat, more flooding events, poor air quality and concerns over biodiversity. In fact, the 10 warmest years since records began have all been recorded since 2002 [1],[2], and the year 2020 was responsible for breaking several records in the UK for weather. In addition, extreme rainfall in Britain could become 10 times more likely this century due to climate change [3], whilst the Urban Heat Island effect is set to intensify in cities, such as London, across the UK and the globe [4]. This increasingly unpredictable pattern of weather was highlighted in mid-July 2021 when severe flooding was followed by a heat wave, in the space of one week.

In addition to the climate, people and populations are also changing. Aging populations are leading to an increased strain on health services as elderly people live longer. This is coupled with a physical and mental health crisis, with concerns over childhood and adult obesity; 10,780 hospital admissions are directly attributable to obesity [6], whilst 1 in 6 people report experiencing a common mental health problem (like anxiety and depression) in any given week in England [7]. Moreover, nearly half (43.4%) of adults think that they have had a diagnosable mental health condition at some point in their life [8].

"2020 has been a year of extremes with the wettest February on record, the sunniest spring, a heatwave in the summer and a day in October breaking rainfall records."[5]

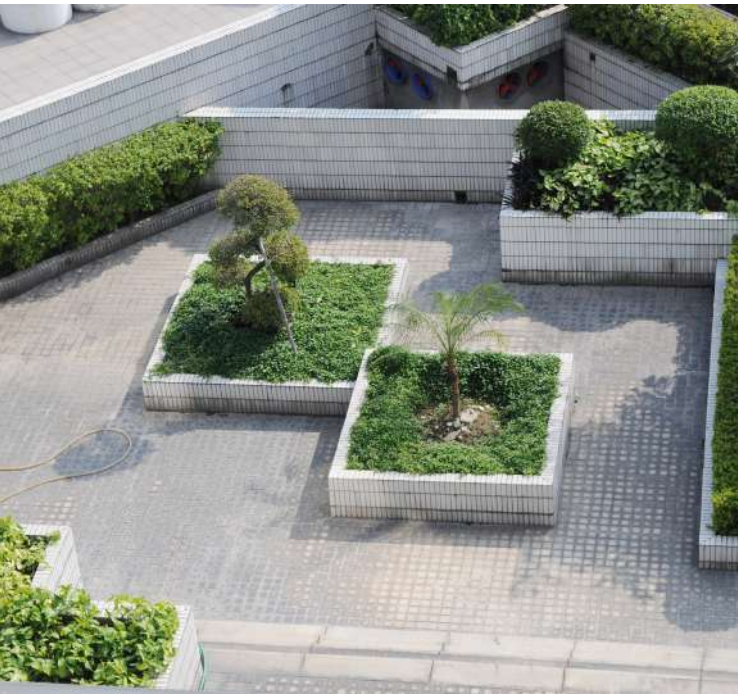
This concoction of issues has also been amplified by new pressures. The coronavirus pandemic has shown how susceptible and vulnerable the world and the UK are to macro impacts; many people's mental and physical health has been impacted, with people spending more time indoors [9].

These challenges create an opportunity, which green infrastructure can contribute to solving. In 2020, the impact of the COVID-19 pandemic saw many people leave London, enabled by home working and the desire for more outdoor space, meaning London's population fell for the first time since 1988 [10],[11].

There is now a renewed appreciation of green spaces across the UK and in London, with a poll on green space attitudes during the Spring 2020 lockdown finds nearly two-thirds (62%) of those living in London think protecting and enhancing green spaces should be a higher priority after the lockdown [12],[13]. During this lockdown, almost half of respondents (44%) reported visiting green spaces more since the start of lockdown in London, which is significantly higher than the national average of just over one third (35%) [14]. This makes investment in green infrastructure and green space critical.

What is Green Infrastructure?

Green infrastructure (GI) is a catch-all term to describe the network of natural and semi-natural features within and between our villages, towns and cities [15]. These features range in scale, from street trees, green roofs and private gardens, through to parks, rivers and woodlands. At the larger scale, wetlands, forests and agricultural land are all captured by the term GI [16].



According to 2019 analysis by Greenspace Information for Greater London CIC, roughly 47% of Greater London is 'green'; 33% of London is natural habitats within open space and an additional 14% is estimated to be vegetated private, domestic garden land [17]. Furthermore, 2% of London is made up of "blue" infrastructure, such as rivers, canals and reservoirs [18].

Yet, green infrastructure can act as a solution to mitigate the climate and social challenges mentioned in the introduction. Greening can contribute to healthier, more pleasant streets, whilst also providing significant environmental, social, economic, and cultural benefits at a relatively low cost. This guidance document aims to build the case for more green infrastructure to be implemented across the capital (and UK more widely) focussing specifically on the benefits and costs of integrating green infrastructure as part of our cities – particularly onto "grey" infrastructure, such as buildings, bridges and pavements [19], [20].

Additionally, the guidance will aim to demonstrate the value of using greening to improve air quality, enable climate adaptation (particularly through heat resilience, air quality and flooding), and act as a tool to improve physical and mental wellbeing through initiatives such as green social prescribing. We therefore hope that this document will help enable and encourage local authorities, planners and engineers involved in designing our cities to integrate greening far more widely as part of the planning process, helping to 'green out the grey' and provide additional benefits to those who live, work and play in our cities.

Healthy Streets Everyday

The Healthy Streets Approach is a global policy framework that "puts people and their health at the centre of decisions about how we design, manage and use public spaces" [21]. It aims to make streets healthy, safe and welcoming for everyone by prioritising people and their needs. Underpinning the Healthy Streets Approach are 10 'Healthy Street Indicators' that are used to create healthy streets.

CRP's Healthy Streets Everyday (HSE) is a cross-sector project to empower boroughs, businesses and communities across London to deliver cycling and pedestrian-priority healthy streets, increase cycling and walking rates and reduce emissions and exposure to toxic air pollution. CRP and the HSE programme are excited to support changes to London's urban realm that promote active travel, greening, environmental health, car-free behaviour and economic resilience.

Greening plays an integral role in the Healthy Streets Approach, and plays a part in almost all of the Healthy Streets indicators. This guidance will focus particularly on the indicators clean air, shade and shelter, safety and relaxation, all of which play vital roles in creating pleasant, healthy streets and improving mental well-being.

02 Improving Air Quality

Air quality is the largest environmental health risk in the UK. Research indicates that over 9,000 Londoners die prematurely each year as a result of air pollution, with short and long-term health impacts identified across all demographics [22],[23]. However, the health impacts of air pollution fall disproportionately on the most vulnerable members of our society, impacting the young, the elderly, the most deprived, and those from black, Asian, and minority ethnic (BAME) groups [24].

Particulate matter (PM10 & PM2.5; hereafter PM) and nitrogen dioxide (NO2) are problem pollutants for London and many cities around the world. Although targets to reduce these pollutants have been set in the UK and air quality levels are improving, London is failing to meet the EU (and subsequently, since Brexit, the UK's) legal limit for NO2, and PM is still considered dangerously high, exceeding the World Health Organization's guideline limit [25],[26]. This poses a significant challenge given the desire for London to have the best air quality of any major world city by 2050 [27].

Pollutant	UK Annual Mean Concentration Legal Limit	UK Hourly Mean Legal Limit	WHO Guideline Annual Mean	WHO Hourly Mean Guideline
NO2	40 µg/m3	No more than 18 exceedances of concentrations above 200 µg/m3	40 µg/m3	200 µg/m3
PM2.5	25 µg/m3		10 µg/m3	25 µg/m3
PM10	40 µg/m3	A 24-hour average of 50 µg/m3 more than 35 times in a single year for PM10	20 µg/m3	50 µg/m3

Standards and guidelines on nitrogen dioxide and particulate matter (Source: Department for Environment, Food & Rural Affairs [28],[29])

Air Quality Benefits of Greening Through Dispersal and Deposition

Plants and trees require carbon dioxide to live and expel oxygen, acting as "the lungs of the earth" and our very own air pollution filtering system for carbon dioxide [30]. However, PM and NO2 are also removed from the environment through plants, trees and other types of green infrastructure by dispersion and deposition [31],[32].

Dispersion: Urban vegetation can greatly reduce the amount of emissions people are exposed to. It does this by changing the speed and distance pollutants travel before they reach people. The further the distance the more the pollution is diluted with cleaner air – this process is known as dispersion. [33]

Deposition: Urban vegetation typically removes a few per cent of emissions by a process called deposition. This refers to when pollution lands on the surface of the leaf and is removed from the air. This process is less important for reducing exposure to air pollutants in the urban environment than dispersion. [34]

The way a street is designed, including the choice of different plants, trees and infrastructure will impact these processes, as well as current air quality challenges of a local area. A street canyon, a street with buildings on both sides, will make up the majority of London's street network and are more suited to certain types of greening, whereas open roads may be more suited to others [35]. The guidance written by the Greater London Authority, in consultation with the Birmingham Institute of Forest Research (University of Birmingham), the Global Centre for Clean Air Research (University of Surrey) and Transport for London (TfL) provides an excellent summary of which green infrastructure may be suited for individual streets to minimise the impacts of air pollution and associated exposure to people.

Completed studies on dispersion show that where vegetation acts as a barrier to a pollution source, e.g., a road link, concentrations immediately downwind of the planted area can be reduced typically by a factor of two, relative to the concentration if the vegetation were not in place [36]. Additionally, the implementation of a planting scheme within an urban area resulted in concentration reductions in the range of 2% to 10% for PM through deposition [37]. Vegetation is not considered a very effective sink for NOx, so produces minimal depositional rates, however when deposition occurs, it is primarily during the daytime and in warmer months [38].

The Cost Savings of Greening as a Response to Poor Air Quality

The economic costs of air pollution are significant to London. In 2017, the estimated cost of air pollution to the NHS and social care in England was £153 million, and this could be as high as £5.3 billion by 2035 [39]. The health impacts from a 2015 report by Kings College London and TfL suggest this could total £3.7 billion annually, based on 2010 concentrations and adjusted to 2014 prices [40]. London also pays the highest total costs of air pollution from roads in the UK and Europe, this includes costs associated with premature death, hospital treatment, lost working days and other health costs caused by particulate matter, ozone, and nitrogen dioxide [41]. According to research by CE Delft and the European Public Health Alliance, air pollution costs London £10.32 billion per year in total, or £1,173 per year per person [42].

Greening measures could therefore provide an opportunity to mitigate some of these costs by helping to reduce the impact of air pollution. CBI Economics analysis, commissioned by the Clean Air Fund, finds that the UK economy could benefit to the tune of £1.6 billion each year if it were to achieve the guidelines set by the WHO for air quality [43]. This would be through increased productivity, fewer premature deaths, fewer illnesses, and 3 million more working days [44].

Given the economic impact of air pollution on London, greening using green walls, roofs or tree planting provides an excellent and cost-effective tool to increase dispersion and deposition from pollutants from the road network, and provide a superior separation from the carriageway for pedestrians than the current status quo. Reducing the exposure that Londoners have from pollution is critical, and greening can be used to solve this.

CASE STUDY: A SCHOOL'S GREEN WALL

Towards the vision of 'Healthy School Streets', the London Borough of Newham's transport team and Earthsense worked together to create a monitoring and behaviour change project for schools in Newham. Nitrogen dioxide levels were monitored outside five schools, with 11 sensors each, in Newham with high traffic and known driver behaviour issues. Pollution levels were compared against trial measures, including building green screens outside schools for a "pollution barrier", moving playgrounds to reduce exposure for children, and timed road closures to create "school streets". These trial measures showed reductions in pollution exposure for children, and this guidance and subsequent interventions on driver behaviour and pollution has been rolled out to all 96 primary schools in the London Borough of Newham to reduce exposure to harmful pollutants [45].

03 Heat Resilience & Cooling

Evidence of global warming of the earth's surface temperatures, derived from many direct and indirect data sources such as thermometers, observations, tree rings and ice cores, shows a 1° Celsius rise since 1900 [46],[47]. A business-as-usual, high emission projection scenario, modelled by the IPCC, could see average surface temperature rises of up to 4.5° Celsius, from 1850-1900 levels [48].

London is now looking to build its heat resilience, as the climate may look more like Marseille or Barcelona's in 2050 [49]. London also suffers from the most significant impacts of the Urban Heat Island effect in the UK, where a metropolitan area is a lot warmer than the rural areas surrounding it [50].

London has seen mean summer temperature increase by c.1.9°C between 1961 and the early 21st Century [51], but despite this, there is limited evidence yet that the Urban Heat Island effect is amplified further by rising temperatures [52]. Nevertheless, heatwaves (like the one experienced in 2018) will become normal by 2040, hot summers will become far more frequent, and days of potential and projected overheating in London are set to increase [53].

Building designs also create challenges for Londoners in implementing and maintaining heat resilience. Many modern buildings have benefitted in cooler months from improvements in insulation, plenty of sunlight and limited ventilation [54]. However, with summer months becoming more extreme for heat, this has become a significant challenge for many who live and work in London. This is coupled with regulatory challenges as part of the planning system; currently regulations are in place for heating buildings, but there are no regulations for the cooling of buildings, or for very hot and busy transport systems [55].

Greening for Heat Resilience and Cooling

Greening for Heat Resilience & Cooling Greening is a cost-effective and easy-to-implement adaptation strategy to extreme heat events. It can reduce the impact of extreme heat events, reduce average temperatures, save lives and provide significant social and economic value for Londoners and its visitors. London's current resilience action plans (see London Resilience Strategy) on reducing the impact of extreme heat events are geared towards introducing cool spots or cooling centres (see glossary), a common practice across cities around the world with warmer climates or those that face more frequent and/or severe extreme heat [56].

Green infrastructure can help to create cool spots throughout a city, such as through green roofs. A green roof is a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly sloped roof [57]. Green roofs can produce cool enclaves, and provide surface cooling through insulation, shading and evapotranspiration mechanisms, with irrigated roofs able to offer greater effects [58]. The impact is greatest at the roof level, with up to 5° Celsius for extensive green roof cover, whilst intensive green roofs can improve ambient temperatures at the pedestrian level by up to 1.7° Celsius due to cool air mixing from the roof top down to the pedestrian level, according to modelling data [59]. Currently, there are an estimated 700 green roofs in London, covering the area of Green Park when combined in size [60].

CASE STUDY: GREEN ROOFS IN FLORIANOPOLIS, BRAZIL

Green roofs in Florianópolis, a southern city in Brazil with a temperate climate, were trialled against ceramic and metallic roofs to assess the impact of heat loss and heat gain during warm and cold periods throughout the year. During warm periods, the green roofs reduced heat gain by 92-97% compared to the ceramic and metallic roofs, respectively [61].

Similarly, vertical green walls can provide cooling elements for buildings, pedestrians, and pavements. Evidence suggests that outdoor temperatures can be reduced by up to 4° Celsius around green walls [62]. Trees are also able to offer shade and shelter and provide additional cooling benefits by "transpiration cooling" [63]. This is where trees release water into the atmosphere from their leaves via transpiration, cooling the surrounding air as water changes state from liquid to a vapor [64].

A map of cool spaces in London, released in July 2021 by the Greater London Authority, shows the direction that the city and Mayor of London is moving towards in demonstrating the importance of cooling and heat resilience; many of these cool spaces in London are comprised of green infrastructure, with large- and small-scale parks and tree cover [65].

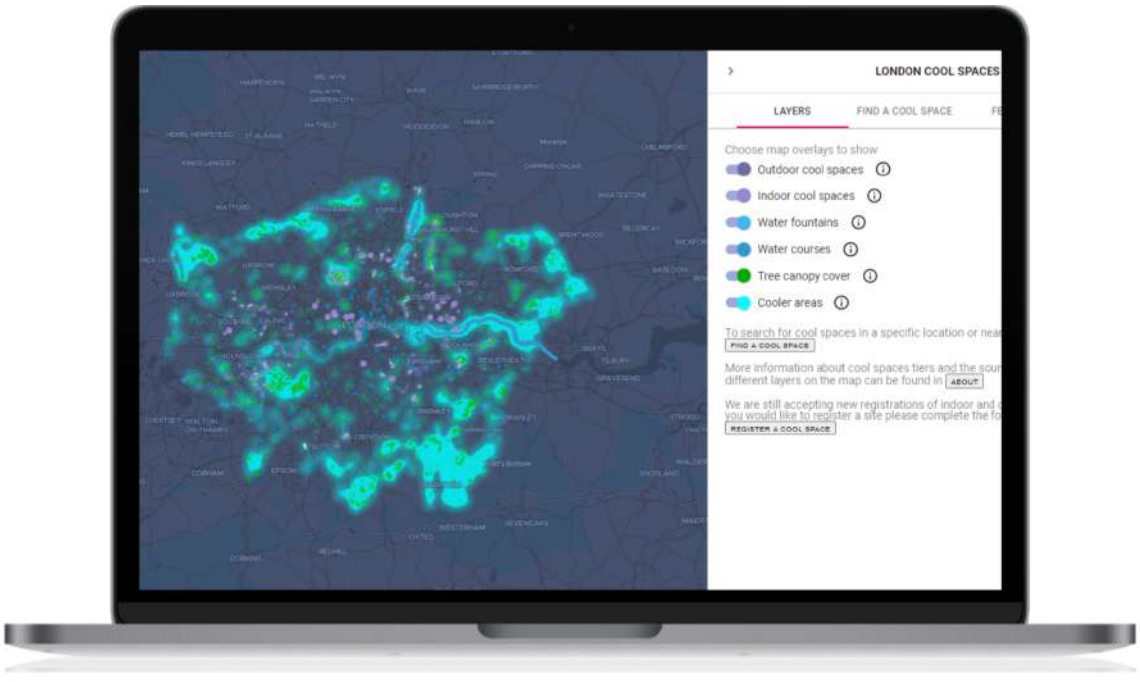


Photo credit: London's Cool Spaces

The Economic Impact of Greening as a Response to Extreme Heat

There could be an estimated 7,000 additional deaths per year by the 2050s as a result of extreme heat events in the UK [66], [67]. These fatalities have high economic costs, estimated in one study as a range from £323 million to £9.9 billion per year by the 2050's [68]. Extreme heat is therefore not just a social problem, but an economic one.

Greening could play a critical and cheap role to combat these costs by creating urban environments that are significantly cooler and shadier, with the average cost of a 5m x 5m living wall in the UK is currently £16,183 [69]. This could go some way to enabling people to feel cooler and more comfortable during extreme heat events. For example, if every London borough implemented 5 green walls of this size in areas of extreme heat, it would cost each borough £80,915, and come to a total of approximately £2.59 million across London.

Not only could this help save the UK economy some of the cost expected to occur from extreme overheating events, but it is also a significantly cheaper solution than the potential billions that extreme heat could cost London's economy.

In addition to monetary savings associated with the impact of extreme heat, greening also creates more pleasant spaces, helping to bring additional value to economic zones of cities. Studies show that greening can encourage people to spend more time in an area and therefore spend more money, aiding the local economy [70],[71]. For example, one study that looked at the impact of greening schemes for different types of business sectors in a district of Central London found that business managers, particularly from retail and leisure sectors, perceived increases in customer footfall and sales in relation to the improvements [72].

As a result, local authorities, landowners and businesses should not only look at greening as a resilience and adaptation strategy for climate change impacts, such as extreme heat, over the next century, but also in terms of its value in creating pleasant environments for residents, tourists and consumers in warm areas of cities.

Photo credit: The Londonist

04 Flooding & Drainage

Climate change is not just impacting London's heat resilience and causing hotter summers. London, and the UK, is set to be wetter and vulnerable to more frequent extreme flooding events [73],[74]. Additionally, warmer and wetter winters are expected to bring greater damage from flooding [75].

London is particularly vulnerable to flooding as fifteen per cent of London is in floodplain, protected by flood defences [76]. As well as people's homes, within this area lies much of the infrastructure we rely upon day to day and to assist us in emergency, including 49 railway stations, 75 underground stations and 10 hospitals [77]. In 2015, half of London's front gardens were paved over, and a 36% increase in paved front gardens was reported since 2005; London also saw the biggest decrease of plant cover in front gardens in the UK, with five times as many front gardens with no plants from 2005 to 2015 [78].

In the Greater London area, in addition to the high proportion of paved areas, infiltration of water into the ground is further hindered by the presence of impermeable London clay, which leads to an increased amount of water running off the surface [79].

Moreover, many areas of London are also susceptible to river (fluvial) flooding; in fact, the two types of flooding often occur simultaneously with fluvial flooding significantly exacerbating pluvial flooding [80]. Projected rising sea and water levels could make this a more problematic challenge for London in the future.

Improving Permeability

London's paved and impermeable surfaces contribute to both increased surface run-off and surface water during extreme flooding events. Sealed surfaces, such as roads and buildings, in urban areas increase the amount and speed of water flowing overland during and after prolonged or heavy rainfall [81]. Urban runoff typically flows into drainage systems for stormwater, which may not be able to handle large volumes of water, potentially leading to flooding in the area [82].

Sustainable drainage systems (SuDS) are a natural approach to managing drainage in and around properties and other developments [83]. There are many different types of green and blue infrastructure that can contribute to SuDS, and cities are increasingly using this method, including vegetated areas, to control stormwater runoff [84]. The use of permeable surfaces can help manage or reduce flooding and other adverse impacts associated with increased rainfall and runoff in urban areas [85]. These allow the water to soak into the ground beneath or provide underground storage [86].

Trees can be an excellent source of flood management for towns and cities. Rainwater interception, where a canopy of leaves, branches and trunks slows down the rain before it hits the ground, and therefore can spread the effect of a rainstorm over a longer time [87]. This allows some of the water (studies suggest up to 30%) to evaporate back into the atmosphere directly from the canopy without ever reaching the ground [88],[89]. Surface water from nearby areas can also flow into the permeable area around the trees, which further increases the amount of water that can soak away and reduces demand on stormwater drains [90].

Rain gardens have been effectively integrated into a number of locations across London, and Designing Rain Gardens: A Practical Guide, by Urban Design London, will help to provide more about how you can design a successful rain garden [91].

Similarly, rain gardens are shallow landscaped depressions that reduce rainfall runoff and can be used to enhance the capacity of the surface water piped drainage network by capturing and storing rainfall, allowing it to soak into the ground or releasing it slowly back into the piped network [92]. Rain gardens are flexible in design and are excellent examples of how a SuDS component can be integrated into a streetscape without negatively impacting on the primary function of our streets and spaces [93].

The Economic Benefits of Greening as a Response to Flooding & Poor Drainage

Flood damage currently costs the UK around £1.3 billion each year; the total economic damages for England from the winter 2015 to 2016 floods were estimated to around £1.6 billion, with 32% of total damages occurring to the business sector [94]. Given that the frequency of damaging flood and storm events is likely to increase from climate change, these costs could be significant. Additionally, London's vulnerability to flood events from the factors mentioned previously, could mean it is more severely impacted than other cities around the UK and the world.

Implementing effective rain gardens, tree planting schemes, or other forms of SuDS can create better conditions for London to mitigate the impacts of climate change as well as providing direct economic benefits.

For example, an economic assessment of motorway SUDs by Robert Bray Associates found that the cost of implementing SUDs was between 20 – 40% lower when compared to conventional drainage methods [95]. Additionally, the construction of a car park for Stroud College found that using SuDs created savings of up to 50%. As a result, the use of GI as a flood prevention and drainage measure needs to be promoted as an opportunity; not only does it improve the aesthetics of the area, as well as provide benefits for pollution, cooling, biodiversity and more, but it can also incur less capital expenditure, particularly if SUDs are incorporated at the beginning of construction, rather than at a later stage [96].

CASE STUDY: HARINGEY'S CRESCENT GARDENS

Haringey's Crescent Gardens were retrofitted to include SuDS to improve the local area's flood management systems and reduce run-off and surface water from local roads [97]. 12 trees were planted, alongside 13 rain gardens, swales and detention basins. The award-winning re-development of the public park reduced the surface water flooding both locally and within the drainage network, provided a space for improving and promoted people's health and wellbeing, and created an environment for improved biodiversity. This shows how SuDS can be integrated at the start of any re-development process for the improvement of the local area.

Photo credit: Susdrain's Crescent Gardens SuDS Project

05 Green Social Prescribing

The UK is facing a mental and physical health crisis. Aging populations are leading to an increased strain on our health services as elderly people live longer. Analysis by Sports Think Tank from 2016 showed that England scores slightly below the global average of "the percentage of the population who are achieving the recommended or sufficient amounts of physical activity per week", at 59% (the average is 63%) [98]. Additionally, in the UK, 10,780 hospital admissions are directly attributable to obesity [99].

Mental health awareness has also increased over the last decade, with more people experiencing mental and emotional distress, and the subject becoming less taboo and more widely discussed. 1 in 6 people report experiencing a common mental health problem (like anxiety and depression) in any given week in England [100]. Moreover, nearly half (43.4%) of adults think that they have had a diagnosable mental health condition at some point in their life [101].

The coronavirus pandemic has placed more strain on people's mental and physical health, with more time spent indoors, many people spending more time alone, and official and unofficial networks of support not being available to people to maintain physical and mental health [102].

It is likely that each one of us will have a mental health challenge at some point in our life, and COVID-19 has demonstrated this vulnerability in many of us.

There is emerging evidence that suggests these mental and physical health challenges are exacerbated in cities. Cities may be with higher rates of most mental health problems compared to rural areas with an almost 40% higher risk of depression, over 20% more anxiety, and double the risk of schizophrenia, in addition to more loneliness, isolation and stress [103]. Additionally, inequality over green spaces and outdoor spaces for physical activity can exacerbate both mental and physical health problems [104].

Reconnecting with Nature and it's Links to Health

Social prescribing, also sometimes known as community referral, is a means of enabling health professionals to refer people to a range of local, non-clinical services [105]. This approaches health and wellbeing in a holistic way and encourages individuals to take greater control of their own health, whilst recognising that health and wellbeing can be determined mostly by a range of social, economic and environmental factors [106].

Green social prescribing focusses on prescribing access to outdoor, green areas to support individuals with their mental and physical health. Outdoor, green spaces have a multitude of positive benefits on mental and physical health. In addition to providing shade, shelter, and less exposure to harmful pollutants, green spaces can reduce depression, anxiety and mood disorders, reduce stress, improve sleep and increase happiness [107],[108].

Green social prescribing programmes, such as ecotherapy, run in the UK have helped many people to combat their experiences of mental and emotional distress, and can incorporate other forms of talking therapy such as Cognitive Behavioural Therapy [109]. These have a profound impact on mental health and wellbeing for individuals.

For example, during Mental Health Awareness Week 2021, a survey by the Mental Health Foundation found that seven in ten UK adults say that being close to nature improves their mood, whilst 44% of adults found that being around nature helped them feel less worried and anxious [110],[111]. The Mental Health Foundation chose nature as their core theme for 2021, which may show how the coronavirus pandemic has meant much of the UK population has been reconnecting with nature.

In 2009/10, the wider economic costs of mental illness in England were estimated at £105.2 billion each year, which includes direct costs of services, loss of productivity at work and reduced quality of life [112], [113]. More recent estimates by the OECD have been at £94 billion per year [114].

Green social prescribing could help to reduce these costs by relieving pressure on health and social care systems. One study by Jules Pretty and Jo Barton, found that the use of nature-based and mind-body interventions (such as woodland therapy, therapeutic horticulture, ecotherapy and green care) provided net present economic benefits per person of £830 – £31,520 (after 1 year) and £6450 –£11,980 (after 10 years) due to reduced public service use [115].

Additionally, the study found that green social prescribing also resulted in rises in life satisfaction/happiness, highlighting the role it can play in helping to reduce the costs on health systems, while also increasing the well-being of participants. Personal accounts of how green spaces and outdoor activities have supported individuals during COVID-19 shows the potential of green social prescribing by health professionals.

Evidence also suggests there is a positive association between green space and physical activity levels [116]. Green social prescribing can lead to greater physical activity, whilst people living near good quality green spaces enjoy better health and live longer [117]. Similarly, research shows that green social prescribing can offer benefits to those receiving cancer treatments and can reduce the likelihood of breast and bowel cancer reoccurring [118].

There is also evidence that exercising outdoors in natural and green spaces is more beneficial to health and wellbeing than indoor exercise [119]. Even small green spaces are critical for reducing rates of some chronic diseases; trees improve air quality and asthma rates in children are found to be lower when there is more tree cover [120].

This is critical given the overall cost to the economy of physical inactivity in England is estimated to be £8.2 billion per year [121]. As a result, the value of encouraging people to be active is huge, simply "reducing the sedentary population by one percent could reduce both morbidity and mortality rates at £1.44 billion a year" [122]. Additionally, £2.1 billion per year could be saved in health costs if everyone in England had good access to greenspace, due to increased physical activity in those spaces [123].

Assessing Green Space & (In)Equality

A major challenge for London will be providing access to green space and to reduce green inequalities and climate gentrification. Green spaces are at a premium in London, and this premium is financial. In England and Wales, houses and flats within 100 metres of public greenspace are an average of £2,500 more expensive than they would be if they were more than 500 metres away – an average premium of 1.1% in 2016, suggesting that the public places a value on being near to greenspace [124]. Fewer children in London (62 per cent) regularly visit a park or green space than in any other part of England (78 per cent in the North East), and this is especially so for BAME children and those from lower income households [125],[126].

Ensuring London has green spaces for green prescribing is critical for the health of the population and the economic costs that can arise from a lack of green spend. The evidence shows that even small green spaces can make a significant difference to people's health (see case study), including tree cover along streets. This may not be green space that people "visit" but has a positive impact on the health of children and adults in London. Being creative with spaces to create small green spaces across London should be encouraged, particularly in areas where there is an inequality in green space access.

Assessing Green Space & (In)Equality

The announcement in June 2021 by the Mayor of London, Sadiq Khan, has of a further £6 million of fresh investment in improving green spaces across London, particularly for those in the most disadvantaged areas of the capital, is an excellent source of funding to close to green spaces inequality gap [127].

A map showing the areas where there is limited green space, released by Possible, may help to pinpoint locations of green space inequalities (see map here).

CASE STUDY: EVEN SMALL URBAN GREEN SPACES CAN IMPROVE MENTAL HEALTH

A study by University of Pennsylvania academics investigated whether self-assessed mental health outcomes would improve after the implementation of a small urban park. Three groups were studied with 442 adults participating in the study from the community.

The three groups were split into:

- The greening intervention group involved removing trash, grading the land, planting new grass and a small number of trees, installing a low wooden perimeter fence, and performing regular monthly maintenance.
- The trash clean-up intervention group involved removal of trash, limited grass mowing where possible, and regular monthly maintenance.
- A control group was used that received no intervention.

The findings showed improve mental health outcomes by the greening intervention group with those who lived near the "greened" lots reported 40% reduction in feeling depressed and a 50% reduction in feeling worthless [128],[129].

CASE STUDY: HOW ECOTHERAPY SAVED DEBBIE'S LIFE

Debbie experienced depression and panic attacks as a result of workplace bullying and redundancy. After initially being referred to a GP that misdiagnosed acid reflux, an enlightened and forward-thinking GP at the Bromley-by-Bow Centre in east London diagnosed depression and panic attacks.

After discovering that Cognitive Behavioural Therapy wasn't for her, her GP recommended "ecotherapy" through the PoLLeN project. Debbie has learnt new skills and gained qualifications in Horticulture, allowed her to pursue a new career, and enabled her to meet new people and make new friends [130].

""I'm a complete convert to the benefits of ecotherapy."

"It's changed my life and I can't believe how much my mental health has improved."

"Ecotherapy at PoLLeN saved my life and changed my life."

06 Recommendations

The document has highlighted that greening can help to mitigate and reduce the impact of several modern-day challenges experienced in cities. However, it has also highlighted the lack of greening initiatives in London and other cities, resulting in limited evidence to support quantifying the economic, social and environmental impacts and lacking the information needed to build a strong case for greening initiatives. Therefore, we have provided a list of recommendations to enhance and improve the use of green infrastructure as a climate mitigation strategy, as well as steps required to help identify and quantify the wider impacts that green spaces have on the population of cities, such as London.

1

More Evidence of Scientific Impacts

There is significantly more evidence that can be drawn to realise the benefits of green infrastructure. London now has an estimated 700 green roofs across the city and should be using these to monitor their impact and benefits for indoor and external temperature, local air quality and implications on flooding. Comparing these outputs with the local area will help to quantify the impact and provide real-world evidence, helping to build the business case for more green infrastructure. This is critical for it to be more widely adopted.

2

More Evidence of Financial Impacts

Although this may be harder to quantify, additional research and analysis should take place on the potential financial and monetary impacts of greening on an area. Once more, this can help to build a business case, but it also helps to quantify greening as a valuable and tangible asset to the community rather than a soft or aesthetic measure. Resources such as Mersey Forest's GI Valuation Toolkit is an excellent example of projecting the value of a greening project, although more green-grey infrastructure (such as green roofs and walls) should be incorporated to understand their value.

3

A more Collaborative and Joined-up Approach to Green Infrastructure

This guidance document has highlighted the many facets of our lives that infrastructure can impact, including across mental and physical health, the economy, planning, architecture, social care, our environment and more. Local authorities should be integrating greening across the board, rather than relying on departmental silos given the impact that green infrastructure can have on planning, the economy and health. Similarly, joined-up approaches with neighbouring boroughs to create connected green networks and corridors needs to be facilitated. Additionally, collaboration across sectors will help to realise the potential of green space. For example, collaboration in the health sector, such as at the Clinical Commissioning Group level, could help to recognise the potential of green social prescribing for mental and physical health benefits.

4

Implementing Cooling Regulations

A) Implement building design regulations on cooling, with a strong emphasis on using green infrastructure to alter the internal temperature of buildings.

The UK has regulations on building design for insulation, however there is limited guidance on cooling. As global temperatures rise and London's extreme weather events become more frequent, buildings are at risk of becoming dangerous to live and work in (as already seen in summer during hot spells and heat waves). As a result, consideration, care and legislation needs to shift towards keeping the city and its' buildings cool in summer. As research has demonstrated the cooling impacts of green infrastructure, architects, planners and building designers should be encouraged to use green infrastructure as a lever to reduce the internal temperatures of buildings.

B) Implement and communicate the value of 'cool spots' at the local and city levels.

This has been addressed by the Mayor of London and the Greater London Authority and is a bedded in concept in many countries across the world, with a new cool spaces map and a component of the London resilience strategy [131]. London has a significant coverage of green spaces and parks, and resources should be directed to communicating the value of a 'cool spot' and how it can help Londoners, particularly those who are vulnerable, avoid the heat and remain cool in extreme heat. Communication is critical for this recommendation. Applications such as Barcelona's "Cool Walks" should be implemented to help Londoners avoid dangerous heat levels, and the cool spaces map should reflect small scale green infrastructure such as green walls, parklets, green roofs, that can reduce local air temperatures and provide shade and shelter.

5

Use Green Infrastructure to Offset, Disperse and Deposit Transport Emissions and Reduce Exposure

A) Consider green infrastructure as a pollution barrier or separation from the road carriageway for pedestrians and cyclists and integrate green infrastructure along the UK, London and Sustrans network of cycleways.

A physical barrier of green infrastructure could have profound impacts on the health of cyclists and pedestrians. Segregated cycleways have become commonplace in London due to the impacts on the safety of cyclists, however using green infrastructure, such as trees, bushes, green walls or shrubs would have additional health and social benefits. Green infrastructure has the potential to reduce cyclists and pedestrian's exposure to harmful pollutants and could make conditions much more pleasant for cycling in London, and other UK and global cities.

B) Increase tree line cover and greening along streets in cities with significant numbers of pedestrians, such as London.

Benefits associated with mental health, air quality, and cooling are noted for pedestrians with access to more green space, whilst economic zones can use green infrastructure to draw people to the area due to the aesthetic impact. For example, parklets located outside of hospitality businesses have been shown to improve sales [132]. Therefore, different types of greening, including parklets, should be seen as an investment to draw more people to an area, and as a result plazas, outdoor dining, and areas of economic activity should be "greened".

Remember that accessibility in design is critical so that all members of the public can use the space, so be careful over kerb heights, level surfaces and tree roots for disabled people. Why not read Transport for All's "Equal Pavement Pledge" and sign up to make streets accessible and safe?

6

Integrate Green Infrastructure into New Developments as a Flood Defence and Mitigation Strategy

Green infrastructure can slow down and mitigate the impacts of some flooding events. Integrating and embedding the importance of rain gardens, increased tree cover and green roofs to reduce flooding impacts into design practice should be adopted. This is particularly pertinent for London's networks of designers, architects and planners due to the prevalence of impermeable surfaces across London. New tools and guidance, such as the Urban Greening Factor by the Greater London Authority, could be particularly useful to realise this potential.

7

Create an Annual Survey on Mental Health and Green Spaces

The Mental Health Foundation's survey data and analysis on the link between mental health and wellbeing and green spaces / nature should be repeated annually. This will help to understand how our relationship and interactions with nature and green space changes over time and the implications on mental wellbeing. This survey can help to build the evidence for the importance of green space for mental wellbeing, and even in the future look at how it can be used to treat mental health conditions.

8

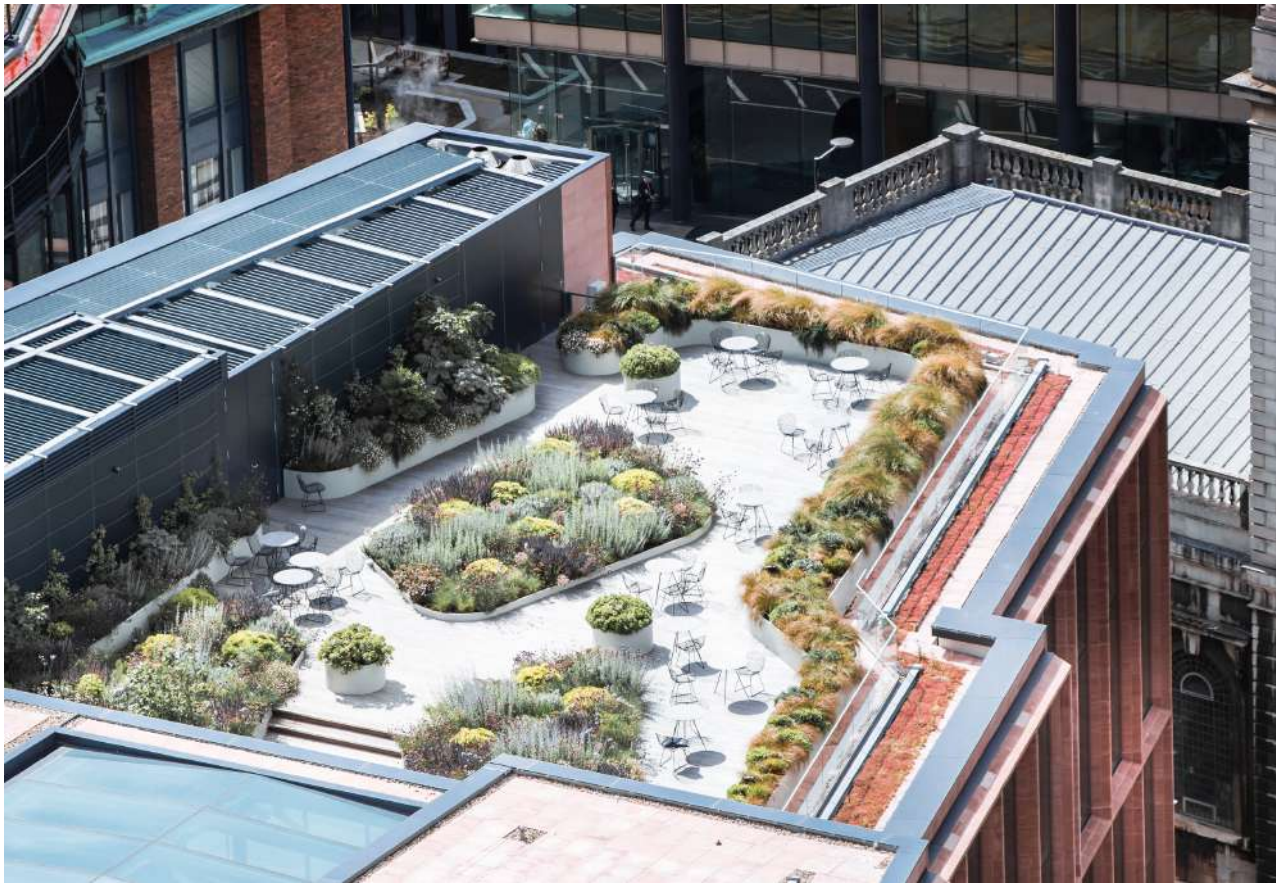
Embrace the Wild!

Rewilding green space can have an impact on biodiversity, flooding, and air quality, and therefore should be cherished and embraced. Unkept green space may not be as aesthetically appealing for users of parks and urban green spaces, but its value should not be underestimated. Educational plaques and stands can help users to understand why spaces are being managed this way, and help to shift attitudes away from the norm of tidy, kept gardens towards that of wild, biodiverse green spaces. As a result, sections of parks could be left to rewild (e.g. through Hackney's development of urban meadows in four parks) providing benefits for biodiversity, flooding and air quality. This guide by the Greater London Authority and the London Wildlife Trust provides practical advice on greening and wilding in the public realm.

9

Set Specific, Local Targets

Targets for your borough or city's green space will enable you to focus your greening initiatives and efforts, and targets should particularly focus on areas of poor access to green space and disadvantaged areas. Each area is different, but having aims and objectives can help build greening into your wider corporate strategy and encourage different departments to think about greening, working in a more collaborative way.



07 Conclusion

This guidance document has explored some of the environmental, social, cultural, economic, and financial challenges facing our cities and populations and how green infrastructure can act as a measure to solve these. Green infrastructure is a cheap and effective way of mitigating against the changing climate, helping to combat increased flooding, hotter weather, more extreme weather, and poor air quality. It also has the potential to support social challenges, by supporting people with experiences of mental health problems or emotional distress, through green social prescribing. This cheap and effective solution could save significant costs to the economy and NHS, helping to save lives and creating more pleasant, healthy streets. Additionally, increased adoption of Green infrastructure to address these challenges will support London with the aim to be the greenest city in the world, and in being the greenest, it may be the coolest, least-polluted, best-drained and happiest.

08 Glossary & Abbreviations

BAME: Black, Asian and minority ethnic

CO2: Carbon dioxide

Cool spots: or cooling centres or spaces, are designated areas of cities, outdoor and indoors, such as parks, municipal air-conditioned buildings, free drinking water spots, fountains, water games and much more, that can provide cooler conditions for a city's residents and visitors [133]

Deposition: Urban vegetation typically removes a few per cent of emissions by a process called deposition. This refers to when pollution lands on the surface of the leaf and is removed from the air. This process is less important for reducing exposure to air pollutants in the urban environment than dispersion [134]

Dispersion: Urban vegetation can greatly reduce the amount of emissions people are exposed to. It does this by changing the speed and distance pollutants travel before they reach people. The further the distance the more the pollution is diluted with cleaner air – this process is known as dispersion [135]

Ecotherapy: Ecotherapy can take place in both rural and urban settings, including parks, gardens, farms and woodlands. It involves varying amounts of physical activity, depending on the type of programme. It can include activities that focus on, working in nature, such as a conservation project, gardening or farming, or experiencing nature, such as enjoying the views on a walk or cycling through woodland [136]

EU: European Union

EV: Electric vehicle

Floodplain: A floodplain (or floodplain) is a generally flat area of land next to a river or stream. It stretches from the banks of the river to the outer edges of the valley [137]

Fluvial flooding: flooding when water levels in rivers rise so that the rivers overtop their ban [138]

Green infrastructure (GI): a catch-all term to describe the network of natural and semi-natural features within and between our villages, towns and cities [139]

NO2: Nitrogen dioxide

NOx: Nitrogen oxides

Pluvial flooding: floods which occur following short intense downpours that cannot be quickly enough evacuated by the drainage system or infiltrated to the ground [140]

PM: Particulate Matter

Rain garden: shallow landscaped depressions that reduce rainfall runoff and can be used to enhance the capacity of the surface water piped drainage network by capturing and storing rainfall, allowing it to soak into the ground or releasing it slowly back into the piped network [141]

Resilience: Resilience is the capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop [142]

Social prescribing: Social prescribing, also sometimes known as community referral, is a means of enabling health professionals to refer people to a range of local, non-clinical services. The referrals generally, but not exclusively, come from professionals working in primary care settings, for example, GPs or practice nurses [143]

SUDS: Sustainable drainage systems (SuDS) are a natural approach to managing drainage in and around properties and other developments [144]

TfL: Transport for London

Transpiration cooling: This is where trees release water into the atmosphere from their leaves via transpiration, cooling the surrounding air as water changes state from liquid to a vapor [145]

Urban Heat Island: An urban heat island, or UHI, is a metropolitan area that's a lot warmer than the rural areas surrounding it. Heat is created by energy from all the people, cars, buses, and trains in big cities like New York, Paris, and London. Urban heat islands are created in areas like these: places that have lots of activity and lots of people [146]

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