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Green infrastructure assessment of Cheshire East

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For Cheshire East Council

Contents

Background

Cheshire East wishes to carry out a green infrastructure audit to gather baseline information that will support a full green infrastructure plan for the borough.

The audit will report on the green infrastructure typology and an initial valuation of some the services provided by the borough's green infrastructure in order to:

- Identify the range and geographic distribution of green infrastructure
- Identify the stock of green infrastructure, the borough's 'natural capital', to enable it to be included in future policy and strategy development
- Inform local delivery of the government's 25 Year Plan for the Environment (25 YEP), enabling bids or other involvement in programmes, such as Northern Forest, that will be funded as part of the 25 YEP delivery programme
- Identify potential "purchasers" of benefits/services that are provided, or other funding opportunities.

There is a wealth of evidence to show how making improvements to green infrastructure can be good for communities and business as well as the environment. The audit will reference this evidence base to enable sound and robust policy to be developed in future.

The audit has four parts

1. The assessment of green infrastructure in Cheshire East – area and distribution
2. Identifying areas in Cheshire East where green infrastructure management, enhancement and/or creation may be beneficial in tackling issues related to
    a. Economic growth
    b. Health
    c. Flood risk
    d. Encouraging active travel
    e. Improving air quality
    f. Improving ecological networks
3. Putting a value on green infrastructure
4. Resourcing green infrastructure investments – traditional and innovative funds

Summary

Green infrastructure can be defined as;

"An interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations"[1]

Overall 93% of Cheshire East is green infrastructure. Whilst there are many types of green infrastructure, including parks, private gardens, woodland and water bodies, agriculture dominates the borough. 68% of Cheshire East is agricultural land. Any strategic green infrastructure planning for the borough will have to have a strong focus on the role that agricultural land plays in delivering services and benefits.

Green infrastructure planning in Cheshire East takes place within the context of a vibrant economy, with relatively low levels of poor heath, although with pockets of significant health deprivation, a changing climate and rapidly evolving land use policy.

The quality of green infrastructure is critical for the future prosperity of the borough, the health of communities and the increase of biodiversity. Green infrastructure is central to a good quality of place and quality of life in the borough.

Cheshire East's Gross Value Added (GVA) is estimated at £12.2bn (2016)[2]. It is seen as a successful borough, with a focus on future growth of high tech industry. New housing, HS2 and other new transport infrastructure will change the land use patterns of Cheshire East. Projections suggest that the population will grow by 2041 to 399,000[3].

Green infrastructure planning looks to work within this context to help to tackle strategic priorities for the borough. In this audit, the focus was on how green infrastructure can help to support:

The economy – With plans for 36,000 new houses, HS2 and other transport infrastructure, 56,000 more people living in the borough and more people travelling into the borough to work, the challenge will be to maintain and enhance quality of place to retain Cheshire East's competitive advantage. The green infrastructure valuation toolkit (GI-Val) suggests that green infrastructure currently provides circa £1bn of GVA and adds around £550m to property value in

[1] Benedict and McMahon, Green Infrastructure 2002, p12
[2] Cheshire East Economic Profile, Cheshire East Council
[3] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/localauthoritiesinenglandtable2

Cheshire East[4]. Without mitigation, current plans may lead to a loss of green infrastructure. Around 8,700ha of land are in development plans. This is mainly focussed on agricultural land.

Health and wellbeing – There are pockets of deprivation and poor health in Cheshire East. There is an increasing body of evidence showing the health protection benefits of green infrastructure. Most recently an extensive study showed 4% lower odds of major depressive disorder with increasing levels of green infrastructure. Green infrastructure in Cheshire East already provides health benefits to communities, estimated at £171m.

Active travel – walking and cycling – can help to deliver benefits for air quality and health as well as helping to reduce transport carbon emissions.

Reduced flood risk – The use of features in the natural environment to slow the flow of water and reduce flood risk is gaining increasing policy and implementation interest, with a developing evidence base. In Cheshire East, using this evidence and the GI-Val tool we can calculate that green spaces, for example, divert an estimated 6,300 billion litres/year of water from the sewerage system. The value of green infrastructure for water management is estimated to be £640m.

Improved air quality – Air quality in Cheshire East is generally good. However, thirteen Air Quality Management Areas have been designated. Green infrastructure can help to improve local air quality if well planned and managed. Increasing opportunities for more active travel, walking and cycling, can also reduce air pollution. It is estimated that 52 tonnes of PM_{10} per year is removed from the atmosphere by green infrastructure in Cheshire East, valued at the equivalent of £8.3m.

Improved ecological networks – Previous work for Cheshire East has used a range of datasets to create an Ecological Framework. In general, biodiversity in the borough is declining, despite targeted efforts to safeguard and enhance priority habitats and species. The Lawton Report[5] set out a clear justification for ecological frameworks, with a simple strapline highlighting the need for "more, bigger, better managed and connected" habitats. The economic value of biodiversity in its own right[6] is estimated at £34m.

In spatial terms, 62% of the non-agriculture green infrastructure in the borough is north of the River Dane. Tree and accessible green space cover are lower south of the Dane, whilst flood risk

[4] GI-Val, a green infrastructure valuation toolkit, has been used to provide economic values for some of the benefits of Cheshire East's green infrastructure.
[5] http://archive.defra.gov.uk/environment/biodiversity/index.htm
[6] Based on an assessment of willingness to pay. Willingness to pay models are one way to determine value. However, this data is generic and not specific to sites in Cheshire East. Nor is it meant to lead to any move to "charge" for access to green spaces.

and health issues are greater. 17% of the non-agricultural green infrastructure in is the top 20% most affluent wards, with 6% in the least affluent[7].

Whilst agriculture dominates the landscape and is a critical part of the local economy and landscape, its future management is most likely to be influenced by national land use policy.

Development and infrastructure works over the next decade provide a challenge and perhaps the greatest opportunity for green infrastructure planning and management to secure no net loss of green infrastructure functionality. The 25 Year Plan for the Environment calls for planning and development to become an engine for delivering overall net gain for the environment[8].

This audit has found, using the GI-Val toolkit, the following indicative values for Cheshire East's green infrastructure;

Gross Value Added[9] – £924m

Property Value – £594m

Wider economic benefit – £257m

A Green Infrastructure Plan adopted by the authority and embedded into future plans and strategies can help to ensure that the current range of benefits is maintained and their value secured.

There should be an aspiration to increase green infrastructure in the areas of the borough where there is greatest need for the benefits that can be delivered and where these can be delivered cost effectively.

[7] This is only part of the story about the relationship between green infrastructure and deprivation, however. More work is needed to explore it exhaustively.
[8] https://www.gov.uk/government/publications/25-year-environment-plan
[9] See page 23 for the definition of these different types of economic value.

Cheshire East's Green Infrastucture Assets

Healthy economies rely on excellent quality of place

A thriving economy

£12.2bn

Cheshire East's Gross Value Added (GVA)

399,000

New housing, HS2 and other new transport infrastructure will change the land use patterns of Cheshire East. Projections suggest that the population will grow by 2041 to 399,000.

36,000 new houses

8,700ha

of land are in development plans.

THE MERSEY FOREST
more from trees

GI Value

Reduced flood risk

Water management is estimated to be valued at: **£640m**

Health benefits

Most recently an extensive study showed 4% lower odds of major depressive disorder with increasing levels of green infrastructure. Green infrastructure in Cheshire East already provides health benefits to communities, estimated at

£171m

The economic value of biodiversity in its own right is estimated at **£34m**

Green infrastucture delivers

£257m	£594m	£924m
Wider economic benefit	Property Value	Gross Value Added

Context and trends

Planning for green infrastructure takes place in the dynamic context of policy, economics, societal trends and technological change.

Understanding this context can help to increase the opportunities to show how green infrastructure can help to achieve a range of positive outcomes for communities in Cheshire East.

This audit does not look at this context in great detail. Some important considerations for the Green Infrastructure Plan will be:

Economy

Cheshire East's Gross Value Added (GVA) is estimated at £12.2bn (2016)[10]. Manufacturing and professional, technical and scientific services have a greater share of employment in Cheshire East than the UK average. The economy has grown at a faster rate than the average for the north west of England and the UK average. Employment has also increased at a faster rate than the North West and UK. This suggests a strong local economy at present.

However, there are areas of deprivation, with 18 Lower Super Output Areas among the 20% most deprived wards in England. Most (13) of these areas are in Crewe.

The Cheshire and Warrington Local Enterprise Partnership Strategic Economic Plan highlights focal points for economic growth in the borough[11]:

- Science Corridor – across the north of the borough
- Constellation Partnership – focussed on the main existing and planned transport corridors across the borough which includes the major project at:
    - Crewe Gateway

Development

The Cheshire East Local Planning Strategy identifies 990ha of land allocation for housing, with approvals already in place for over 20,000[12] new homes in the borough (36,000 new homes planned). Whilst some of this land will be allocated for public open space and gardens, a large proportion will be built on agricultural land.

[10] Cheshire East Economic Profile, Cheshire East Council
[11] www.871candwep.co.uk/content/uploads/2017/07/Revised-SEP.pdf
[12] Approvals for over 20,000 of the planned 36,000 new homes

In addition, a number of major road schemes are planned, including the link roads and bypasses at Alderley Edge, Poynton, Congleton and Crewe.

The route for HS2 passes through the west of the borough, with a major infrastructure investment at the northern gateway of Crewe.

Natural England's National Character Area statement[13] also highlights increased development pressure from housing and transport infrastructure as issues that will impact on the landscape quality of the area.

Population

The number of people living in Cheshire East has increased by nearly 15% since 1981, and now stands at 377,000. Projections suggest that the population will grow by 2041 to 399,000[14].

Health and wellbeing

The Joint Strategic Needs Assessment[15] for Cheshire East provides a detailed picture of health and wellbeing in Cheshire East. Whilst, in general, levels of health and wellbeing are above the national average for most measures, there are pockets of health deprivation around urban areas[16].

Life expectancy varies considerably across the borough, with life expectancy of 72 years in Central Crewe compared to 84 years in Wilmslow East.

The ageing population, with the population aged 65+ projected to grow by 68% by 2041 in Cheshire East, will shape public heath provision, the delivery of the wider determinants of health as well as health improvement and protection plans.

Climate change

Projected climate change will lead to increased total rainfall, but also more episodes of summer drought and increased incidence of storms. The effects of hotter summers will be felt most in urban areas where the urban heat island effect can exacerbate the effects of heatwaves. These changes to climate will impact on land use management as well as on development, with the

[13] http://publications.naturalengland.org.uk/publication/6076647514046464?category=587130

[14] www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/localauthoritiesinenglandtable2

[15] https://www.cheshireeast.gov.uk/council_and_democracy/council_information/jsna/jsna.aspx#overview

[16] https://www.cheshireeast.gov.uk/council_and_democracy/council_information/jsna/jsna.aspx#overview clearly highlights the variation in need across the borough with concentrated levels of need around Crewe and Macclesfield.

need to protect property from flood risk and protect people from risks associated with heatwaves, particularly those most at greatest risk[17].

Land management

Changes to the way in which land owners are supported to manage land for food and the wide range of other benefits that they produce will change over the next few years as the UK leaves the European Union. It is likely future support will have a focus on supporting land management that will improve water quality, reduce flood risk, lock up carbon, improve access and improve habitats for wildlife as well as continue to produce food. For example, there may be more support to reverse the decline in the area of wildflower meadow and length of hedgerow.

The total farm gate income for crops and livestock in the borough is £215m, with GVA of £83m.

Policy

Green infrastructure planning and delivery is shaped by local and national policy. A summary of the most relevant policies and strategies is provided in Appendix 1.

[17] https://www.nhs.uk/Livewell/Summerhealth/Documents/dh_HeatwavePlan2011.pdf

Figure 1 Plans and policies that impact upon green infrastructure planning and interventions

Language used to describe the natural environment

There are a range of terms used to describe the natural environment. These terms describe processes and systems that make up the natural environment and the services and benefits that they provide to society. However, the language can be quite different. This reflects the evolution of the different terms, some of which come from a landscape perspective, others from planning and others still from a scientific, ecological approach to describing the natural environment.

Green infrastructure has been used increasingly in local planning strategies, and has strong links to National Planning Policy Framework and other government strategies including the 25 Year Plan for the environment.

Green infrastructure can be defined as:

"An interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations"[18]

Further information on the language used to describe the natural environment is provided in Appendix 2.

[18] Benedict and McMahon, Green Infrastructure 2002, p12

Green infrastructure in Cheshire East

A GIS-based audit of green infrastructure typologies has been carried out for Cheshire East. The methodology is described in Technical Appendix 1.

The following map shows where different types of green infrastructure can be found in Cheshire East. White on the map indicates areas that are not green infrastructure, such as buildings and roads.

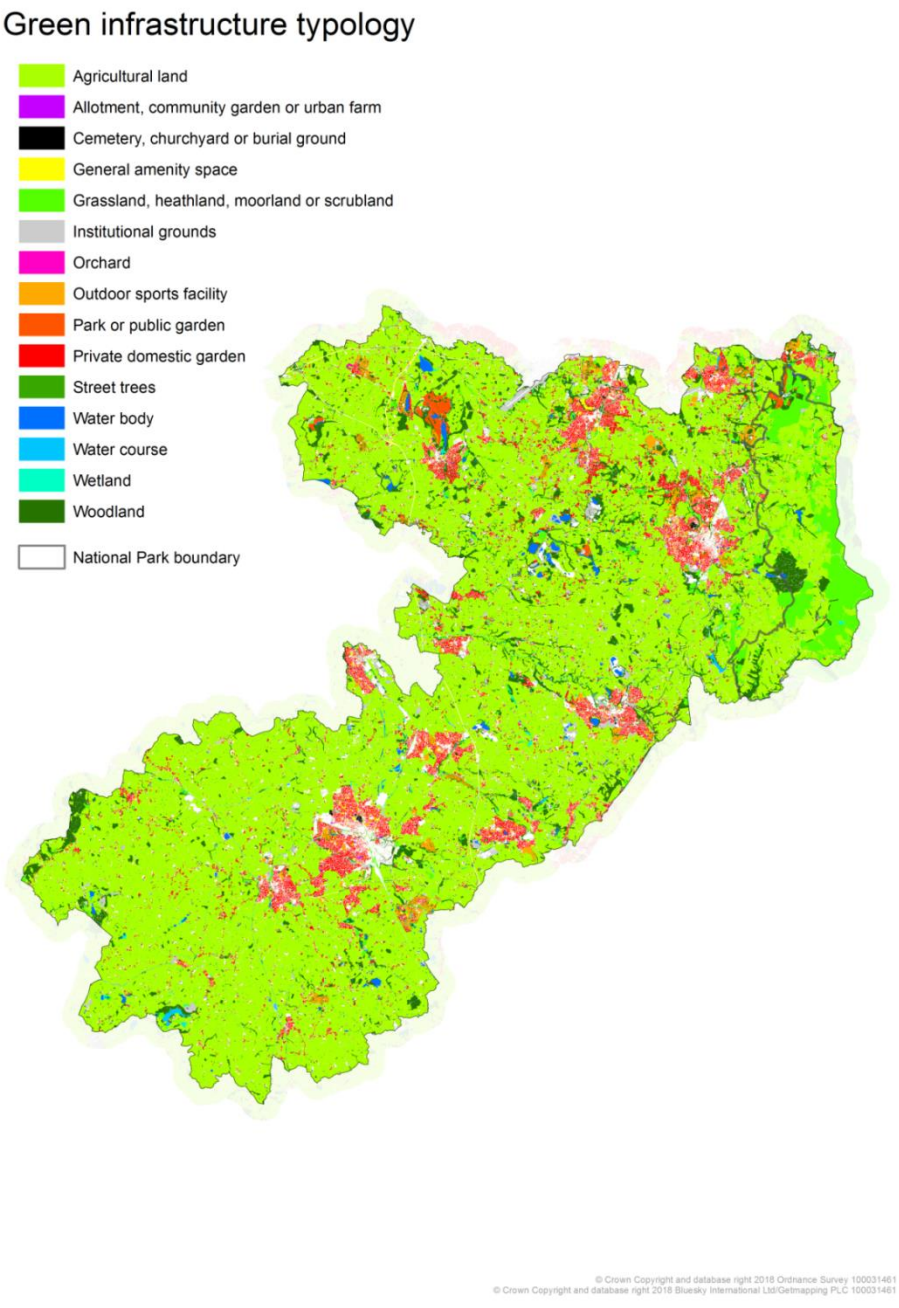


Figure 2 Green infrastructure typology for Cheshire East

This mapping is also provided in a GIS format for more detailed inspection of specific areas that might be of interest for land use planning.

The following is the breakdown of green infrastructure types in Cheshire East according to the mapping.

Green infrastructure type	Area (ha)	Percentage	Percentage of GI
Agricultural land	79618	68.26%	73.49%
Allotment, community garden or urban farm	39	0.03%	0.04%
Cemetery, churchyard or burial ground	41	0.04%	0.04%
General amenity space	1122	0.96%	1.04%
Grassland, heathland, moorland or scrubland	4830	4.14%	4.46%
Institutional grounds	3304	2.83%	3.05%
Not GI	8302	7.12%	
Orchard	24	0.02%	0.02%
Outdoor sports facility	1479	1.27%	1.37%
Park or public garden	455	0.39%	0.42%
Private domestic garden	6329	5.43%	5.84%
Street trees	901	0.77%	0.83%
Water body	1196	1.03%	1.10%
Water course	639	0.55%	0.59%
Wetland	252	0.22%	0.23%
Woodland	8117	6.96%	7.49%

Overall 93% of Cheshire East can be identified as green infrastructure. The typology mapping simply identifies the green infrastructure types. At this stage, it does not assess quality or functionality of the green infrastructure.

68% of Cheshire East is agricultural land. Any strategic green infrastructure planning for the borough will have to have a strong focus on the role of agricultural land plays in delivering services and benefits.

There are a total of 1,543 farm holdings in Cheshire East; dairy farms predominate by area (37%) followed by grazing livestock and general cropping farms. In recent years there has been an increase in the area of cropping. It is estimated that there are around 52,000 dairy cows, 5,500ha of wheat and 4,800ha of maize in Cheshire East. The agricultural labour force is 4,015.

The share of employment in agriculture is 1.8%, below both the GB and North West average employment share. The Gross Value Added from agriculture in Cheshire East is estimated to be £83m, 0.8% of the borough's total GVA[19].

The 2016 report on The Role of Best and Most Versatile Land in Cheshire East[20], identified that 47% of the agricultural land in Cheshire East was Best and Most Versatile Land (BMV). BMV is regarded as a national asset, a critical part of our natural capital. It allows for the widest range of crops to be grown and the land is often more easily worked by farm machinery, reducing costs of production.

Private gardens, grassland and woodland are the other main green infrastructure types in Cheshire East, though each is approximately 10 times less in extent than the agricultural land cover.

In spatial terms, 62% of the non-agriculture green infrastructure in the borough is north of the River Dane.

17% of the non-agriculture green infrastructure in is the top 20% most affluent wards, with 6% in the least affluent[21].

The following maps zoom in on the typology map, to look more closely at Crewe and the Middlewich-Sandbach-Congleton corridor respectively.

[19] Agriculture GVA is estimated by Farm Business Return data, and not from the GI-Val toolkit.
[20] The Role of Best and Most Versatile Land in Cheshire East, Report for Cheshire East, July 2016
[21] This is only part of the story about the relationship between green infrastructure and deprivation, however. More work is needed to explore it exhaustively.

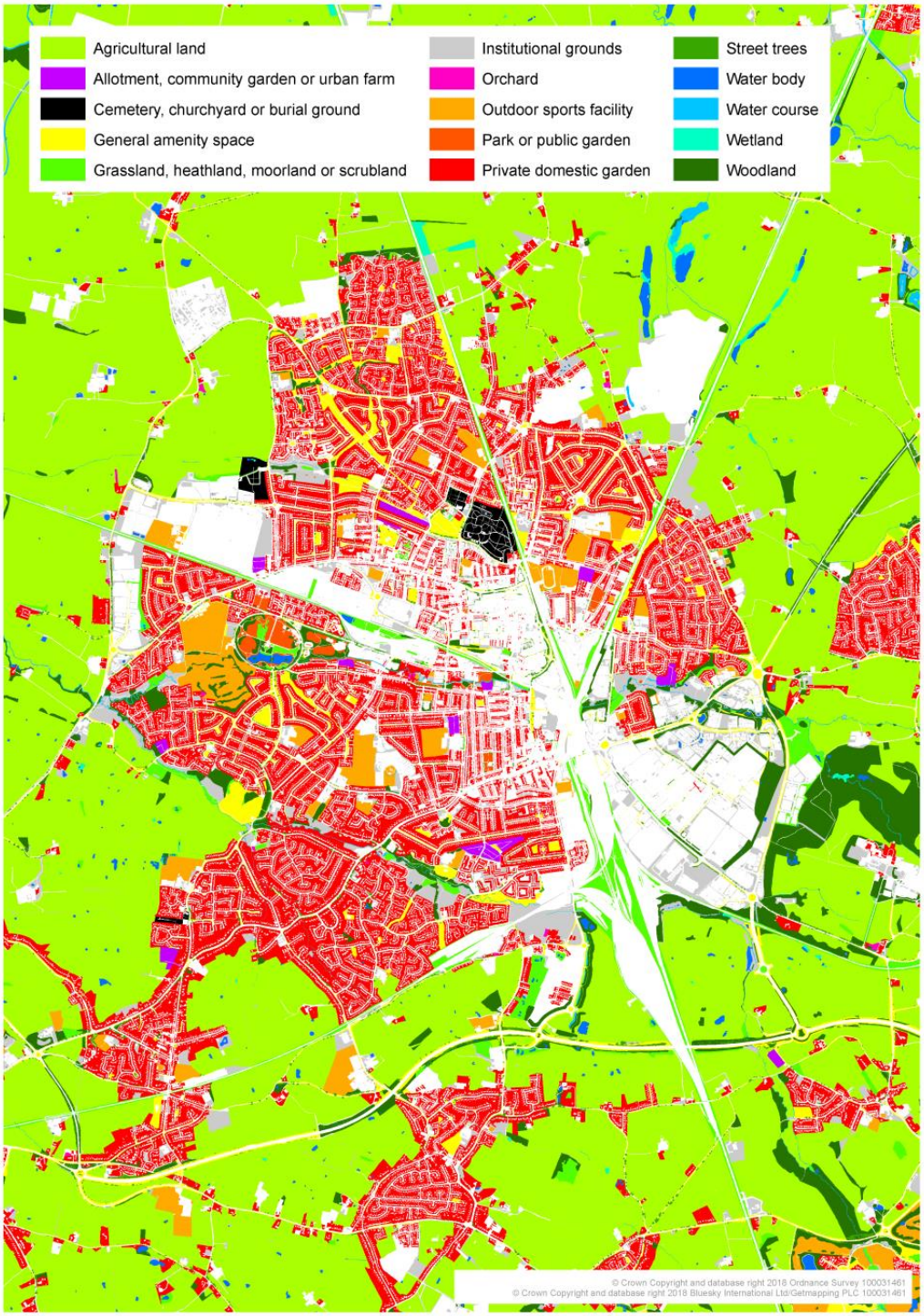


Figure 3 Green infrastructure typology for Crewe

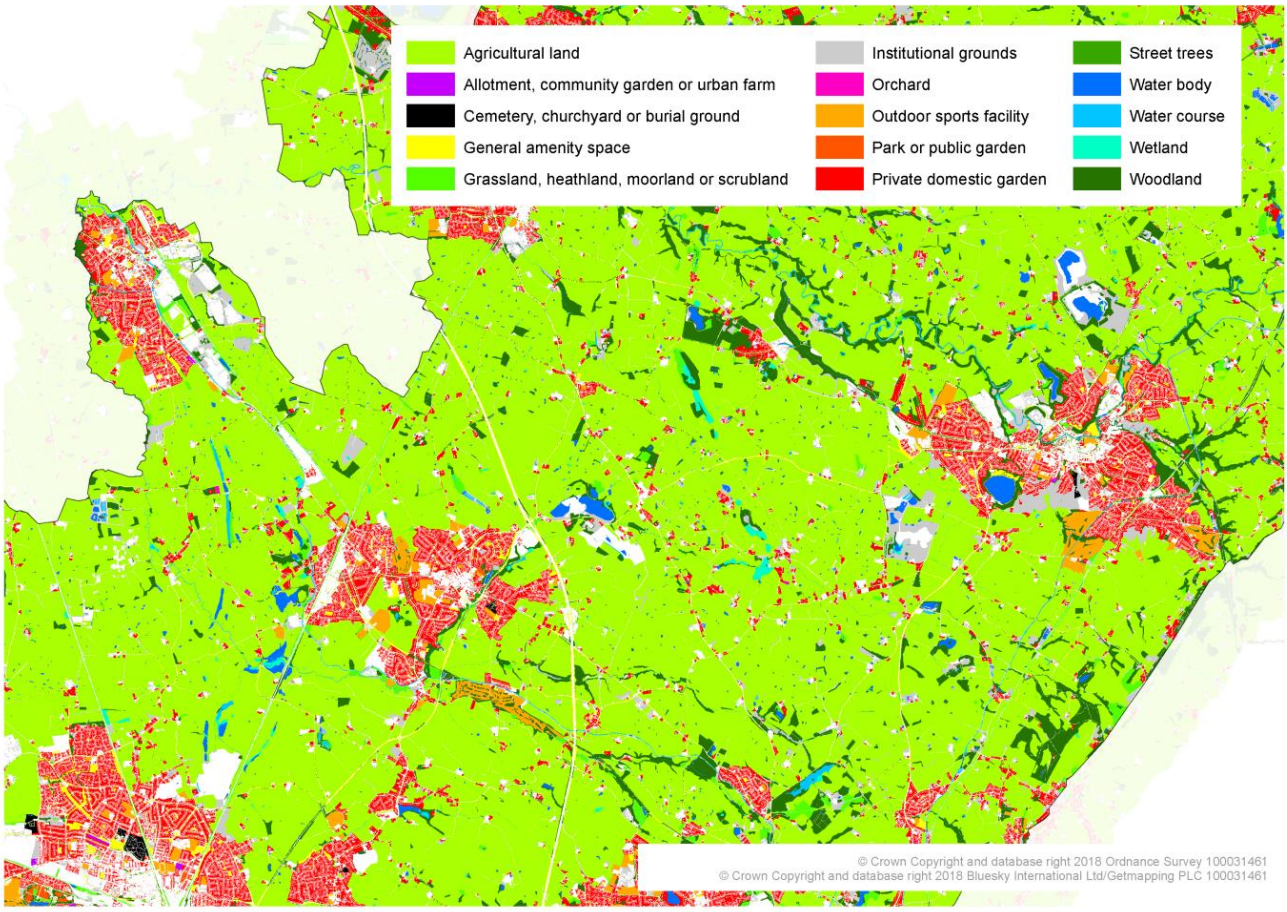


Figure 4 Green infrastructure typology for the Middlewich-Sandbach-Congleton corridor

The following table shows the breakdown of green infrastructure types in the Crewe area.

Type	Area (ha)	Percentage	Percentage of GI
Agricultural land	3390	52.33%	64.91%
Allotment, community garden or urban farm	14	0.21%	0.27%
Cemetery, churchyard or burial ground	16	0.25%	0.31%
General amenity space	147	2.26%	2.81%
Grassland, heathland, moorland or scrubland	99	1.53%	1.90%
Institutional grounds	229	3.53%	4.38%
Not GI	1255	19.38%	
Orchard	2	0.03%	0.04%
Outdoor sports facility	114	1.76%	2.18%
Park or public garden	13	0.21%	0.26%
Private domestic garden	860	13.27%	16.46%
Street trees	46	0.71%	0.88%
Water body	46	0.70%	0.87%

Water course	20	0.31%	0.38%
Wetland	13	0.20%	0.25%
Woodland	214	3.31%	4.10%

The following table shows the breakdown of green infrastructure types in the Macclesfield-Sandbach-Congleton corridor.

Type	Area (ha)	Percentage	Percentage of GI
Agricultural land	20987	69.83%	76.66%
Allotment, community garden or urban farm	6	0.02%	0.02%
Cemetery, churchyard or burial ground	20	0.07%	0.07%
General amenity space	334	1.11%	1.22%
Grassland, heathland, moorland or scrubland	336	1.12%	1.23%
Institutional grounds	1051	3.50%	3.84%
Not GI	2678	8.91%	
Orchard	6	0.02%	0.02%
Outdoor sports facility	272	0.91%	1.00%
Park or public garden	14	0.05%	0.05%
Private domestic garden	1927	6.41%	7.04%
Street trees	257	0.86%	0.94%
Water body	282	0.94%	1.03%
Water course	189	0.63%	0.69%
Wetland	67	0.22%	0.25%
Woodland	1627	5.41%	5.94%

The following figure compares the data from the two sub-areas of the borough with the green infrastructure data for the whole borough.

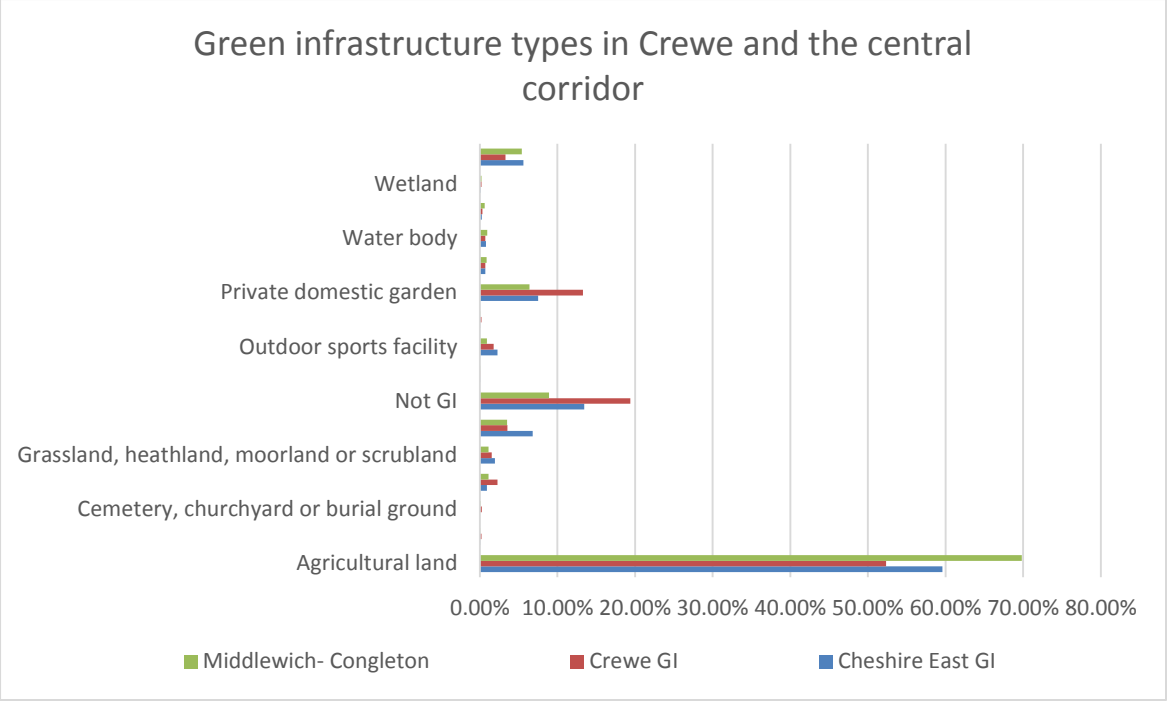


Figure 5 Green infrastructure data for Cheshire East and two sub-areas

Comparing the three areas shows that:

Crewe has a lower percentage of green infrastructure compared to the borough as a whole. Unsurprisingly, Crewe has a greater area of private gardens than the borough average.

The central corridor, with a network of towns within the agricultural landscape, has higher levels of green infrastructure as a parentage of the study area than the borough as a whole (91% as against 87%). The corridor has more agricultural land, but lower levels of institutional grounds, private gardens and woodland.

Tree canopy cover in Cheshire East

As part of the Green Infrastructure Audit a tree canopy map has also been produced using the aerial imagery newly available under the Aerial Photography for Great Britain agreement[22].

This indicates that there is approximately 10,000ha of tree canopy in Cheshire East, including the woodland and street trees identified in the green infrastructure mapping[23]. This would suggest that there are approximately 982 ha of tree canopy cover outside of woodland and not on streets. These trees are likely to be in gardens and parks as well as in the wider agricultural landscape.

[22] https://www.apgb.co.uk/
[23] Although some parts of the woodland identified are not actual canopy

Tree and woodland canopy cover in the borough is higher north of the River Dane, with a noticeable drop off in cover south of the River Dane.

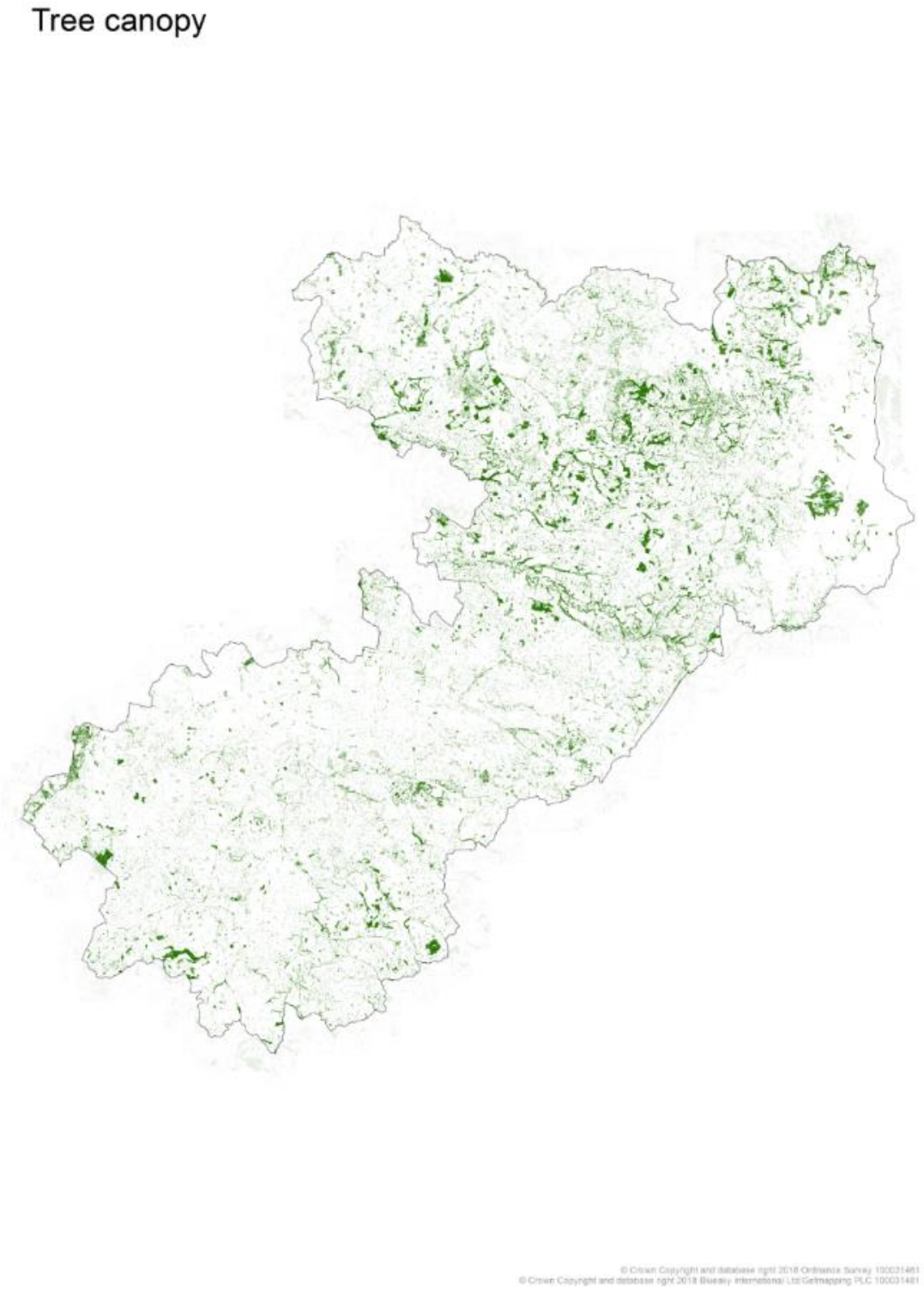


Figure 6 Tree canopy cover in Cheshire East

Previous work on green infrastructure in Cheshire East

GI Framework for North Wales, Cheshire West and Chester, Cheshire East and the Wirral

In 2011 Natural England funded a Green Infrastructure Framework for the urban and rural locations of Denbighshire, Flintshire, Wrexham, Cheshire West and Chester, Cheshire East and the Wirral[24]. The Framework set out a vision of how a healthy natural environment could help sustain economic growth and self-supporting communities.

The Framework's purpose was fourfold:

- To identify priorities for management of the natural environment across this wide area
- To support delivery of cross-boundary initiatives and local projects
- To provide robust evidence for policy to protect and enhance the natural and historic environment in plans produced by local authorities, community partnerships and infrastructure providers
- Address the conditions of the Growth Point

The Framework also includes a more detailed assessment of Crewe as an area of particular interest due to the rate and scale of growth.

National Trust

In 2016, The National Trust has led on the development of a landscape scale plan for the northern area of Cheshire East. In particular this looks at landscape connectivity and the impacts that development may have on the delivery of landscape services in future years. The approach is similar to a green infrastructure plan. The Plan will help to shape policy and strategy in the north of Cheshire East.

Neighbourhood Plans

Green infrastructure planning has been used in several of Cheshire West's Neighbourhood Plans.

For example, in 2017, as part of the Wilmslow Neighbourhood Plan[25], an assessment of green infrastructure in and around the town was carried out. This data can be used to inform the development of more detailed neighbourhood policy,

[24] http://www.merseydeealliance.org.uk/green-infrastructure/
[25] http://wilmslownp.org.uk/faqs/

Meeting local need

Whilst the natural environment, our natural capital, has intrinsic value, green infrastructure planning also looks to identify issues that green infrastructure can help to tackle.

These issues are often driven by local and national policy.

Green infrastructure planning also aims to identify where interventions should be made by creating maps that indicate areas where issues are most prevalent.

Using a range of datasets, we can look at issues facing the borough, identified in corporate strategy and documents such as the Joint Strategic Needs Assessment, and identify where the green infrastructure provided by Cheshire East is playing a role in tackling these issues, or where the green spaces can be managed to help alleviate these problems in the future.

With increasing pressure on budgets, this helps to show how green spaces play a role in tackling strategically important issues that assist with strengthening the economy of the borough and/or with improving quality of life, reducing pressure on a range of local authority services.

There is a strong and developing evidence base to support green infrastructure investment to support or sustain improved quality of place and life. A summary of some aspects of this evidence base is provided in Appendix 3 Evidence. This section looks at mapping the relationship between the borough's green spaces and some of the key issues facing the borough.

In particular we looked at:

- Improving image and supporting the economy
- Improving health and wellbeing
- Encouraging active travel – walking and cycling
- Managing water run-off
- Trapping air pollutants
- Improving ecological networks

GI-Val, a valuation toolkit, has been used to provide indicative economic values for Cheshire East green infrastructure benefits that are particularly relevant to the issues in the bullet list above.

Whilst putting a financial value on nature can be controversial, not having any financial data can lead to poor decision making.

GI-Val looks at three types of value:

Gross Value Added – the traditional measure of value of goods and services in the economy in cash terms

Property Value increase – Whilst not an economic benefit, property value is a useful indicator of the attractiveness of an area. This might be particularly important in areas of regeneration.

Wider economic benefit – Captures values that are not normally priced into the costs of goods and services, and so do not feature in GVA calculations. This might, for example, include the value of biodiversity in a local area calculated by "willingness to pay" assessments.

These values are of different types. They should not be added together to give a total value but can give a picture of the types of value that green infrastructure is providing. More information about GI-Val is provided in Appendix 4 Valuing our vital green infrastructure.

Using GI-Val and data from the green infrastructure audit carried out for this study, the following figures were found. The values are all Present Value calculations, based on a 25-year period.

Gross Value Added – £924m

Property Value – £594m

Wider economic benefit – £257m

This is made up the following benefit types.

SUMMARY OF ECONOMIC VALUE

BENEFITS Benefits groups	BENEFIT MONETISATION GVA value	Land and property value	Other economic value
1 Climate Change Adaptation & Mitigation	£2.8m	n.a.	£32.4m
2 Water management & Flood Alleviation	£642m	n.a.	n.a.
3 Place & communities	£0	n.a.	£21.8m
4 Health & Well-being	£8.3m	n.a.	£171m
5 Land & Property Values	n.a.	£594m	n.a.
6 Investment	n.a.	n.a.	n.a.
7 Labour Productivity	£13.3m	n.a.	n.a.
8 Tourism	£257m	n.a.	n.a.
9 Recreation & leisure	n.a.	n.a.	£73.6m
10 Biodiversity	n.a.	n.a.	£31.3m
11 Land management	£0	n.a.	n.a.
TOTAL ECONOMIC VALUE OF BENEFITS	£924m	£594m	£257m
	These three figures should not be added together, as they represent different kinds of value		

The value of recreation & leisure benefits has not been included in the other economic value total because of the risk of double counting

Figure 7 GI-Val calculations of economic value of Cheshire East's green infrastructure

Improving image and supporting the economy

Figure 8 shows the concentration of businesses in Cheshire East. Green spaces provide an attractive setting for business, improving property value and, in some cases, encouraging inward investment.

Through the LEP, Cheshire and Warrington there will be delivery plan for quality of place. This is in recognition of the competitive value of green infrastructure for areas such as Cheshire East.

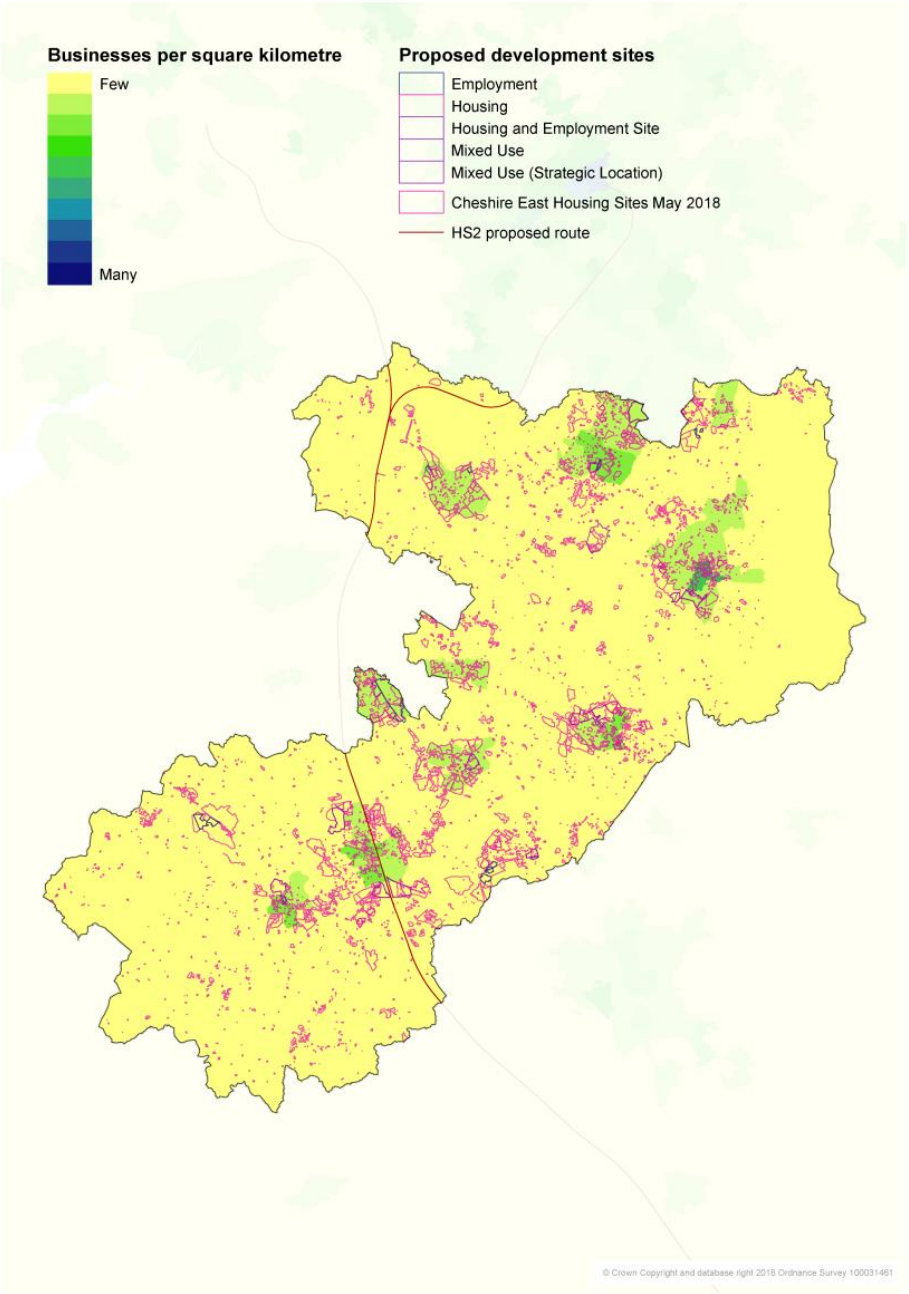


Figure 8 Business density and proposed development locations across Cheshire East

The Cheshire and Warrington LEP Quality of Place[26] report showed that quality of place was an important driver for businesses in Cheshire East, influencing investment plans.

With 36,000 additional homes, HS2 and other transport infrastructure, 56,000 more people living in the borough and more people travelling into the borough to work, the challenge will be to maintain and enhance quality of place to retain Cheshire East's competitive advantage.

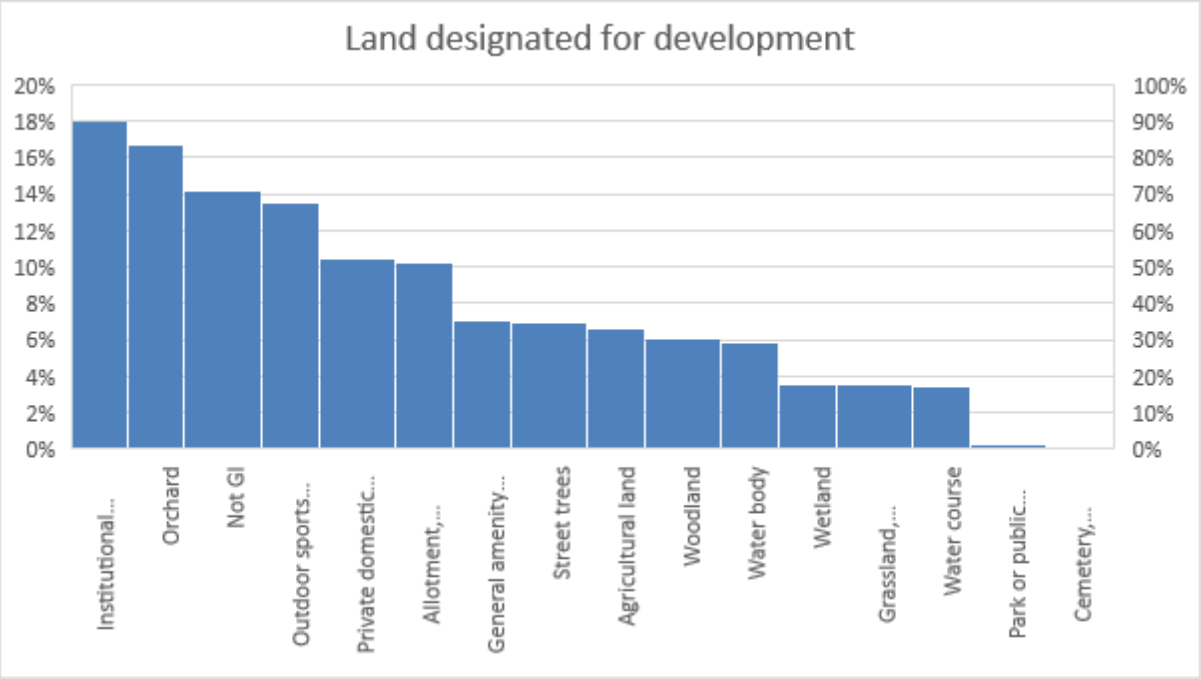
The following table shows the breakdown of green infrastructure types within proposed development sites and housing sites as set out in the Local Plan Strategy.

Type	Area (ha)	Percentage	Percentage of GI
Agricultural land	5240	59.59%	68.84%
Allotment, community garden or urban farm	4	0.05%	0.06%
Cemetery, churchyard or burial ground	0	0.00%	0.00%
General amenity space	79	0.90%	1.04%
Grassland, heathland, moorland or scrubland	171	1.95%	2.25%
Institutional grounds	597	6.79%	7.84%
Not GI	1181	13.43%	
Orchard	4	0.05%	0.06%
Outdoor sports facility	200	2.28%	2.63%
Park or public garden	1	0.01%	0.01%
Private domestic garden	660	7.50%	8.67%
Street trees	63	0.71%	0.82%
Water body	70	0.80%	0.92%
Water course	22	0.25%	0.29%
Wetland	9	0.10%	0.12%
Woodland	491	5.59%	6.45%

Not all of this green infrastructure will necessarily be lost. New developments will be required to make provision for gardens, green spaces and other green infrastructure. Strengthened commitment to net gain in the National Planning Policy Framework may flag the opportunity to aspire to net gain for the borough.

[26] Cheshire and Warrington - Quality of Place Study, KPMG, 2017 – Cheshire and Warrington LEP

Overall, 7% of Cheshire East's agricultural land falls within the development areas. Higher percentage losses are seen for institutional grounds and sports facilities, but these are, in area terms, much lower than the area of agricultural land planned for development.



Evidence

There is good evidence to support green infrastructure investment to sustain or enhance quality of place.

The presence of high quality green infrastructure can improve the 'investability' of an area and its competitiveness as a business location[27,28]. Shoppers indicate that they will travel greater distance and a longer time to visit a district having high quality trees and spend more time there once they arrive[29].

Greener settings not only attract but also help to retain workers: businesses located next to green spaces in Glasgow recorded improved staff morale and staff retention rates due to the

[27] BE Group (2014) Green Infrastructure - Added Value - http://www.merseyforest.org.uk/BE_group_green_infrastructure.pdf
[28] CABE (2004) The Value of Public Open Spaces. Commission for Architecture and the Built Environment, London.
[29] Wolf, K.L. (2005) Business District Streetscapes, Trees, and Consumer Response. Journal of Forestry. 103, 8, pp. 396-400.

attractiveness of the location[30]. Green infrastructure also improves productivity: office workers who enjoyed a natural view out of the window reported fewer physical ailments and greater job satisfaction compared to those workers without a view[31].

The development of a community woodland on the former Bold Colliery site in St. Helens has enhanced existing property values in the surrounding area by £15 million[32].

Commercial developments alongside major roads leading to the city that contain trees are generally preferred to both developments without trees and undeveloped agricultural land without trees[33].

Value

The valuation toolkit (GI-Val) suggests that green infrastructure currently provides circa £1bn of GVA and adds around £550m to property value in Cheshire East.

Agriculture contributes £83m of GVA and employs over 4,000 people.

[30] Gen Consulting (2006) Glasgow Green Renewal Benefits Analysis. A report to Glasgow City Council. Gen Consulting, Glasgow.
[31] Kaplan R (1993) The role of nature in the context of the workplace. Landscape and Urban Planning 26: 193-201.
[32] Forestry Commission (no date) Bold Colliery Community Woodland. District Valuer's report on Property Values. Forestry Commission
[33] Crompton JL (2007) Competitiveness: Parks and Open Space as Factors Shaping a Location's Success in Attracting Companies, Labor Supplies, and Retirees in de Brun C (Ed.) The economic benefits of land conservation. The Trust for Public Land, pp.48-54.

Improving health and wellbeing

The new government 25 Year Plan for the Environment emphasises the value of green spaces for health and wellbeing. There is a growing evidence base supporting the role that green space plays in helping to improve wellbeing and also reducing health inequalities.

Good quality natural environment and access to green spaces are part of the wider range of determinants of health. It is not to suggest that on their own green spaces keep people well, but reduced access or poorer quality green space add to the burden of factors that impact on wellbeing[34].

By mapping a series of health issues for which there is evidence that access to green spaces has a potentially positive effect, we can assess the value of Cheshire East green spaces for wellbeing[35].

Cheshire East has many areas of green space in parts of the borough with a high risk of poor mental health, concentrated around town centres and areas to the south of the borough. In urban areas, where there is a higher risk of poor mental health, provision of accessible greenspace is lower than in other urban areas (Figure 9).

[34] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/357411/Review8_Green_spaces_health_inequalities.pdf

[35] See Appendix7 for additional mapping of health issues across the borough

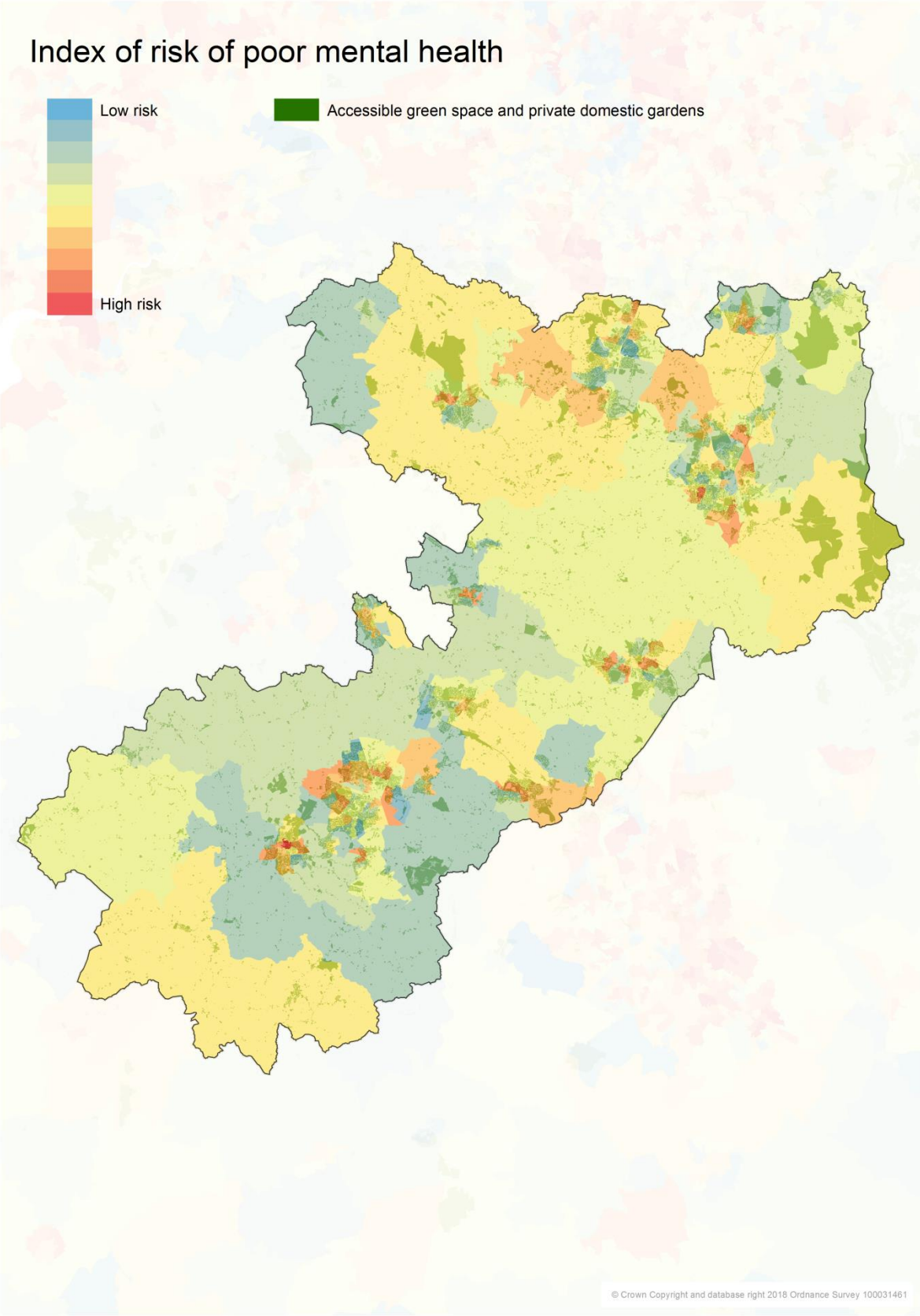


Figure 9 Risk of poor mental health in Cheshire East

Green spaces in Cheshire East already play a role in keeping people active and supporting good mental health. There is more that can be done. There may be opportunities to link to the Natural Health Service to act as a framework for discussions with Clinical Commissioning Groups and Public Health.

Additional maps showing the distribution of a range of health issues are shown in Appendix 8.

Evidence

In a recent study[36], a protective effect of green infrastructure on depression was consistently observed, with 4·0% lower odds of major depressive disorder with increasing levels of green infrastructure. Beneficial effects of greenness were more pronounced among women, participants younger than 60 years, and participants residing in areas with low neighbourhood socioeconomic status or high urbanicity. The results point to the benefits of well-designed green environments on mental health.

The cost of stress to the UK economy stood at £6.8bn in 2014, with ACAS figures reporting that mental ill-health (including stress, depression and anxiety) caused 91 million lost working days each year, with sickness absence costing £8.4 billion each year, £15.1 billion loss in reduced productivity, and £2.4 billion in the cost of replacing staff who leave[37]. The World Health Organisation forecasts depression to be the second greatest health concern globally by 2020. Contact with nature in green space has been shown to reduce stress and improves attention[38], whilst unsatisfactory access to green space had been found to be related to mental ill-health by a study in Greenwich, London[39].

Mental disorders in young people, in particular, have grown in significance and with up to 20% of young people suffering at any one time, both in Europe and worldwide. Common disorders found in populations of young people include anxiety, depression and behavioural disorders. Cheshire East JSNA identifies this as an issue for the borough.

Social interaction between residents of all ages in the same area develop mainly through outdoor contacts and green and open spaces such as parks and gardens attract people to use these

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[36] https://www.sciencedirect.com/science/journal/25425196

[37] Zehndorfer, E., Mackintosh, C. & Darko, N. (2016) Outdoor recreation as a potential lever for health improvement: A review of the health benefits, barriers and opportunities for the sector: Evaluation Report. Manchester, Manchester Metropolitan University.

[38] Kaplan R & Kaplan S (1989) The experience of nature: A psychological perspective, Cambridge University Press.

[39] Guite HF, Clark C & Ackrill G (2006) The impact of the physical and urban environment on mental well-being. Public Health 120, 1117-1126.

spaces[40]. This may become increasingly important as the population of Cheshire East rises. Reducing social isolation can help to improve wellbeing.

Living closer to parks has thus been shown to be linked to increased physical activity[41,42] such as walking and cycling[43].

In England, people who live furthest from public parks are 27% more likely to be overweight or obese, and children able to play in natural green space gain 2.5 kg less per year than children who do not have such opportunities[44]. There is also evidence suggesting that people are more likely to walk or cycle if streets are lined with trees[45].

Over 40% of people in England visit parks at least once a week, and only 7% never use parks[46]; 87% of the population use their local parks or open spaces regularly[47].

The NHS Heatwave Plan[48] identifies four vulnerable groups to increased risk of illness or death during heatwave. Older people are one of the four groups. Cheshire East will have an increasing population of older people. Climate change projections also suggest that the prevalence of heat wave will increase in the coming decades. Green infrastructure can significantly lower the temperatures in urban areas, thereby reducing the health risks to vulnerable people such as the elderly[49].

Value

Using GI-Val to assess some aspects of the health value of Cheshire East's green infrastructure, the estimated wider economic value for health is £171m.

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[40] Coley RL, Kuo FE & Sullivan, WC (1997) Where does community grow? The social context created by nature in public housing. Environment and Behavior 29: 468-494.
[41] Kaczynski A & Henderson KA (2007) Environmental correlates of physical activity: A review of evidence about parks and recreation. Leisure Sciences 29: 315-354.
[42] Coombes E, Jones A & Hillsdon M (2010) The Relationship Of Physical Activity And Overweight To Objectively Measured Green Space Accessibility And Use. Social Science And Medicine 70: 816-822.
[43] Zlot, AI. & Schmid, TL. (Relationships Among Community Characteristics And Walking And Bicycling For Transportation Or Recreation. American Journal Of Health Promotion 19: 314-7.
[44] Natural England (2009) Green Space Access, Green Space Use, physical activity and overweight: a research summary.
[45] Neilsen. A.B. and Hansen, R.B. (2007). Do green areas affect health? Results from a Danish Survey on the use of green areas and health indicators. Health and Place 13(4), 839-50
[46] CABE Space (2010) Urban green nation: Building the evidence basis. London, CABE Space
[47] DCLG (2008) Place Survey: England. London, DCLG.
[48] https://www.england.nhs.uk/2015/06/2015-heatwave-plan/
[49] Oven et al. (2012) Climate change and health and social care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England. Applied Geography, 33, pp. 16-24.

Through providing space for exercise more than nine lives are saved per year, and people's well-being is improved, saving over 15,000 days of potential sickness absence, providing over £7m of GVA benefit.

Managing water run-off

The use of features in the natural environment to slow the flow of water and reduce flood risk is gaining increasing policy and implementation interest. This natural approach to flood risk management has to be part of a wider programme of harder engineering to manage water. Natural Flood Management can be cost effective and can form part of a green infrastructure approach: the flood risk reduction benefits can be delivered alongside the other benefits, such as biodiversity, access etc. Maximising the flood risk reduction potential and therefore value of Cheshire East green spaces may require changes to management. Rougher surfaces, meadow grassland, wildflower areas and woodland all have a greater capability to slow water than closely mown grassland.

There is an increasing amount of funding available for natural flood management. This may provide an opportunity for Cheshire East to generate external resources to support service delivery.

The mosses and meres in Cheshire East are an important part of the natural water management system. Incorporating these areas (carefully to ensure no loss of biodiversity, and aiming at net gain) in rural sustainable drainage plans can complement work on sustainable urban drainage systems (SuDS).

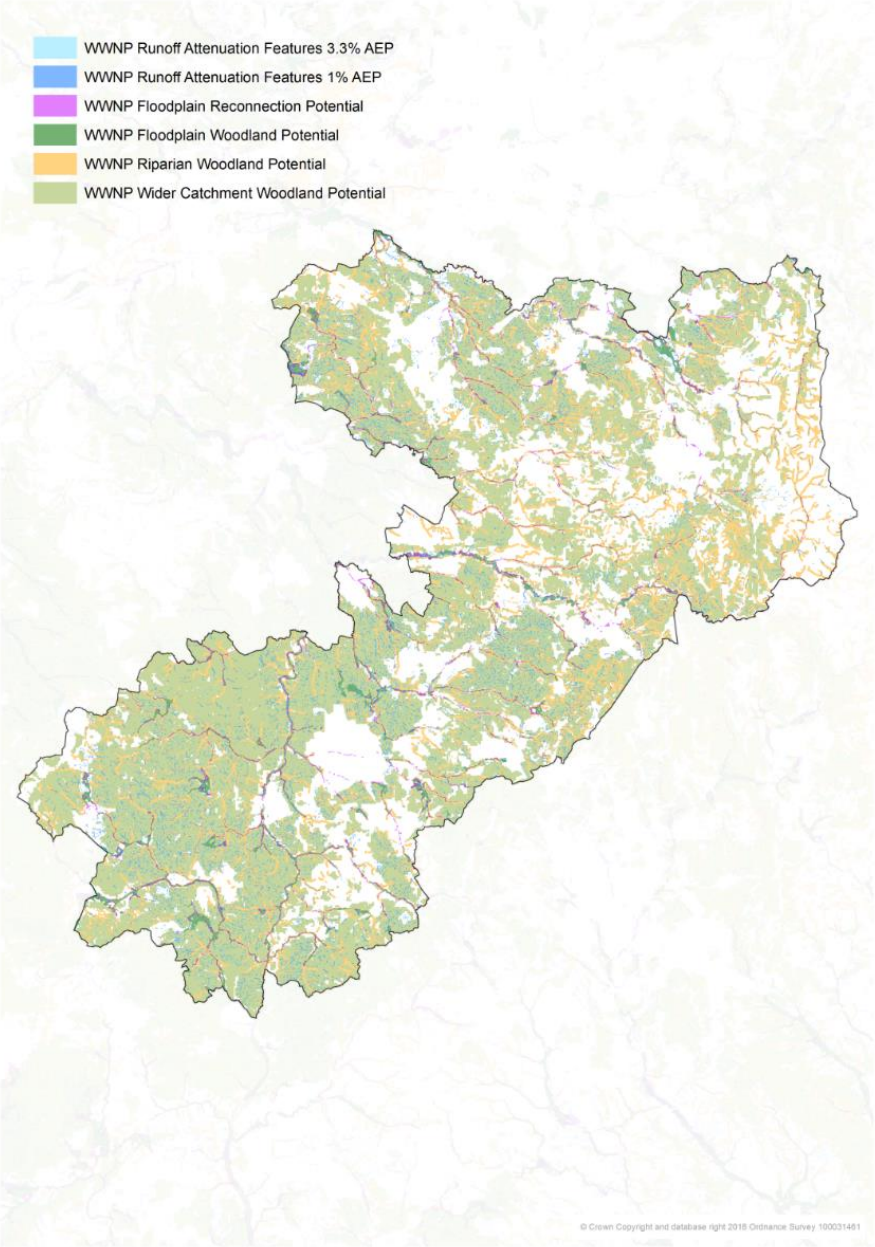

Figure 10 Potential for working with natural processes to reduce flood risk

We can identify the communities that would have risk reduced and through more detailed work start to put a value on this risk reduction.

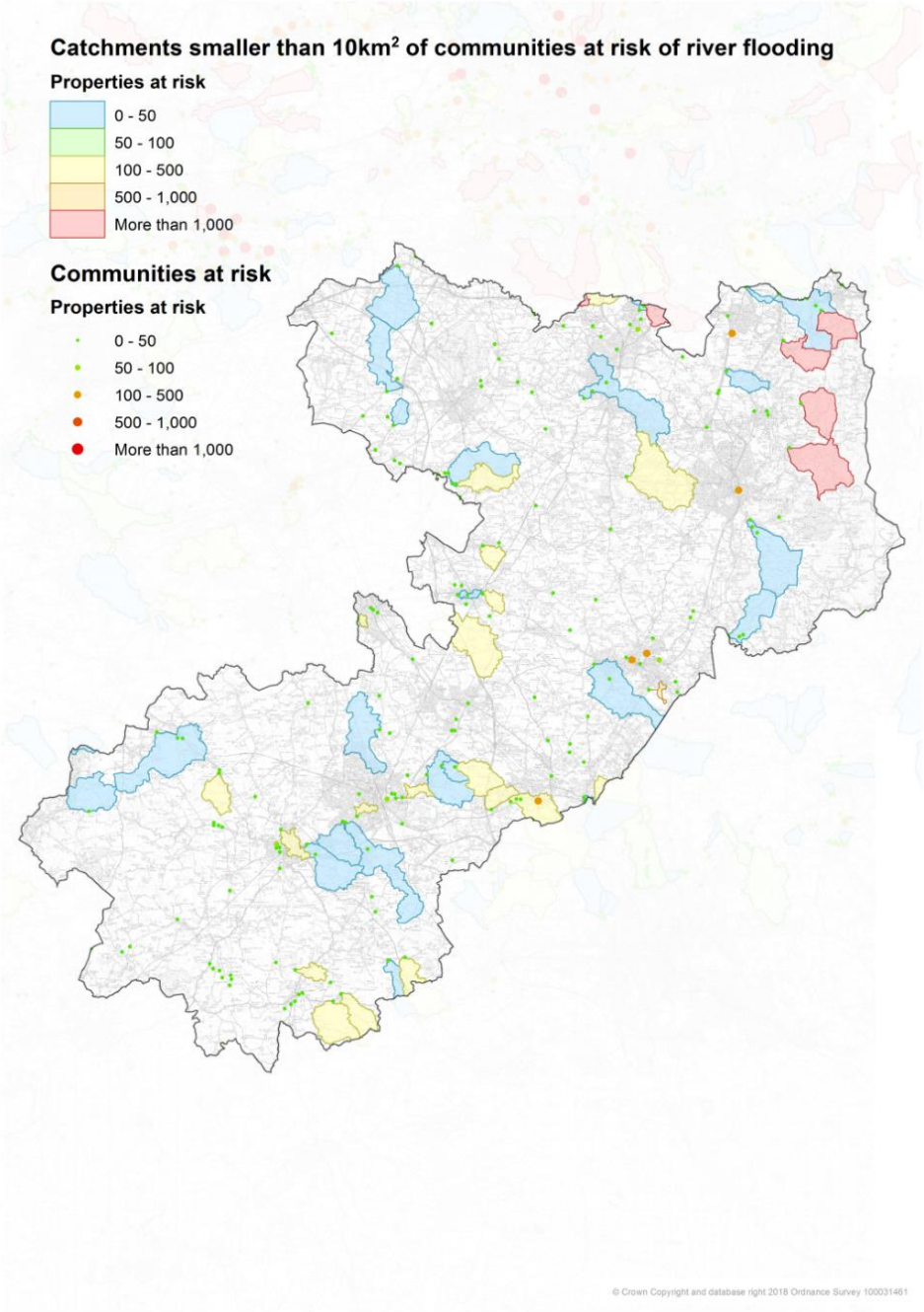

Figure 11 Catchments smaller than 10km² of communities at risk of river flooding

The opportunities to place runoff attenuation features, such as leaky dams, swales and temporary ponds, are mainly focussed on the eastern boundary of the borough.

Evidence

Green infrastructure intercepts, infiltrates, stores and evaporates rainwater, thereby reducing the rate and peak volume of water entering drains and limiting the risk of them being overwhelmed during extreme rainfall. Peri-urban and even rural woodlands (in the riparian zone and floodplain)

can contribute to flood alleviation in urban areas by delaying the downstream passage of flood flows[50].

Urban Catchment Forestry brings this approach into the heart of urban areas to help to manage pluvial storm events, reducing pressure on urban water drainage infrastructure and reduce risk of flood damage. Runoff can be reduced by 60% by trees over hard surfaces and by nearly 100% over grassland[51]. Modelling conducted on Manchester shows that adding 10% of green space can reduce runoff by 5-6% and adding green roofs to all buildings in densely built-up areas could reduce runoff by 17.0-19.9%[52].

Value

In Cheshire East, using this evidence and the GI-Val toolkit, we can calculate that green spaces, for example, divert an estimated 6,300 billion litres/year of water from the sewerage system.

The value of green infrastructure for water management is estimated to be £640m.

[50] Forest Research (2010) The case for trees in development and the urban environment. Bristol, Forestry Commission

[51] See Ennos, R. (2011) Quantifying the cooling and anti-flooding benefits of green infrastructure. Available at: http://www.sed.manchester.ac.uk/architecture/research/ecocities/news/documents/UoM_Roland_Ennos.pdf

[52] See Gill, S.E., Handley, J.F., Ennos, A.R. and Pauleit, S. (2007) Adapting cities for climate change: the role of the green infrastructure. Built Environment 33: 115-133.

Air quality

Air quality is a UK-wide public health issue, with an estimated 50,000 deaths per year caused by poor air quality. The UK Air Quality Strategy sets binding targets for air quality. Local authorities monitor air quality and identify areas with poor air quality that require action as Air Quality Management Areas.

Cheshire East publishes an annual report on the borough's air quality, based on data from the authority's network of air quality monitoring points. In general, air quality in Cheshire East is good, however there are 13 areas identified as Air Quality Management Areas[53].

Green infrastructure can help to improve local air quality if well planned and managed as part of the wider infrastructure scheme and at a more strategic level to provide more opportunities for active travel (see above) and increase the distance between polluting sources and people.

New housing and transport infrastructure are assessed for air quality impacts through the planning process. The Trees and Design Action Group have produced an excellent, evidence-based guide to improving air quality through green infrastructure[54].

Figure 12 Air quality, shows that areas of poor air quality are close the main towns and road infrastructure.

[53] https://www.cheshireeast.gov.uk/environment/environmental_health/local_air_quality/review_and_assessment/aqma_area_maps.aspx

[54] http://epapers.bham.ac.uk/3069/

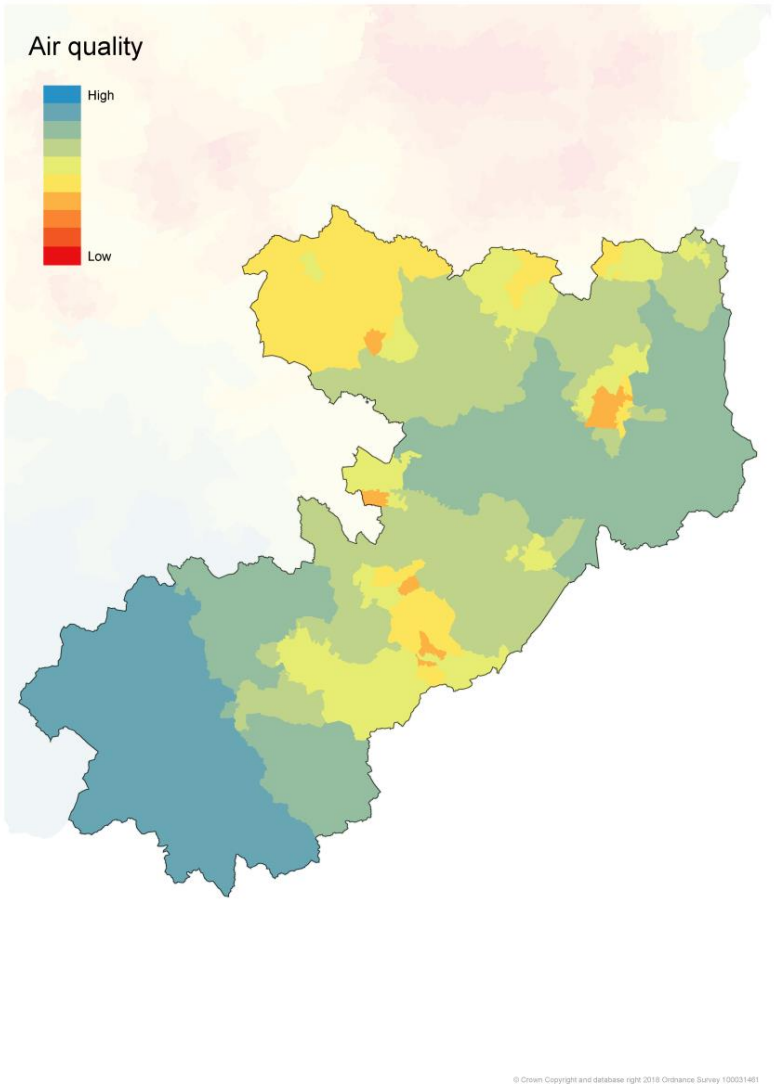

Figure 12 Air quality

Evidence

See TDAG publication described above.

In 2012 the Woodland Trust published an extensive evidence-based review related to urban air quality[55]. Trees are very effective at removing pollutants which are harmful to human health from the atmosphere, as they absorb gases including as ozone, nitrogen dioxide, sulphur dioxide, and

[55] The Woodland Trust (2012) Urban Air Quality: Discussion Paper. Grantham, The Woodland Trust

help to deposit pollutant particles smaller than 10 microns in diameter (PM_{10})[56]. Up to 70% of air pollution in cities can be filtered out by investments in street trees[57].

Value

It is estimated that 52 tonnes of PM_{10} per year is removed from the atmosphere by green infrastructure in Cheshire East (likely to be an underestimate), valued at £8.3m.

[56] Nowak DJ (1994) Air pollution removal by Chicago's urban forest, Chicago's urban forest ecosystem: results of the Chicago urban forest climate project. United States Department of Agriculture.

[57] Bernatzky A (1983) The effects of trees on the urban climate. In: Trees in the 21st century. Academic Publishers, Berkhamsted, 59–76. Based on the first International Arboricultural Conference.

Access

The 2015-2019 Cheshire East Rights of Way Improvement Plan (ROWIP) highlights that 80% of the borough's 1,947km of public paths and bridleways have good ease of access and the borough fares well in national benchmarking of its access route management[58].

The ROWIP highlights the role of the network in promoting active travel (Policy H2) and its role in enabling access to the borough's green infrastructure (Policy H3).

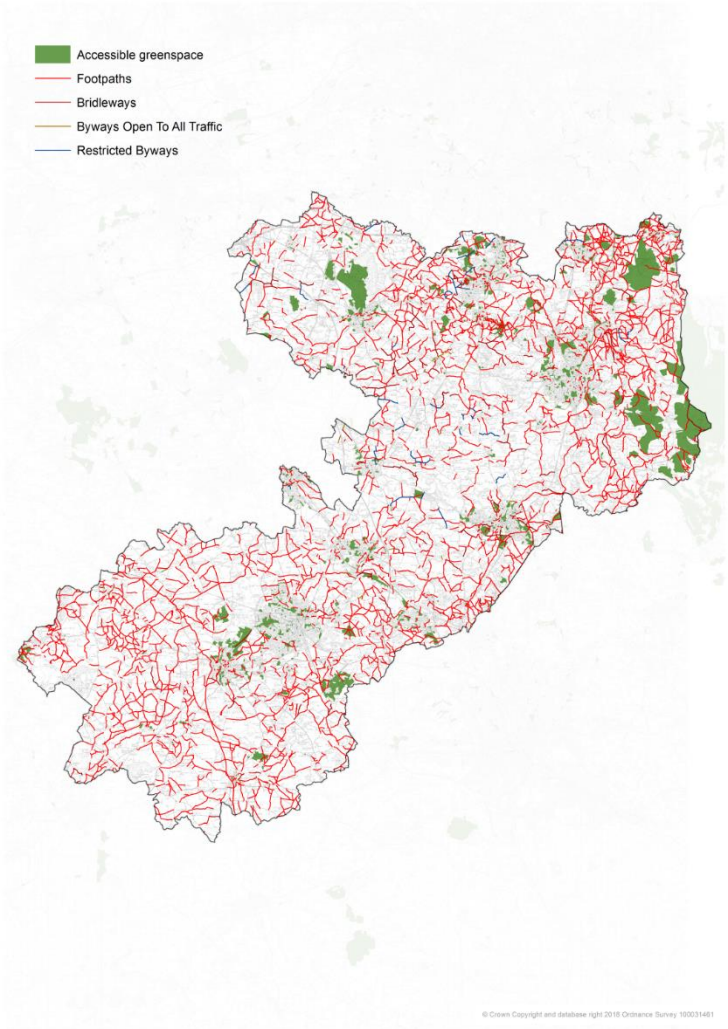

Figure 13 Accessible greenspace and Public Rights of Way

An assessment of availability of green spaces close to Cheshire East communities has used the Accessible Natural Greenspace Standards[59] (ANGSt)

[58] https://moderngov.cheshireeast.gov.uk/documents/s46725/CE%20ROWIP%20Implementation%20Plan%202015-2019%20Final.pdf

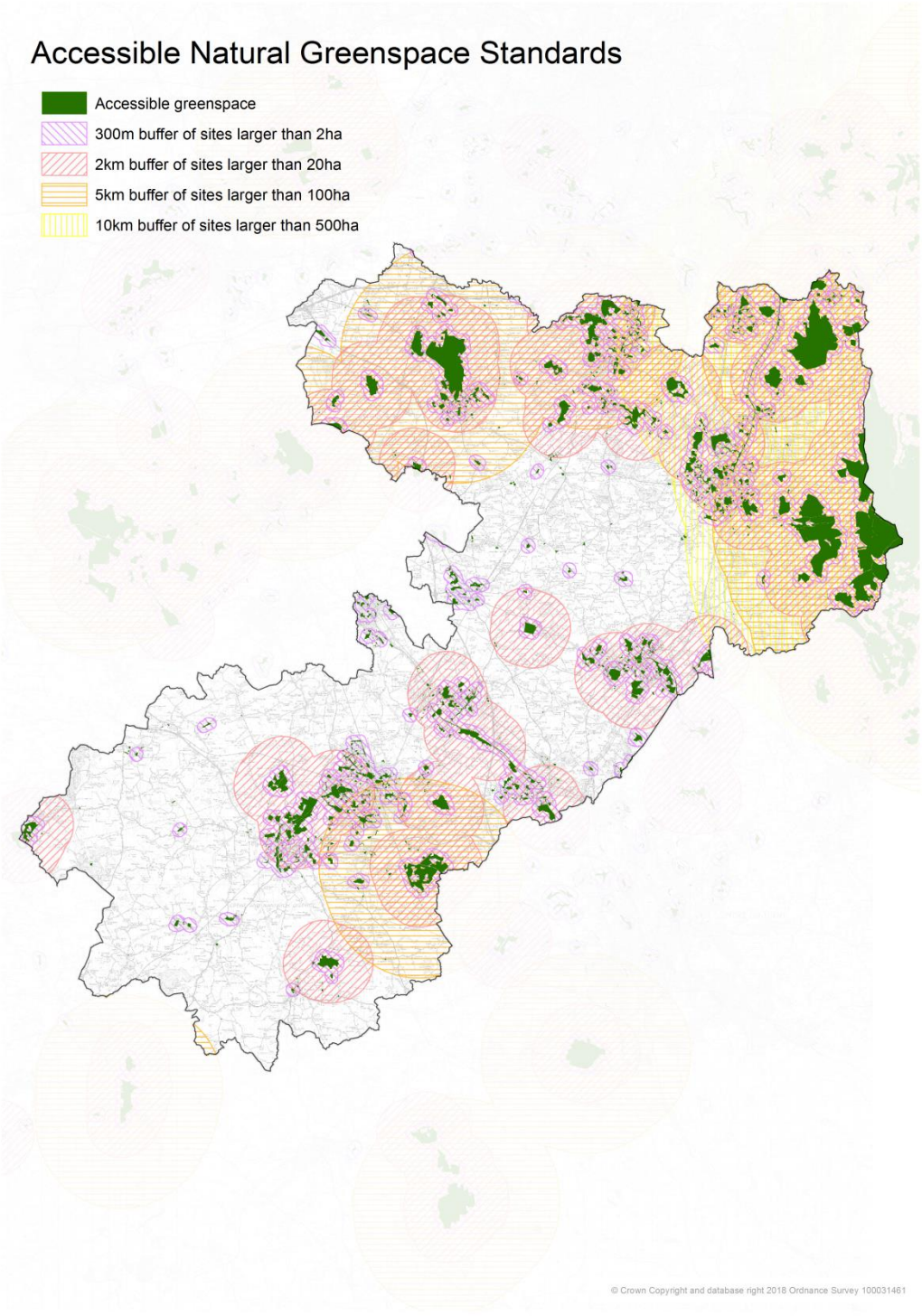

Figure 14 Accessible Natural Greenspace Standards (ANGSt)

59 http://webarchive.nationalarchives.gov.uk/20140605111422/http://www.naturalengland.org.uk/regions/east_of_england/ourwork/gi/accessiblenaturalgreenspacestandardangst.aspx

The area north of the River Dane meets more of the ANGSt than the area to the south. This is partly due to the larger areas of accessible greenspace north of the Dane.

There is a relative lack of larger sized accessible greenspace to the south of the Dane.

The extensive network does provide access into the countryside and, in particular, to the 68% of agriculture green infrastructure typology in the borough. However, this is not "open access"[60].

Evidence

A study in Maastricht highlighted that the more parks people had within their neighbourhood, the more their commuted by bicycle[61]. In the UK, from a survey of 5,844 respondents, 78% agreed with the statement 'Improved traffic free footpaths and cycle routes would encourage me to walk or cycle'[62]. Green infrastructure can be used to facilitate non-vehicular transport by providing alternative routes and infrastructure that links areas together and promotes a safer environment for people of all ages to cycle[63]. The Green Street programme in The Mersey Forest resulted in a 6% increase in walking and cycling along tree lined routes[64].

Value

Leisure and recreation are estimated to have a wider economic value of £74m. Tourism linked to green infrastructure in the borough is estimated to have a GVA of £250m.

[60] By open access we mean that an individual would be able to wander widely over an area without trespassing.
[61] Wendel-Vos W, Schuit AJ, De Niet R, Boshuizen HC, Saris W & Kromhout D (2004) Factors of physical environment associated with walking and bicycling. Medicine and Science in Sports and Exercise 36: 727-730.
[62] Green space (2010) GreenSTAT visitor survey system.
[63] Austin, G. (2014) Green Infrastructure for Landscape Planning: Integrating Human and Natural Systems. Abingdon, Routledge.
[64] Mersey Forest (nd) http://www.merseyforest.org.uk/our-work/green-streets/

Biodiversity and Cheshire East's ecological network

Previous work has used a range of datasets to create an Ecological Framework for Cheshire East. This identifies core areas for biodiversity, corridors and stepping stones in the landscape for wildlife, and indicates where restoration of habitat can be most beneficial.

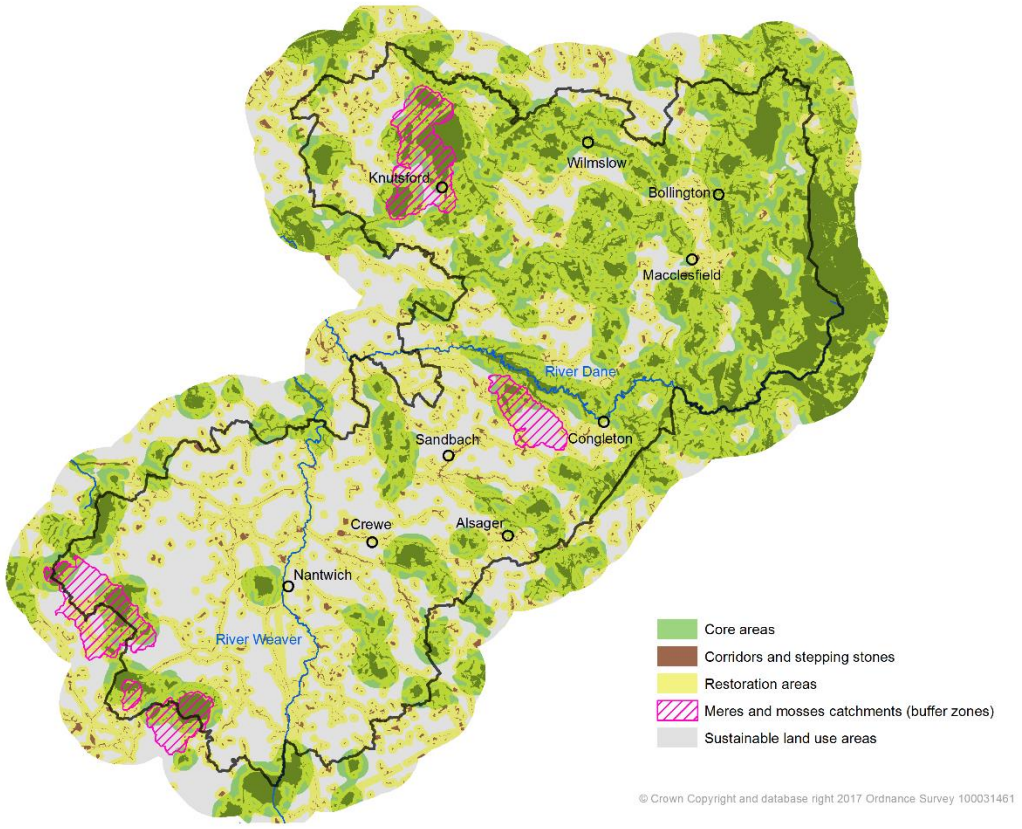

Figure 15 Cheshire East Ecological Framework

Again, a split between the areas north and south of the River Dane can be seen. The National Park, unsurprisingly, has a greater concentration of ecological network elements.

In line with many parts of the UK, despite national and local policy, biodiversity in Cheshire East is continuing to decline. A recent review of Local Wildlife Sites reported a decline in the area of Cheshire East's wildflower meadows. Biodiversity is an indicator of the health of the countryside.

Work is currently underway to map Great Crested Newt Habitat and this should be incorporated into the ecological framework in future iterations if the current network does not reflect the findings from this new study.

Evidence

The Lawton Report set out a clear justification for ecological frameworks, with a simple strapline highlighting the need for “more, bigger, better managed and connected” habitats.

Value

The economic value of biodiversity in its own right (based on an assessment of willingness to pay) is estimated at £34m.

External funding opportunities

For this audit of Cheshire East's green infrastructure an overview of potential funding sources is provided, based on work that has been completed for other local authorities and individual towns and cities.

Funding falls into three categories in our assessment:

1. Competing for funding from traditional sources, such as Lottery and Landfill Tax credits.
2. Offering new solutions to potential beneficiaries of the services and benefits that you provide as managers of the parks and green space resources in Cheshire East.
3. New funding models, bonds and endowments, developing new, long term funding streams.

Categories 2 and 3 are focussed on capturing the value of green infrastructure through payments or investments. This could evolve into a "Value Capture Framework" for Cheshire East green infrastructure, or key, strategic elements of it.

Details of the opportunities in each of these categories are provided in Appendix 6 Funding sources.

Next steps

This audit of Cheshire East's green infrastructure is one element of the Green Infrastructure Strategy.

Next steps include:

- Review of existing green infrastructure strategies and plans – what works elsewhere?
- More detailed assessment of need and function to provide basis for this additional work. This will identify areas as "Assets" or "Pinch Points".to target funding to either safeguard/enhance assets or tackle pinch points. Mapping of multifunctionality will be important for this stage of the work. More detail on the "Pinch Point" approach is provided in

- Appendix 8 Pinch Points

From this initial work the following arise:

- Development of detailed action plans for green infrastructure planning and management in the areas of greatest need across the borough: areas of poor health, flood risk, poor air quality etc., to feed into relevant strategies and plans (rather than the creation of stand-alone action plans for green infrastructure)
- At a strategic level, working to shape emerging policy, particularly land use management as this has such a major impact in Cheshire East. Green infrastructure planning can help to inform payments for public benefits that are suggested as the ways in which future land use funding will be delivered.
- Incorporate green infrastructure requirements into all major housing and transport infrastructure – development of SPD?
- Promote the value of green infrastructure as a critical infrastructure for the success of Cheshire East. Communicate the value of green infrastructure to the right audiences, in the right language. Series of leaflets or member briefings.
- Develop new ways to fund green infrastructure, from a variety of sources, working with partners and looking to gear and lever existing resources to best effect.
- Build green infrastructure into SPD on health and wellbeing? Further work on where and how green infrastructure can help to deliver Public Health and Clinical Commissioning Group targets.
- Green infrastructure and net gain assessment – what might net gain look like, where is the capacity to improve green infrastructure? Links to SPDs.
- Review of delivery mechanisms
- Identify the main drivers of change for the borough and focus green infrastructure work/strategy/policy on these areas/programmes. Link to SPDs.

The five stage approach to developing green infrastructure plans has been effective for other local authorities and can be used as a guide for this work in Cheshire East.

In this Audit, stages 1, 2 and 4 have been covered.

In future work to develop the Green Infrastructure Plan, continued focus on Stage 1, Partnerships and priorities will be important. Developing Stage 3, the Functionality assessment and assessing this alongside this Audit will help to develop Stage 5 – the Action Plan or Implementation Plan.

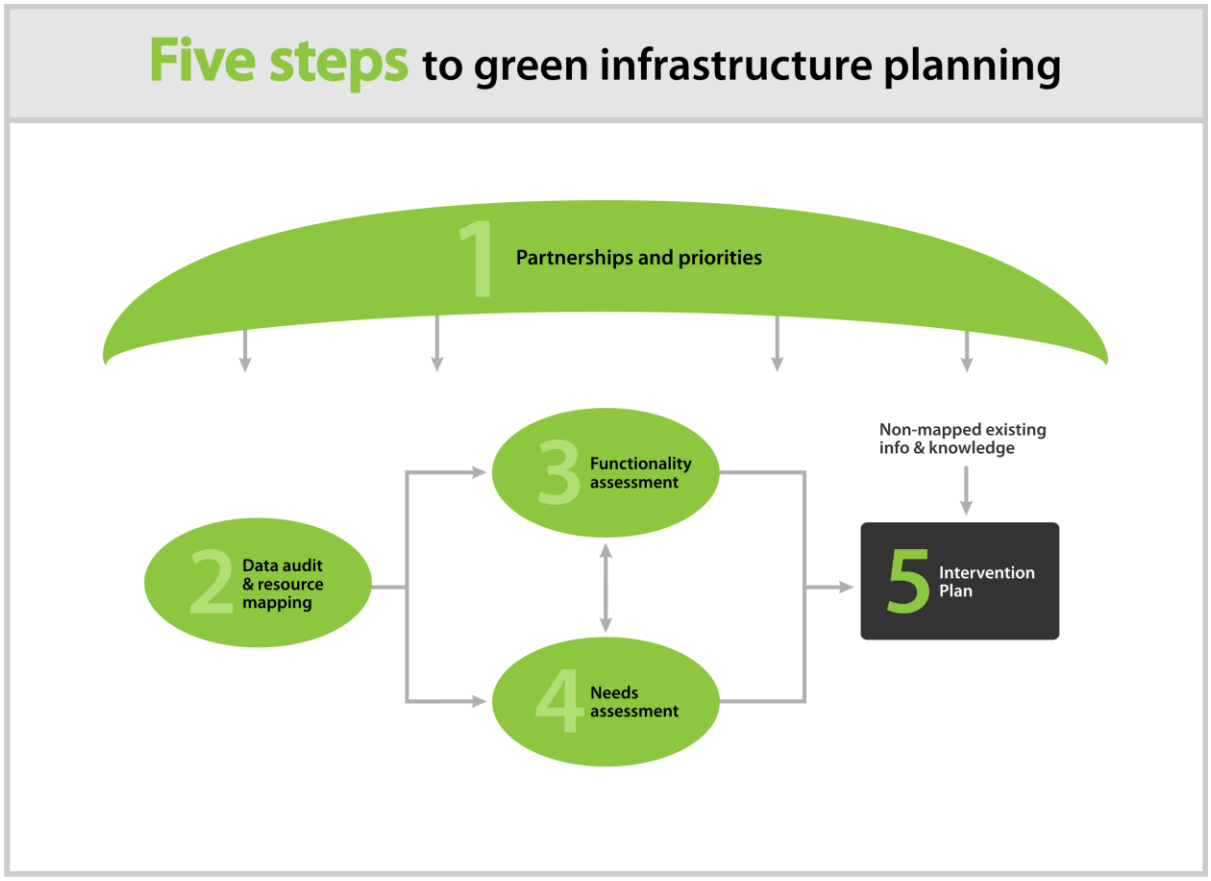

Figure 16 5 Step model for green infrastructure planning

Appendix 1 Policy and Strategy

National

The 25 YEP along with the Industrial Strategy, the Clean Growth Strategy and National Planning Policy Framework, provides, in principle, a strong policy framework for green infrastructure planning and delivery. The consultation document "food" also points clearly toward a future policy for land use and farming that has a greater focus on natural capital.

Document	Support for Green Infrastructure (example, not exhaustive)	Implications/opportunities include
25 YEP	Focus on increasing Natural Capital, the importance of a healthy environment for people and the economy.	Environmental net gain in planning, nature recovery network, Northern Forest, Natural Flood Management, improving health and wellbeing, new environmental land management scheme.
Industrial Strategy	Increasing productivity through investment in infrastructure, skills, research and sector deals to tackle projected changes to the global economy.	"We will work not just to preserve, but to enhance our natural capital."
Clean Growth Strategy	"In order to meet the fourth and fifth carbon budgets (covering the periods 2023 to 2027 and 2028 to 2032) we will need to drive a significant acceleration in the pace of decarbonisation and in this strategy, we have set out stretching domestic policies that keep us on track to meet our carbon budgets."	Trees and woodland (Northern Forest) are seen as a key mitigation intervention.
National Planning Policy	"Contributing to protecting and enhancing our natural, built and historic environment; and, as part of this, helping to improve biodiversity, use natural resources prudently, minimise waste and	The purpose of the planning system is to contribute to the achievement of sustainable development. Improve quality of new development, including green infrastructure

	pollution, and mitigate and adapt to climate change including moving to a low carbon economy."	provision.
Health and Harmony	Consultation on farming and land use, with a focus on natural capital gains and a refocussing of public subsidy for farmers and landowners to provide a simpler system with greater public benefits, including food security.	Green infrastructure interventions supported on farmland. These may focus on helping to reduce flood risk, capture carbon, manage soil and increase habitat connectivity.
Transport for the North	Includes references to natural capital.	Working with Transport for the North to identify where transport projects can help to deliver natural capital benefits, improving the cost: benefit of some planned transport schemes.

Local

Document	Support for Green Infrastructure (example, not exhaustive)	Implications/opportunities include:
Local Plan Strategy	Sustainability and quality of place are important elements of the Local Plan Strategy. There are a number of policies, including SE 1- 5, that are of particular relevance to green infrastructure planning for the borough.	Use of policy to guide green infrastructure delivery and ensure functionality is sustained. Use of green infrastructure planning to support "no net loss" targets. Improve quality of life benefits from new developments.
Cheshire and Warrington Strategic Economic Plan	Quality of Place is highlighted in the SEP: "clear link between economic success and creating attractive, vibrant places that people want to live in; more specifically, creating the kind of places that creative, entrepreneurial people want to live and work in, is seen as a key	Ensure that the planned Natural Capital Audit by the LEP reflects the Cheshire East Green Infrastructure Strategy.

	factor in growing a modern economy"	
Health and Wellbeing Strategy 2018-21	The Health and Wellbeing Strategy provides an overarching framework that will influence the commissioning plans of the local NHS, the Council, and other organisations in Cheshire East. It will be a driver for change, focussing upon those key areas that will make a real impact upon improving the health and wellbeing of all our communities.[65]	People have access to good cultural, leisure and recreational facilities. People are fitter and healthier – participating in physical activity and eating more healthily.

[65] http://moderngov.cheshireeast.gov.uk/documents/s61598/Health%20and%20Wellbeing%20Strategy%202018%20-%2021%20version%205%20Draft%20-%20FR%20GK%202.pdf

Appendix 2 Language and describing the Green Infrastructure approach

There are a range of terms used to describe the natural environment. These terms often come with particular ways of describing processes and systems that make up the natural environment and the services and benefits that they provide to society.

'Green infrastructure' can be described as "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations"[66]. Over the past 15 years, green infrastructure planning and policy has evolved a language that mirrors that of conventional infrastructure, focussed on functionality and benefits to society of different land types, with valuation of these benefits as an important element. This approach has become embedded in many local and national policy documents. It has enabled the natural environment to be considered not as an optional extra, but as critical infrastructure alongside transport, water and energy.

In recent years, 'natural capital' has been emerged as another, similar way to describe the stock of natural assets which include geology, soil, air, water and all living things. It has a wider perspective that green infrastructure, but again promotes the idea that managing this stock is critical to our wellbeing and economy. Natural capital thinking is part of the five capitals model[67] and is central to the government 25 Year Plan for the Environment.

[66] (Benedict and McMahon, 2002, p12)
[67] https://www.forumforthefuture.org/project/five-capitals/overview

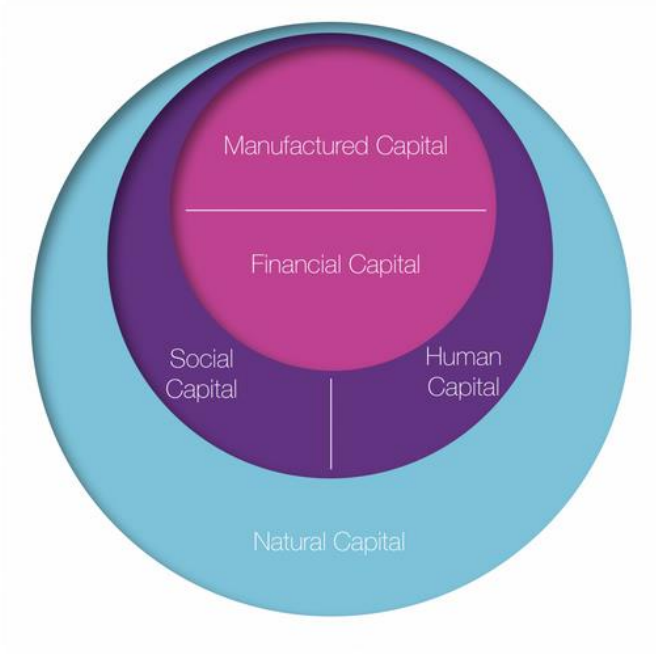

Figure 17 Five Capitals model

Ecosystem services approach is very similar to green infrastructure, but the language is much more akin to that used in ecology. It has gained less traction in policy, but has a stronger academic base than green infrastructure, partly because of its more scientific and precise language to describe the natural environment.

Ecological networks are also widely seen in policy documents and again this approach has its own language, based on landscape ecology approaches proposed and developed by Richard Forman[68].

These different languages may be confusing. However, each has its use audience and there is a need for those involved in planning and delivering projects and programmes to be multi-lingual, adapting the language to suit the target audience.

For this Audit, the language of green infrastructure is used, reflecting key local and national policy and placing the audit in the realm of infrastructure planning alongside other critical infrastructures. More information on the approach is set out in Appendix 1.

Green infrastructure principles

Eight principles of green infrastructure planning, design and implementation have been proposed[69]:

[68] https://books.google.co.uk/books/about/Landscape_Ecology.html?id=ZvNEVs2MWqcC&redir_esc=y

- Identify and protect green infrastructure assets
- Engage diverse people and organisations from a range of sectors
- Linkage is key, connecting green infrastructure components with each other and with people
- Design green infrastructure systems that function at different scales and across boundaries
- Green Infrastructure activity must be grounded in good science and planning practice
- Fund green infrastructure up-front as a primary public investment
- Emphasise green infrastructure benefits are afforded to all; to nature and people
- Green infrastructure should be the framework for natural environment projects and programmes.

[69] Benedict, M.A. and McMahon, E.T. (2000) Green Infrastructure. Linking Landscapes and Communities. Island Press, Washington.

Describing green infrastructure

A standard approach to describing green infrastructure has developed by The Mersey Forest Team. It is based on a model that describes green infrastructure in terms of:

Types – A description of the elements that make up an area's green infrastructure. In developing a typology, PPG17[70] was been used as a starting point, with the addition of a number of additional types so that all land cover is included. For each green infrastructure type a range of functions can be identified.

Functions - Green infrastructure functions describe what the green infrastructure type does; it could range from intercepting water to reducing noise. In all, 28 functions have been identified. A particular green infrastructure type may have several functions. One of the aims of green infrastructure planning is to achieve high levels of multi-functionality where possible.

Benefits - Green infrastructure planning is set firmly in a context of public benefit. There are many ways of identifying and categorising benefits. Work by Natural Economy Northwest[71] developed a model of eleven benefits. Each of the benefits is achieved through a mix of GI functions. For example, the flood alleviation and water management benefit are provided by four functions – water conveyance, water storage, water interception and evapotranspiration. It is also the case that each of these functions may contribute to several other benefits.

[70] Recognising that PPG 17 has been superceded by the National Planning Policy Framework, it still provides a useful starting point for developing the green infrastructure typology and has the advantage of having been used to develop current policies and strategies.
[71] Ecotec and NENW (2008) The economic benefits of Green Infrastructure: The public and business case for investing in Green Infrastructure and a review of the underpinning evidence. Available at: http://www.naturaleconomynorthwest.co.uk/resources+reports.php

Figure 18 Economic benefits provided by green infrastructure

Values – It is important to be able to show the value of green infrastructure in monetary terms so that it can be compared to other potential investments.

At present this involves identifying the economic value of a project or intervention in order to be able to compare investments and their likely return. This "market mimicking" approach to the natural environment can be controversial, but it does enable a debate about the value that may be delivered through green infrastructure investments and for comparison with other values.

The UK Treasury Green Book[72] recognises that not all environmental benefits can be monetised. Techniques have been developed and are developing to enable economic value to be ascribed to GI[73].

The Green Infrastructure Valuation Toolkit developed by a range of partners across England can be used to help to calculate indicative economic values for green infrastructure.

The toolkit itself recognises the limitations in the evidence base and the need for care to avoid issues such as double counting and ignoring additionality. It does however represent the one of the best tools available at present for a relatively quick, indicative assessment of green infrastructure value, without having to fund a fully cost-benefit assessment[74].

Economic value from green infrastructure may be delivered in a number of ways;

- **Direct** - Direct jobs and business development from the creation and management of green infrastructure
- **Indirect**- Green infrastructure creating the setting for jobs and investments (Quality of Place and Quality of Life)
- **Reducing Cost** - By using a green infrastructure approach as an alternative, for instance, to traditional "grey infrastructure" approaches
- **Reducing Risk** - Green infrastructure mitigating or adapting an area for a given risk (not just climate change risk)

The logic chain used to describe green infrastructure from type to value is shown in Figure 19. It is possible to trace value delivered from green infrastructure back to a particular type of green infrastructure, but importantly, and in line with our definition of green infrastructure as a system; the relationships between type and function or function and benefits are not merely simple one to one relationships but are more complicated and commonly relationships are "many to many."

[72] HM Treasury (2010) The Green Book, Appraisal and Evaluation in Central Government TSO, London. Available at: http://www.hm-treasury.gov.uk/d/green_book_complete.pdf
[73] Genecon (2010) Green Infrastructure Valuation toolbox. Available at: http://www.genecon.co.uk/projects/green-infrastructure-valuation-toolbox.aspx
[74] https://www.forestry.gov.uk/fr/urgc-7etczh

Figure 19 Green Infrastructure Logic Chain

Data sources used for GI-Val are provided in the Technical Appendix. Technical Appendix 1 – Data sources for green infrastructure mapping of Cheshire East

Appendix 3 Evidence

1.1.1 Green environment for retail

Green infrastructure can play a role in creating a pleasant environment in city centres, which increases footfall and revenue in retail areas. Shoppers claim that they will spend 9% to 12% more for goods and services in central business districts having high quality tree canopy[75]. Shoppers indicate that they will travel greater distance and a longer time to visit a district having high quality trees and spend more time there once they arrive.[76]

1.1.2 Attracting and retaining skilled and productive workforce

Quality of life is becoming an increasingly important consideration in modern business location decisions, in particular in the high-tech and knowledge industries, and cities with attractive parks and natural surroundings are more likely to attract knowledge workers[77]. In particular for small businesses and individuals on high salaries, the quality of life becomes more important than remuneration (potentially 40% of decisions can be based on quality of life indicators)[78]. Greener settings not only attract but also help to retain workers: businesses located next to green spaces in Glasgow recorded improved staff morale and staff retention rates due to the attractiveness of the location[79]. Green infrastructure also improves productivity: office workers who enjoyed a natural view out of the window reported fewer physical ailments and greater job satisfaction compared to those workers without a view[80]. Even the presence of office plants may increase the speed of completing tasks, lower levels of stress and improve attention[81].

75 Wolf, K.L. 2010. Community Economics - A Literature Review. In: Green Cities: Good Health (www.greenhealth.washington.edu). College of the Environment, University of Washington

76 Wolf, K.L. (2005) Business District Streetscapes, Trees, and Consumer Response. Journal of Forestry. 103, 8, pp. 396- 400.

77 Crompton JL (2007) Competitiveness: Parks and Open Space as Factors Shaping a Location's Success in Attracting Companies, Labor Supplies, and Retirees in de Brun C (Ed.) The economic benefits of land conservation. The Trust for Public Land, pp.48-54.

78 Shapiro, J.M. (2006) Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital. The Review of Economics & Statistics, 88, 2, pp. 324-335.

79 Gen Consulting (2006) Glasgow Green Renewal Benefits Analysis. A report to Glasgow City Council. Gen Consulting, Glasgow.

80 Kaplan R (1993) The role of nature in the context of the workplace. Landscape and Urban Planning 26: 193-201.

81 Lohr VI, Pearson-Mimms CH & Goodwin GK (1996) Interior plants may improve worker productivity and reduce stress in a windowless environment. Journal of Environmental Horticulture 14: 97-100.

1.1.3 Attracting investment and increasing employment

The presence of high quality green infrastructure can improve the 'investability' of an area and its competitiveness as a business location[82,83]. A survey of real estate developers and consultants across Europe found that 95% of respondents believe that open space adds value to commercial property, and they would be willing to pay at least 3% more to be in close proximity to open space[84]. Research focusing on the construction sector in the UK illustrates a comparable willingness by investors to include green infrastructure in their development due to the added rental/sales returns they generate[85]. An example of returned investment in green infrastructure can be seen in Riverside Park Industrial Estate in Middlesbrough, where extensive planting of trees helped to create a setting for stimulating business growth, which attracted new, high profile, occupants; increased occupancy from 40% to 78%; levered over £1m of private investment; and saw 28 new businesses and more than 60 new jobs created[86]. Landscaping improvements in Portland Basin, Tameside and Winsford, Cheshire yielded respectively over 16% and 13% of net growth in employment[87]. Furthermore, green infrastructure could help to make towns more attractive for investment and increase the profitability of businesses by increasing staff productivity. A number of studies have demonstrated this latter effect[88], which operates through improved health, stress alleviation, and attracting and retaining motivated people.

1.1.4 Higher property prices in greener areas

Many studies have looked at the impact of green infrastrucrture on property value in urban areas. All have found that green infrastructure increases value[89]. In North West England, a view of a natural landscape added up to 18% to property value, and residents in peri-urban settings are willing to pay £7,680 per household for views of broadleaved woods[90]. The development of a community woodland on the former Bold Colliery site in St Helens have enhanced existing

82 BE Group (2014) Green Infrastructure - Added Value - http://www.merseyforest.org.uk/BE_group_green_infrastructure.pdf

83 CABE (2004) The Value of Public Open Spaces. Commission for Architecture and the Built Environment, London.

84 Gensler and Urban Land Institute (2011) Open Space: an asset without a champion? Available at: http://www.gensler.com/uploads/documents/Open_Space_03_08_2011.pdf

85 Payne, S. & Baker, A. (2015) Implementing green infrastructure through residential development in the UK. In: Sinnett, D., Smith, N., & Burgess, S. (Eds) (2015) Handbook on Green Infrastructure: Planning, design and implementation. Pp. 375-394. Cheltenham, Edward Elgar Publishing.

86 CLES POLICY ADVICE. 2007. The Contribution of the Local Environment to the Local Economy presented to Groundwork UK.

87 BE Group (2014) Green Infrastructure-Added Value-http://www.merseyforest.org.uk/BE_group_green_infrastructure.pdf

88 Other issues include the effectiveness and economic impact of worksite interventions to promote physical activity and healthy diet. World Health Organisation, 2008; Windows and Offices: A Study of Office Worker Performance and the Indoor Environment, California Energy Commission, 2003

89 Davies, H., Doick, K., Handley, P., O'Brien, L., and Wilson, J. (2017). Delivery of ecosystem services by urban forests Forestry Commission Research Report Forestry Commission, Edinburgh. i–iv + 1–28pp.

90 Cousins and Land Use Consultants (2009). Economic contribution of green networks: current evidence and action. North West Development Agency, Manchester.

property values in the surrounding area by £15 million[91]. Research in central Manchester highlighted willingness to pay higher local taxes that could contribute over £4 million per annum when extrapolated to the city scale[92]. In Aberdeen, properties next to a park can attract a premium of 0.4%-19% compared to a property located 450m away from a park[93]. Trees have been reported to add between 4% and 25% to the total value of property, depending on their size, condition, location and species[94, 95]. Another study found that high quality green infrastructure can boost property values by up to 20%[96]. Overall, green areas are vital to the UKs economic competitiveness:

A view of a park was shown to raise house prices by 8 per cent and having a park nearby by 6 per cent[97]. This compares with a view of an apartment block, which can reduce the price by 7 per cent[98]

The Chartered Association of Building Engineers (2004) as citing Luttik (2000)

This is likely due to the multiple benefits that trees provide: they make an area more visually attractive, but also reduce air pollution and provide a variety of microclimates that can make an area more comfortable (especially shade in summer). Our understanding of the existing housing stock, local amenities, and development trends all need to be accounted for before assessing the added-value of investment in NBS and green infrastructure to generate valid results[99].

1.1.5 High quality gateways to the city

The visual amenity of green space can create attractive gateways to the city, which is often a key first impression for investors. Pleasant journeys to and from work also contribute to a higher

91 Forestry Commission (no date) Bold Colliery Community Woodland. District Valuer's report on Property Values. Forestry Commission

92 Mell, IC., Henneberry, J, Hehl_Lange, S. & Keskin, B. (2013) Promoting urban greening: Valuing the development of green infrastructure investments in the urban core of Manchester, UK. Urban Forestry & Urban Greening. 12, 3, pp. 296-306.

93 Dunse N, White M & Dehring C (2007) Urban parks, open space and residential property values. RICS Research Paper Series. RICS, London.

94 Regeneris Consulting (2009) The economic contribution of the Mersey Forest's objective one-funded investments. Regeneris Consulting. Available at: http://www.merseyforest.org.uk/pages/displayDocuments.asp?iDocumentID=246.

95 CTLA (2003) Summary of tree valuation based on CTLA approach. Council of Tree and Landscape Appraisers.

96 BE Group (2014) Green Infrastructure – Added Value. Available at: http://www.merseyforest.org.uk/BE_group_green_infrastructure.pdf

97 CABE (2004) The Value of Public Space: How high quality parks and public spaces create economic, social and environmental value: http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/files/the-value-of-public-space.pdf

98 Luttik, J. (2000) 'The value of trees, water and open spaces as reflected by house prices in the Netherlands'. Landscape and Urban Planning, Vol. 48, pp161-167.

99 Mell, IC., Henneberry, J., Hehl-Lange, S. & Keskin, B. (2016) To green or not to green: Establishing the economic value of green infrastructure investments in The Wicker, Sheffield. Urban Forestry & Urban Greening, 18, pp. 257-267.

quality of life of residents and reduced stress levels[100,101]. Commercial developments alongside major roads leading to the city that contain trees are generally preferred to both developments without trees and undeveloped agricultural land without trees[102].

1.1.6 Cost-benefit of green vs. grey infrastructure

Evidence from the UE, North America and increasingly Asia the added-value that green infrastructure can deliver to urban landscapes. This can be in the form of increased house prices, reduced health costs, improved resilience to climate change or the promotion social interactions103. Where investment in green infrastructure occurs it, generally, is cheaper to implement, cheaper to maintain and provides a greater number of affordances for uses that more traditional grey/built infrastructure[104]. Moreover, the ongoing costs of maintaining green space is significantly lower than comparable engineered investments, especially in terms of water/flood management[105]. However, engineers and developers remain reluctant to transfer their focus onto green infrastructure because the evidence is less grounded and more contemporary. There is a significant body of research though that identifies using cost-benefit analysis the returns that can be generated by investment in green infrastructure[106]

1.1.7 Reducing flood risk

Investing in green infrastructure to manage pluvial and fluvial resources is central to mainlining the functionality of our cities. Working with Environment Agency, water utilities companies and Local Authorities urban greening can be used to developed innovative sustainable drainage systems that work at the local, city and regional scale. This includes the use and creation of water bodies of flood event sinks and locations for supplying water to urban areas[107]. Green

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100 Regeneris Consulting (2009). The economic contribution of the Mersey Forest's objective one-funded investments. Regeneris Consulting. Available at: http://www.merseyforest.org.uk/pages/displayDocuments.asp?iDocumentID=246.

101 Antonson, H., Mårdh, S., Wiklund, M. & Blomqvist, G. (2009) Effect of surrounding landscape on driving behaviour: A driving simulator study. Journal of Environmental Psychology, 29, 4, pp. 493-502.

102 Crompton JL (2007) Competitiveness: Parks and Open Space as Factors Shaping a Location's Success in Attracting Companies, Labor Supplies, and Retirees in de Brun C (Ed.) The economic benefits of land conservation. The Trust for Public Land, pp.48-54.

103 James et al. (2009) Towards an integrated understanding of green space in the European built environment. Urban Forestry & Urban Greening. 8, 2, pp. 65-75.

104 South Yorkshire Forest Partnership & Sheffield City Council (2012) The VALUE Project: The Final Report. Sheffield, South Yorkshire Forest Partnership & Sheffield City Council.

105 Naumann, S,. Davis, M., Kaphengst, T., Pieterse, M. & Rayment, M. (2011) Design, implementation and cost elements of Green Infrastructure projects. Final report to the European Commission, DG Environment, Contract no. 070307/2010/577182/ETU/F.1. Ecologic institute and GHK Consulting

106 New York City Environmental Protection (2010) NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways. New York, New York City Environmental Protection.

107 Benedict, MA. & McMahon, ET. (2006) Green Infrastructure: Linking Landscapes and Communities. Washington DC, Island Press.

infrastructure can also be used to develop targeted woodland planting where it can "Slow the Flow" and act as seasonal biodiversity hubs as seen in the Chicago Wilderness project[108]. The development of Urban Catchment Forestry approaches can maximise the value of urban trees for flood risk reduction and are increasingly being scoped to address flooding in coastal and terrestrial areas such as Liverpool[109]. Moreover, following extensive flooding in Cumbria, JBA consulting and Lancaster University undertook dynamic modelling of the Eden, Kent and Derwent catchments and found:

The combined effects of enhanced wet canopy evaporation, infiltration and surface roughness associated with the addition of deciduous trees to key locations in the landscape produced significant reductions to flood peaks even for an event as extreme as Desmond [110]

1.1.8 Managing runoff

Green infrastructure intercepts, infiltrates, stores and evaporates rainwater, thereby reducing the rate and peak volume of water entering drains and limiting the risk of them being overwhelmed during extreme rainfall. Peri-urban and even rural woodlands (in the riparian zone and floodplain) can contribute to flood alleviation in urban areas by delaying the downstream passage of flood flows[111].

Green infrastructure can play a part in reducing flood risk, especially in dealing with the increased risk likely to be caused by climate change. Trees can play a role in intercepting rain, channelling rainwater into the soil and also "slowing" the flow of water in an area; reducing surges on sewer systems[112]. Trees with larger canopies are most effective at intercepting water[113,114]. Individual tree canopies can intercept as much as 79% of a 20mm, 24-hour rainfall

108 Mell, IC. (2016) Global Green Infrastructure: Lessons for successful policy-making, investment and management. Abingdon, Routledge.

[109] The Mersey Forest (nd) http://www.merseyforest.org.uk/our-work/urban-catchment-forestry/

[110] Hankin et al (2016) The Rivers Trust Life-IP Natural Course Project: Strategic Investigation of Natural Flood Management in Cumbria. http://naturalcourse.co.uk/uploads/2017/04/2016s4667-Rivers-Trust-Life-IP-NFM-Opportunities-Technical-Report-v8.0.pdf

[111] Forest Research (2010) The case for trees in development and the urban environment. Bristol, Forestry Commission

[112] Davies, H., Doick, K., Handley, P., O'Brien, L., and Wilson, J. (2017). Delivery of ecosystem services by urban forests Forestry Commission Research Report Forestry Commission, Edinburgh. i–iv + 1–28pp.

113 Nisbet, T. (2005) Water Use by trees. Forestry Commission Information Note, Forestry Commission, Edinburgh

event under optimum, full leaf conditions[115] A single young tree planted in a small pit over an impermeable asphalt surface can reduce runoff by around 60%, even during the winter when it is not in leaf[116]. Tree roots can increase infiltration rates in compacted soils by 63%, and in severely compacted soils by 153%[117]. Increasing tree cover by 10% in built-up town centres can reduce runoff from an 18mm rainfall event by 8%[118]. Urban runoff is a source of urban diffuse pollution, containing pollutants such as metals and chemicals from road transport, faecal matter from animal fouling, and sediment[119]. Trees in biofiltration systems resulted in significant reductions of soluble nitrogen and phosphorus in storm water, compared to unplanted controls; reducing nitrate plus nitrite (NO-2) by 2-78% and reactive phosphorus by 70-96% (PO43-), depending on the soil profile120. Suggesting capabilities to filter faecal pollution and dry nutrient deposition from exhausts and industry, biofilm and heterotrophic process may reduce nutrient concertation too. 121. The annual storm water benefit of an urban tree is $34 (equivalent to £26) from a sample of 17 US cities122, with cities including Chicago and Philadelphia gaining significant benefits from investment in urban green infrastructure123,124. A hectare of grassland and broadleaved woodland in the UK can also help evaporation of 3.4 and 4.0 million litres of water respectively[125]. Modelling conducted on Manchester shows that adding 10% of green space can

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[114] Inkiläinen, E.N.M., McHale, M.R., Blank, G.B., James, A.L. & Nikinmaa, E. (2013) The role of the residential urban forest in regulating throughfall: A case study in Raleigh, North Carolina, USA. Urban Forestry & Urban Greening, 119, 91-103.

[115] Xiao and McPherson (2003). Rainfall interception by Santa Monica's municipal urban forest. Urban Ecosystems, 6: 291–302.

[116] Armson et al (2013). The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK. Urban Forestry Urban Greening, 12: 282–286.

[117] Bartens et al (2008). Can urban tree roots improve infiltration through compacted subsoils for stormwater management? Journal of Environmental Quality, 37 (6): 2048-2057.

[118] Gil, S.l (2006). Climate change and urban green space. PhD thesis, University of Manchester.

[119] Defra (2012). Tackling water pollution from the urban environment: Consultation on a strategy to address diffuse water pollution from the built environment.

[120] Denman et al (2012). The use of trees in urban stormwater management. Trees, people and the built environment. Proceedings of the Urban Trees Research Conference. 104-112.

[121] Denman et al (2012). The use of trees in urban stormwater management. Trees, people and the built environment. Proceedings of the Urban Trees Research Conference. 104-112.

[122] Averaging data from 17 US cities presented on p11 of: US EPA (2013). Stormwater to Street Trees – Engineering urban forests for stormwater management.

[123] Chicago Wilderness (nd) http://www.chicagowilderness.org/index.php

[124] Philadelphia Water Department (2011) Green City, Clean Waters: The City of Philadelphia's Program for Combined Sewer Overflow Control. Philadelphia, Philadelphia Water Department.

[125] Hölzinger O (2011) The Value of Green Infrastructure in Birmingham and the Black Country. The Total Economic Value of Ecosystem Services provided by the Urban Green Infrastructure. The Wildlife Trust for Birmingham and the Black Country.

reduce runoff by 5-6%[126]. Several of these options can be scaled up from the site, i.e. an individual buildings or streets to become wider neighbourhood initiatives and provide important management strategies, especially in locations with variable rainfall or climates.

1.1.9 Reducing the risk of river and coastal flooding

The risk of flooding from rivers can be reduced by a series of measures, for rivers they can be restored in channel or through their connected floodplain, through leaky barriers and through offline attenuation areas. River restoration measures create space for water, allowing water to spill out of banks and sometimes into palaeo or relict river channels, leaky dams attenuate peak flows and levels, forcing water onto the floodplain before it would otherwise travel downstream.

Trees increase the capacity of the soil to absorb water. A modelling study in Somerset showed that planting woodland along a 2.2 km grassland reach of the River Cary could reduce water velocity by 50%, increase the temporary water retention by 71% and delay the downstream progression of the flood peak by 140 minutes[127]. Restoring riparian forest cover over 20-40% of one catchment area reduced flood peak magnitude by up to 19%, whilst engineered log jams to hold back flow increases or decreases peak flows by 6%[128]. Salt marshes also help to dissipate wave energy before it reaches the shore, and it has been estimated that an 80m-wide zone of inter-tidal habitat fronting sea walls can save £4,600 per metre in sea defence costs.[129]

1.1.10 Maintaining sustainable water supplies

Water Sensitive Urban Design can also help to increase groundwater recharge through porous paving systems and detention ponds allowing water to reach, de-compact and infiltrate the soil[130]. The maintenance of water supply of an appropriate quality and quantity is important in providing a reliable service for homes and businesses. Sustainable drainage and the intervention of green infrastructure in and on homes, businesses and on municipal infrastructure will provide

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[126] See Gill et al. (2007)
[127] Thomas H & Nisbet TR (2006) An assessment of the impact of floodplain woodland on flood flows. Water and Environment Journal 21: 114-126
[128] DIXON, S.J., SEAR, D.A., ODONI, N.A., SYKES, T. AND LANE, S., 2016. The effects of river restoration on catchment scale flood risk and flood hydrology. Earth Surface Processes and Landforms, 41 (7), 997-1008.
[129] Collins T, Empson B, Leafe R & Lowe J (1997) Sustainable flood defence and habitat conservation in estuaries - a strategic framework. . In Proceedings of the 32nd MAFF Conference of River and Coastal Engineers. University of Loughborough, July 2-4, 1997
[130] Carter T & Butler C (2008) Ecological impacts of replacing traditional roofs with green roofs in two urban areas. Cities and the Environment 1: 9-17.

options to intercept, retain and release of rainfall and runoff in a controlled manner[131]. Natural water retention measures have been observed to increase groundwater table considerably, suggesting that Runoff Attenuation Features (RAFs) and trees together can recharge groundwater supplies[132,133].

NFM also aids municipal water planners and utilities companies to manage flow through a greater awareness of the added-capacity that natural systems can provide in support of engineered solutions[134]

1.2 Health

Cities the provide opportunities for its population to engage with its landscape are considered to be healthier and more sustainable[135]. Whilst a one-size fits all solution is unviable in most cities there is scope to characterize what a healthy city should be and what green infrastructure can do to assist in this process[136].

1.2.1 Better mental health

The cost of stress to the UK economy stood at £6.8bn in 2014, with ACAS figures reporting that mental ill-health (including stress, depression and anxiety) caused 91 million lost working days each year, with sickness absence costing £8.4 billion each year, £15.1 billion loss in reduced productivity, and £2.4 billion in the cost of replacing lost staff137. The World Health Organisation

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[131] Williamson, K. (2003) Growing with Green Infrastructure. Doylestown, Heritage Conservancy.
[132] Hut, R, Ertsen, M, Joeman, N, Vergeer, N, Winsemius, H, Van de Giesen, N. 2008. Effects of sand storage dams on groundwater levels with examples from Kenya. *Physics and Chem-istry of the Earth*. ***33:*** 56 – 66
[133] Mack, TJ., Chornack, MP, Vining, KC, Amer, SA, FahimZaheer, M, Meldin, JH. 2014. Water Resources Activities of the U.S. Geological Survey in Afghanistan From 2004 Through 2014. United States Geological Survey. Fact Sheet 2014–3068; USGS Afghanistan Project Product No. 265. Available at: https://pubs.usgs.gov/fs/2014/3068/pdf/fs2014-3068.pdf (Accessed: 12th February 2017).
[134] Falkenmark, M. & Rockström, J. (2006) The New Blue and Green Water Paradigm: Breaking New Ground for Water Resources Planning and Management. Journal of Water Resources Planning and Management, 132, 2, pp. 129-132.
[135] Tzoulas et al. (2007) Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning, 81, 3, 167-178.
[136] Kabisch et al. (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21, 2, 39.
[137] Zehndorfer, E., Mackintosh, C. & Darko, N. (2016) Outdoor recreation as a potential lever for health improvement: A review of the health benefits, barriers and opportunities for the sector: Evaluation Report. Manchester, Manchester Metropolitan University.

forecasts depression to be the second greatest health concern globally by 2020. Contact with nature in green space has been shown to reduce stress and improves attention[138], whilst unsatisfactory access to green space had been found to be related to mental ill-health by a study in Greenwich, London[139]. Research investigating residents in a Swedish town found that the more often a person visits urban open green spaces, the less often they will experience stress related illnesses[140]. Playing in green spaces and living in greener areas has also been shown to have a beneficial impact on the levels of concentration and the ability to focus attention of children[141,142,] thereby improving their performance at school. Lower levels of stress associated with the use of green space enable people do cope better with major life issues, such as the effects of poverty in low-income areas of Chicago[143]. There is also an evidence for synergistic physical and mental health improvements related to contact with nature discussed through the notion of interaction and 'environmental affordances'[144]. For example, patients recovering from a surgical procedure were found to heal much quicker and require less painkillers if they had a view of nature out of their window compared to those without such a view[145].

1.2.2 Mental health of young people

There is a growing evidence base to support the proposal that contact with nature increases resilience against stress, anxiety and irritability, along with other factors that may cause young people to develop mental health disorders[146] (see Maller et al., 2008 for a synthesis of relevant

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[138] Kaplan R & Kaplan S (1989) The experience of nature: A psychological perspective, Cambridge University Press.

139 Guite HF, Clark C & Ackrill G (2006) The impact of the physical and urban environment on mental well-being. Public Health 120, 1117-1126.

[140]Grahn P & Stigdotter UA (2003) Landscape planning and stress. Urban Forestry and Urban Greening 2: 1-18.

[141] Taylor AF, Kuo FE & Sullivan WC (2001) Coping with ADD: The surprising connection to greenplay settings. Environment and Behavior 33: 54-77.

[142] Wells NM (2000) At home with nature: effects of "greenness" on children's cognitive functioning. Environment and Behavior: 32: 775-795.

[143] Kuo F E (2001) Coping with poverty: impacts of environment and attention in the inner city. Environment and Behaviour 33, 5–34.

[144] Louv, R. (2005) Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder. Chapel Hill, Algonquin Books

[145] Ulrich RS (1984) View through a window may influence recovery from surgery. Science 224: 420-421.

[146] Pretty et al. (20106) the mental and physical health outcomes of green exercise. International Journal of Environmental Health Research, 15, 5, pp. 319-337.

evidence[147]). However, limited information on how specific elements of nature deliver health outcomes restricts its use for enhancing population health (Shanahan et al 2014). As a consequence, mental health disorders have become a major issue in modern society as their prevalence was significantly underestimated historically (1). Mental disorders in young people, in particular, have grown in significance and with up to 20% of young people suffering at any one time, both in Europe and worldwide (3, 4). Common disorders found in populations of young people include anxiety, depression and behavioural disorders (Mental health stats, 6); with these issues increasing consistently over the last few decades (7). Young people suffer from mental health disorders usually due to a combination of biological, psychological and social factors, which can range from genetic tendencies and illnesses to academic failure, destructive lifestyles and bullying (7). Human disconnection with nature is related to poorer health[148]. The influence of chronic stress on depression appears definitive [149], [150], with research suggesting that depressive symptoms intensify during periods of persistent stress[151]. Chronic stress may also be a precursor to anxiety disorders (Bernstein, 2015), which is supported by prevalence rates[152]. Chronic stress can also worsen disease progression across a number of non-communicable conditions according to the World Health Organisation (WHO). The degree of comorbidity between chronic stress, anxiety and depression is extremely high[153] and this association is strengthened by chronic environmental stressors. Those living in deprived areas are exposed to a higher risk of depression compared to those living in more affluent regions[154,155]. Contact with

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nature through the medium of green space encourages psychological well-being[156] and can lessen the negative impact of a stressful life[157]. Moreover, research[158] has explored how stress can be reduced through access to nature, where results indicated a significant relationship between the quantity of green space within the local environment, self-reported stress and cortisol levels. It was concluded that providing green space in deprived communities may enhance well-being[159]. Adding to this, the more individual visits green space, the less they will report stress[160]. Furthermore, if individuals have access to green space locally within their neighbourhood, the advantageous effects are enhanced. The distance between areas of residence and green zones is equally important in predicting levels of stress[161].

1.2.3 Forest school and health

A range of Forest School outcomes have been identified, including positive learning dispositions, strengthened self-esteem and enriched children's practices in the early years162. Forest School provides opportunities for children to develop confidence and self-esteem through their experiences. For example, adults using the Forest School approach in schools and early year settings have reported that quiet children aged 5 to 11 years had an increased ability to express themselves and had improved confidence[163]. Further research[164] conducted in the UK evaluated children attending Forest School sessions using observations conducted by the Forest School leaders over an 8-month period. The observations indicated that children's self-esteem and confidence increased. Notably, positive changes in children's language and communication

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[157] van den Berg, Maas, Verheij & Groenewegen (2010) Green space as a buffer between stressful life events and health. Social Science & Medicine, 70, 8, pp. 1203-1210.
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[159] Roe et al. (2013) Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities. International Journal of Environmental Research and Public Health, 10, 9, pp. 4086-4103.
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[163] O'Brien, L. (2009) Leaning ourdoors: the Forest School approach. Education 3-13: International Journal of Primary, Elementary and Early Years Eudcation, 27, 1, pp. 45-60.
[164] O'Brien, L. & Murray, R. (2007) Forest School and its impacts on young children: Case studies in Britain. Landscape and Urban Planning, 6, 4, pp. 249-265.

skills, improvements in physical motor skills and a greater knowledge, care for and understanding of the environment were observed during the Forest School program[165]. Research has also been conducted with primary school-aged children to explore their thoughts, perceptions, and experiences of Forest School. Overwhelmingly, children typically report positive experiences and that Forest School is enjoyable and fun to do[166,167]. Broad Futures and Norfolk County Council reported that teachers viewed Forest School as a 'child-led approach [that] build confidence, encourages creativity and promotes independence which are essential skills for learning and for life' (p.11).

The restorative effects of Forest School for children and young people have also been investigated. Changes to positive participation were demonstrated during Forest School sessions by higher levels of verbal communication with peers reported by teachers[168], whilst increases in social interactions, self-esteem and concentration have been noted in children with special educational needs and shy children[169]. One study reported that Forest School provided an optimal learning environment, whereby children's wellbeing and involvement levels were very high during Forest School sessions, subsequently supporting children's learning as well as their wider developmental needs[170]. The results of this study were particularly pertinent for those children who had low school academic achievement levels. Roe and Aspinall[171] found that teenagers classified as having 'good' and 'bad' behaviour by the schools benefitted from Forest School sessions, with those in the 'bad' behaviour group including those with ADHD, those at risk of exclusion or those exhibiting withdrawn behaviour, experiencing optimal benefits in particular. Forest School could, therefore, facilitate the management of challenging behaviours, and/or positively influence health and wellbeing. The Mersey Forest and the Physical Activity Exchange

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[165] O'Brien, L. & Murray, R. (2007) Forest School and its impacts on young children: Case studies in Britain. Landscape and Urban Planning, 6, 4, pp. 249-265.

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[170] Kenny, R. (2010) Involve, Enjoy, Achieve: Forest School and the Early Years Foundation Stage – An Exploratory Case Study. Bath: Bath Spa University.

[171] Roe, J. & Aspinall, P. (2011) The restorative outcomes of forest school and conventional school in young people with good and poor behavior. Urban Forestry & Urban Greening, 10, 3, 205-212.

at Liverpool John Moores University are collaborating on a Forest School study investigating whether Forest School sessions increase physical activity in children, supporting improved mental health and wellbeing[172].

In addition to the role that physical activity can play in promoting physical and mental health there is a growing discussion of how 'mindful contact' with nature as part of Forest School could also facilitate better health and well-being. To tackle chronic stress, mindfulness-based interventions (MBIs) aim to focus an individual on their moment-by-moment experience[173]. As a result, they can effectively manage and respond to mental processes which trigger emotional anguish and maladaptive behaviour[174]. Furthermore, the stress-reduction techniques taught through mindfulness meditation can be utilised to help prevent relapse of major depressive disorders[175]. For the psychological advantages of green space to be enhanced, a connection with nature should be encouraged. Studies conducted by the University of Oregon[176] established that those who displayed more mindfulness traits also demonstrated a greater connection with nature, which, in turn, implemented a shift towards psychological well-being. This view has been extended to explain that a well-established relationship with nature can enhance psychological and emotional health in ways that cannot be elicited by alternative means[177]. Mindfulness therefore allows an enhanced sensory experience when present in nature, one which strengthens the connection to it. This mindfulness and nature connection positively correlates with psychological well-being[178]. Being connected with nature comforts the constantly thinking mind, calming its restlessness and easing concerns and allows the mind to be still and quiet is taught through MBIs, encouraging people to be mindful within nature can allow people to find peace

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[172] Austin, C., Z. Knowles, and J. Sayers. 2013. "Investigating the Effectiveness of Forest School Sessions on Children's Physical Activity Levels." The Mersey Forest in Partnership with the Physical Activity Exchange at Liverpool John Moores University.

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within themselves[179]. Therefore, nature relatedness could provide a path to reduce chronic stress[180].

1.2.4 Social well-being

Social interaction between residents of all ages in the same area develop mainly through outdoor contacts and green and open spaces such as parks and gardens attract people to use these spaces[181]. For example, CABE Space[182] discussed the collectivism of parks for South Asian and Afro-Caribbean communities in the UK, whilst neighbourhoods with open spaces in Chicago, reported that 83% more individuals engaged in social activity in green spaces than in barren spaces.[183] Furthermore, older people and families with young children are more likely to engage with other people in parks and green spaces compared to other places[184]. The use of green spaces can positively influence the quantity and strength of social relationships of diverse groups, including older adults[185], teenagers from different ethnic backgrounds[186], and female residents of social housing[187].

1.2.5 Space for exercise

A study in the UK188 found that a higher proportion of green space in an area was generally associated with better population health. Living closer to parks has thus been shown to be linked

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to increased physical activity189,190, such as walking and cycling191. Whilst the majority of the exercise in parks tends to be gentle (over 56% of park users in London simply walk or stroll)192, it still has a positive impact on people's health. A study in Tokyo shows that presence of walkable green space increases the longevity of the elderly193. In England, people who live furthest from public parks are 27% more likely to be overweight or obese, and children able to play in natural green space gain 2.5 kg less per year than children who do not have such opportunities194. There is also evidence suggesting that people are more likely to walk or cycle if streets are lined with trees195. In The Mersey Forest, the "Green Streets" programme led to a 6% increase in cycling to work from local residents[196]. Moreover, The Woodland Trust Woodland Standard suggests people should have access to a woodland of at least 2 ha within walking distance (500 m) from their home, and a woodland of at least 20 ha within 4 km of their home[197] The urban deprived and Black, Asian and Minority Ethnic groups are more likely to access urban rather than rural nature compared to other population groups[198].

1.2.6 Space to grow food

Participation in food growing projects offers a growing opportunity to increase physical activity and increase consumption of fresh fruit and vegetables. Urban allotments in the UK, USA and Italy have seen extensive uptake from local communities, and particularly from older people who

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[189] Kaczynski A & Henderson KA (2007) Environmental correlates of physical activity: A review of evidence about parks and recreation. Leisure Sciences 29: 315-354.

190 Coombes E, Jones A & Hillsdon M (2010) The Relationship Of Physical Activity And Overweight To Objectively Measured Green Space Accessibility And Use. Social Science And Medicine 70: 816-822.

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have benefited from the physical exercise and social interactions[199],[200]. Moreover, psychological benefits are possible, due to contact with nature, increased serotonin through sunlight exposure, sense of achievement, and enhanced social networks.[201]

1.2.7 Improving air quality

In 2012 the Woodland Trust published an extensive evidence-based review related to urban air quality[202]. Trees are very effective at removing pollutants which are harmful to human health from the atmosphere, as they absorb gases including as ozone, nitrogen dioxide, sulphur dioxide, and help to deposit pollutant particles smaller than 10 microns in diameter (PM10)[203]. Up to 70% of air pollution in cities can be filtered out by investments in street trees[204]. For example, doubling the number of trees in the West Midlands would reduce excess deaths due to particulate pollution by up to 140 per year[205]; just 5% of green space including trees within a 10 x 10 km^2 of East London could significantly reduce particulate pollution with an estimated effect of two deaths and two hospital emissions avoided per year[206]. Furthermore, the positioning of trees, with consideration of local air flows including along arterial roads within cities significantly affects the removal of pollutants from the atmosphere. In terms of health benefits areas with street trees have been found to reduce the incidence of childhood asthma[207]. As well as filtering pollution from the atmosphere, trees also produce Volatile Organic Compounds (VOCs), which in

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certain conditions can cause increases in ozone pollution. The Urban Tree Air Quality Score attempts to balance the pollution removal and VOC emission effects of different tree species[208]. Trees in closer proximity to a pollution source will be more effective at mitigating it, thus locating trees between areas of high pollution such as roads and vulnerable areas such as playgrounds, schools, hospitals and residential areas should be prioritised[209]

1.2.8 Reducing noise

The effectiveness of vegetation in reflecting and absorbing noise depends on the density, height, length and width of planting[210]. Dense shrubs combined with trees are the most effective; up to 10 decibels/20 metres width can be achieved[211]. In less dense settings, every 33m width of forest can achieve 7 decibel noise reduction[212] . Visibility and width of a tree belt are more important for reducing noise than height and length (which become insignificant above 4 m and 50 m respectively)[213] Densely planted tree belts and deep woodlands have greater relative noise attenuation than sparsely planted trees or shallow woodlands[214].

1.2.9 A major recreation resources

Over 40% of people in England visit parks at least once a week, and only 7% never use parks[215]; 87% of the population use their local parks or open spaces regularly[216]. Urban parks in England are estimated to receive 2.6 billion visits a year[217], making parks the most frequently used public

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service[218].The majority of the public believe that parks and open spaces improve their quality of life (90%) and that they are important to physical and mental well-being (74%)[219]. This is illustrated by activities in parks: the main reasons for visiting the Royal Parks in London are 'for a walk or stroll' (54%), 'for fresh air' (33%) and 'peace and quiet' (25%), the average visit taking 72 minutes[220]. In a survey in Amsterdam, nearly three-quarters of the respondents went to parks to relax and 54% to listen and observe nature[221]. Sport is an important activity: for example, Leicester's urban green spaces were found to support 1,985 team games a year involving 54,249 men and 1,136 women[222]. However, people over 65, the disabled, black and ethnic minorities (BME groups), women and 12-19-year-olds use parks less frequently[223]. Whilst less than 10% of people in the UK do not visit parks for fear of their personal safety[224],[225] research in Leicester shows that this disproportionately affects the above groups[226].

1.2.10 Proximity of green space

The majority of visits to green spaces are made on foot[227,228], with the majority of visits being made to spaces that are less than five minutes-walk[229,230]. However, in a large proportion of UK cities, only a small proportion of people live within this distance: this was the case in Sheffield

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(36.5% of people lived close to parks)[231] and Leicester (10.3% close to a green space over 2 ha).[232] Moreover, the distribution of green space is unequal. The most affluent 20% of wards in England have five times the number of parks or general green space than the most deprived 10% of wards, and areas which are more than 98% white have 6 times as many parks as wards which are 40% non-white.[233]

1.2.11 Quality of green space

Surveys suggest that the following make for a good quality green space: vegetation and water, play opportunities, seating, toilets and shelters, good access, sport, and events[234], which give a sense of community, and allow for relaxation, escapism and contact with nature[235]. The main issues negatively affecting the use of green spaces are lack or poor condition of facilities; other users, including undesirable characters; concerns about dogs/dog mess; safety; litter, graffiti and vandalism.[236,237,238]

1.3 Climate change

As the urban form of our urban areas leads to increased changes in their climate planners, landscape architects and environmental specialists have becoming increasingly focused on adapting and mitigating our cities to climate change[239,240]. The global projections for climate change identify drier summers, with more heatwaves likely, and an increased risk of flooding in both summer and winter. They also illustrate changes in air quality and quality of life.

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[231] Barbosa O, Tratalos JA, Armsworth PR, Davies RG, Fuller RA, Johnson P & Gaston KJ (2007) Who benefits from access to green space? Landscape and Urban Planning 83: 187-195.
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1.3.1 Mitigation

Mitigation activities use green infrastructure and NBS to limit the magnitude or rate of long-term change in landscape and urban climate change, and include the following:

1.3.2 Carbon storage and sequestration

UK woodlands currently hold as much carbon as the UK emits in one year of fossil fuel burning; however, an enhanced woodland creation programme involving planting 23,200 hectares could deliver abatement of approximately 15 megatons of CO_2 per year by the 2050s[241] (10% of projected emissions at that time)[242]. Better management of woodland for fuel and timber can also reduce carbon emissions. Wood fuel is carbon neutral and timber can replace fossil fuel-based products, such as building materials[243].

Around 36.6 billion tonnes of potential CO_2 are stored in UK soils. Grassland and arable soils provide the largest storage (due to their overall size)[244]. However, peatlands contain the highest concentrations of carbon and degraded peatlands release 2.8-5.8 million tonnes of carbon a year, making peat restoration a priority[245]. Saltmarshes are also important for carbon storage and sequestration and returning 26 km^2 of coastal land to intertidal area in Humber Estuary could result in storing about 800 tonnes of organic carbon and 40 tonnes of non-organic carbon[246]. Across the UK woodlands currently provide a balance neutralizing as much carbon as the UK emits in one year from fossil fuel burning; however, an enhanced woodland creation programme involving planting 23,200 hectares could deliver abatement of approximately 15 mega tonnes of CO_2 per year by the 2050s[247], 10% of projected emissions at that time[248]. Better

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[247] Read DJ,, D.J., Freer-Smith PH,, P.H., Morison JIL,, J.I.L., Hanley, N,., West CC &, C.C. and Snowdon, P. (2009) Combating climate change - a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change. TSO, Edinburgh.

management of woodland for fuel and timber would also reduce carbon emissions: wood fuel is carbon neutral and timber can replace fossil fuel-based products, such as building materials[249].

1.3.3 Natural cooling and insulation

A study on wind sheltering by trees of a two-storey office building in Scotland predicted a reduction of 400 kg/floor area on CO_2 emissions compared to the use of natural gas was used for the heating). [250]

1.3.4 Reduced car travel

The Green Street programme in The Mersey Forest resulted in a 6% increase in walking and cycling along tree lined routes[251]. A further study in Maastricht (Belgium) highlighted that the more parks people had within their neighbourhood, the more their commuted by bicycle[252]. In the UK, from a survey of 5844 respondents, 78% agreed with the statement 'Improved traffic free footpaths and cycle routes would encourage me to walk or cycle'[253].Green infrastructure can be used to facilitate non-vehicular transport by providing alternative routes and infrastructure that links areas together and promotes a safer environment for people of all ages to cycle[254].

1.3.5 Adaptation

Adaptation techniques are complementary to mitigation activities and are used to reduce the social and ecological systems vulnerability of a resource base to changing climatic variation and global warming[255,256]. Green infrastructure and NBS can be used to adapt the ways in which we

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[248] Broadmeadow, M. and Mathews, R. (2003) Forests, Carbon and Climate Change: the UK Contribution. Forestry Commission, Edinburgh.
[249] Broadmeadow, M. and Mathews, R. (2003) Forests, Carbon and Climate Change: the UK Contribution. Forestry Commission, Edinburgh.
[250] Wang F, Hunt T, Liu Y, Li W & Bell S (no date) Reducing Space Heating in Office Buildings Through Shelter Trees. Available at: http://www.cibse.org/pdfs/8cwang.pdf.
[251] Mersey Forest (nd) http://www.merseyforest.org.uk/our-work/green-streets/
[252] Wendel-Vos W, Schuit AJ, De Niet R, Boshuizen HC, Saris W & Kromhout D (2004) Factors of physical environment associated with walking and bicycling. Medicine and Science in Sports and Exercise 36: 727-730.
[253] Green space (2010) GreenSTAT visitor survey system.
[254] Austin, G. (2014) Green Infrastructure for Landscape Planning: Integrating Human and Natural Systems. Abingdon, Routledge.
[255] Kabisch et al. (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21, 2, pp. 39.
[256] Norton et al. (2015) Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landsacpe and Urban Planning, 134, pp. 127-138.

manage cities and the practices undertaken to ensure that socio-economic and environmental resources become resilient to the stresses placed on them by changing demographic, ecological, economic and infrastructure needs. A suite of NBS and green infrastructure adaptation options are available to landscape and urban mangers including:

1.3.6 Cooling urban areas

Green infrastructure can significantly lower the temperatures in urban areas, thereby reducing the health risks to vulnerable people such as the elderly[257]. Grassed surfaces in tree shade can be 15-20°C cooler than tarmac exposed to sun, and the air temperature in tree shade can be 5-7°C lower than in the sun.[258] Urban parks with dense vegetation are on average 1°C cooler than built up areas during the day[259]. Green infrastructure and NBS therefore have the potential to help urban areas cope with increased temperatures, by providing evaporative cooling and shading. Trees with large mature canopies are especially important for their shade provision[260]. In addition, surface temperature has been shown to vary with levels of green infrastructure cover[261]. Figure 2 below illustrates the relationship between green infrastructure cover and maximum surface temperature, using both current climate data and climate change projections. Surface temperature, rather than air temperature, is used here as a proxy for the temperature that people sense in a particular area, and so how comfortable they feel. Within Figure 2 we can identify that as green infrastructure increases, the maximum surface temperature reduces, providing a mechanism for planners and urban designers to take some control of the impacts of projected climate change on the comfort of the city for residents and visitors. If temperature is to be maintained at a comfortable level, the area of green infrastructure will need to be increased.

Therefore, by increasing the amount of green infrastructure in a given location a level of moderation of increasing temperatures with climate change could be achieved. For example, the

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[257] Oven et al. (2012) Climate change and health and social care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England. Applied Geography, 33, pp. 16-24.

[258] Ennos R (2011) Quantifying the cooling and anti-flooding benefits of green infrastructure. Available at: http://www.sed.manchester.ac.uk/architecture/research/ecocities/news/documents/UoM_Roland_Ennos.pdf

[259] Bowler DE, Buyung-Ali L, Knight TM & Pullin AS (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning 97: 147-155.

[260] Amrson, D., Stringer, P. & Enoos, AR. (2012) The effect of tree shade and grass on surface and globe temperatures in an urban area. Urban Forestry & Urban Greening, 11, 3, pp. 245-255.

261 Gill, S. (2006). Climate change and urban green space. PhD thesis completed as part of the ASCCUE project, University of Manchester. Available at: http://www.ginw.co.uk/resources/Susannah_PhD_Thesis_full_final.pdf

evaporative cover of Liverpool Knowledge Quarter is approximately 30%, thus, to maintain surface temperatures at levels similar to present day hot periods green infrastructure must be increased by 10%.

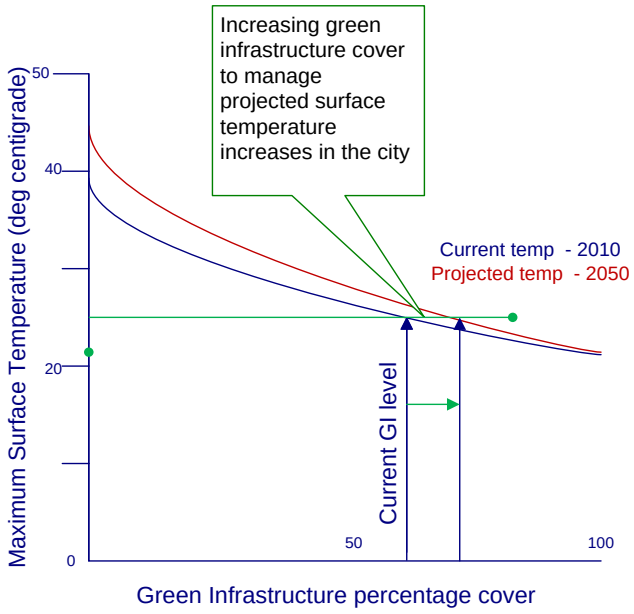


Figure 20 Relationship between green infrastructure and maximum surface temperature

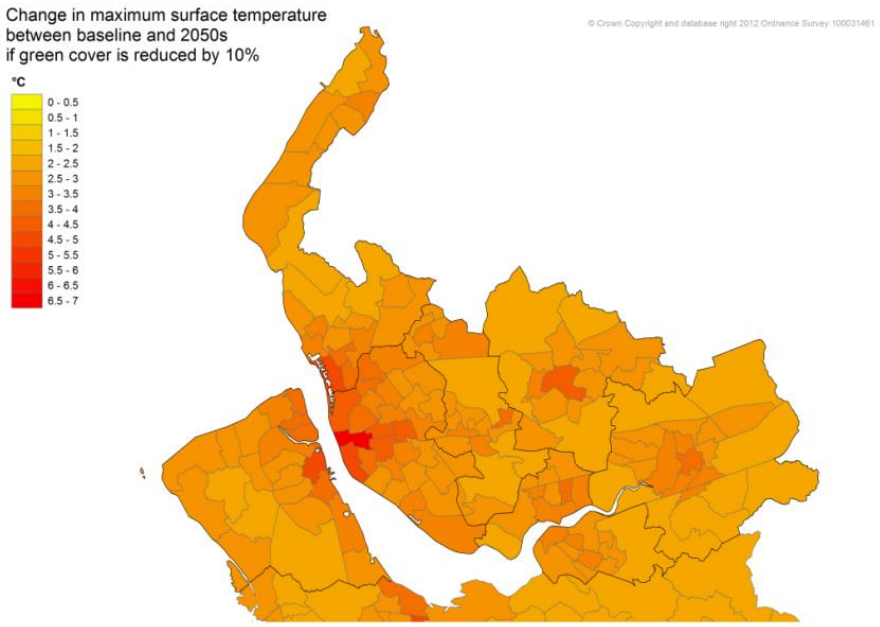
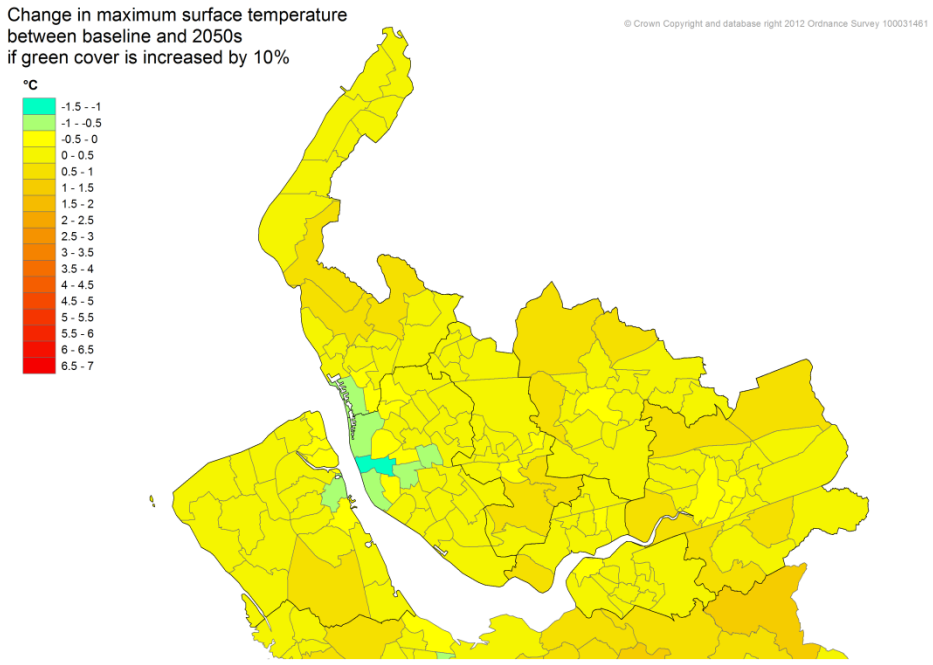


Figure 21 Change in maximum surface temperature with 10% decrease in green space coverage

In support of Gill's research, the GRaBS (Green & Blue Space adaptation for urban areas and eco towns) Interreg Project[262] developed an online assessment tool (STARS tool) that can be used to evaluate future maximum surface temperatures based on this model and the assessment of current green infrastructure. Star Tools[263] has been used to calculate temperature values for the city region and Warrington based on UK Climate Change projections. The STAR tool has been used to illustrate the impact of increasing or decreasing green cover on maximum surface temperature across Mersey Forest area (see Fig. 3 and 4 below).

Decreasing green cover by 10% increases Maximum Surface Temperature across all areas, but the increase is particularly significant in urban areas. This is important for day and night time comfort and is linked to incidence of overhearing and potentially heat wave induced deaths as seen in 2003 and 2006. In contrast increasing cover by 10% keeps temperatures close to the current levels.



[262] See Krauuse, A. (2011) GRaBS Expert Paper 6 the green space factor and the green points system. London, Town and Country Planning Association. http://nextcity.nl/wp-content/uploads/2017/01/1701256-Malmoe-Tools-c-Annika-Kruuse.pdf

[263] Mersey Forest (nd) http://maps.merseyforest.org.uk/grabs/

Figure 22 Change in maximum surface temperature with 10% increase in green space

Within this assessment grassed surfaces in tree shade can be 15-20°C cooler than tarmac exposed to sun, and the air temperature in tree shade can be 5-7°C lower than in the sun[264]. Urban parks with dense vegetation are on average 1°Ccooler than built up areas during the day[265]. Whilst research in Manchester suggests that a 10% increase of green space in densely built-up areas would reduce the urban heat island effect by 2.2-2.5% and would help to maintain the current temperatures at the end of the 21st century[266]. Using green infrastructure to manage high temperatures helps to reduce heat stress and mortality, particularly in vulnerable communities[267]. It also ensures that cities continue to be comfortable places to live, work, visit and invest in the future[268]. It should be noted that green infrastructure responses which help to manage high temperatures, can also help mitigate climate change by reducing energy use for cooling buildings[269].

Urban areas can also display an 'urban heat island' effect, where they are warmer than the surrounding countryside[270]. It is here where green infrastructure can make the biggest impact in terms of helping manage high temperatures, and is critical where vulnerable people live, where green infrastructure levels are currently lowest, and in areas where people congregate [271].

[264] Ennos, R. (2011) Quantifying the cooling and anti-flooding benefits of green infrastructure. Available at: http://www.sed.manchester.ac.uk/architecture/research/ecocities/news/documents/UoM_Roland_Ennos.pdf

[265] Bowler DE,, D.E., Buyung-Ali, L,., Knight TM, T.M. and Pullin AS, A.S. (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning 97: 147-155.

[266] Gill SE,, S.E., Handley JF,, J.F., Ennos AR &, A.R. and Pauleit, S. (2007) Adapting cities for climate change: the role of the green infrastructure. Built Environment 33: 115-133.

[267] Lafortezza, Carrus, Sanesi & Davies (2009) Benefits and well-being perceived by people visiting green spaces in periods of heat stress. Urban Forestry & Urban Greening, 8, 2, pp. 97-108.

[268] Norton et al. (2015) Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landscape and Urban Planning, 134, 127-138.

[269] Mell, IC. (2016) Global Green Infrastructure: Lessons for successful policy-making, investment and management. Abingdon, Routlegde.

[270] Center for Clean Air Policy (2011) The value of green infrastructure for urban climate adaptation. Washington, DC. Center for Clean Air Policy.

[271] Dunn, AD. (2010) Siting Green Infrastructure: Legal and Policy Solutions to Alleviate Urban Poverty and Promote Healthy Communities. Boston College Environmental Affairs Law Review, 27, 41-66.

By the 2080s, it is predicted that a heat wave similar to that experienced in England in 2003 will happen every year. The NHS Heat Wave Action Plan[272] sets out long term planning to increase green infrastructure as a key action to help to reduce the impacts of heat waves. It identifies the factors which make people more vulnerable to increased temperatures as:

Older age: especially women over 75 years old, or those living on their own who are socially isolated, or in a care home.

Chronic and severe illness: including heart conditions, diabetes, respiratory or renal insufficiency, Parkinson's disease or severe mental illness. Medications that potentially affect renal function, the body's ability to sweat, thermoregulation or electrolyte balance can make this group more vulnerable to the effects of heat.

Inability to adapt behaviour to keep cool: having Alzheimer's, a disability, being bed bound too much alcohol, babies and the very young.

Environmental factors and overexposure: living in urban areas and south facing top floor flats, being homeless, activities or jobs that are in hot places or outdoors and include high levels of physical exertion.

1.3.7 Natural cooling and insulation

Green roofs act as effective insulators[273], reducing the requirement for both heating and air-conditioning. A study on wind sheltering by trees of a two-storey office building in Scotland predicted a reduction of 400 kg/floor area on CO_2 emissions (if natural gas was used for the heating) 274. Moreover, research in the UK suggests that approximately 50% of buildings could be suitable for the retrofitting of a green roof, which would have significant impacts of energy efficiency, as well as urban heat island275. Given the variability of green roof performance in warmer climates the UK is well suited to the water and heat stresses which can be minimized

272 NHS England (2015) Heatwave plan for England: Protecting health and reducing harm from severe heat and heatwaves. London, NHS England.

[273] Kumar, R &. and Kaushik SC, S.C. (2005) Performance evaluation of green roof and shading for thermal protection of buildings. Building and Environment 40, 1505-1511.

[274] Wang, F,., Hunt, T,., Liu, Y,., Li, W &. and Bell, S. (no date) Reducing Space Heating in Office Buildings Through Shelter Trees. Available at: http://www.cibse.org/pdfs/8cwang.pdfhttp://www.cibse.org/pdfs/8cwang.pdf.

[275] Castleton et al. (2010) Green roofs; building energy savings and the potential for retrofit. Energy and Buildings, 42, 10, pp. 1582-1591.

through green roof implementation (Especially when compared to warmer European countries)276.

1.3.8 Managing runoff

Green infrastructure intercepts, infiltrates, stores and evaporates rainwater, thereby reducing the rate and volume of water entering drains and limiting the risk of them being overwhelmed during extreme rainfall[277]. Runoff can be reduced by 60% by trees over hard surfaces and by nearly 100% by grassland[278]. Moreover, a hectare of grassland and broadleaved woodland in the UK can evaporate, respectively, 3.4 and 4.0 million litres of water[279]. Modelling conducted on Manchester shows that adding 10% of green space can reduce runoff by 5-6% and adding green roofs to all buildings in densely built-up areas could reduce runoff by 17.0-19.9%[280]. In addition, the Forestry Commission and the Environment Agency published research[281] looking at how woodland can help to achieve Water Framework Directive objectives, including reducing runoff and soil erosion and flood alleviation. The study reported that there was significant scope for using woodland to help reduce flood risk, and in particular floodplain and riparian woodlands were identified as valuable for attenuating flooding in downstream towns and cities.

1.3.9 Helping other species to adapt

As the climate changes, the range of species may shift northwards and upwards to higher altitudes as they seek new 'climate spaces'. A number of factors will limit their ability to do this, including their own dispersal ability and the nature of the landscape through which they are moving (i.e. the fragmentation of existing habitats and the permeability of the landscape between

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[276] Ascione et al. (2013) Green roofs in European climates. Are effective solutions for the energy savings in air-conditioning? Applied Energy, 104, pp. 845-859.
[277] Natural England and Landuse Consultants (2009) Green Infrastructure Guidance. Peterborough, Natural England.
[278] See Ennos (2011) Ennos, R. (2011) Quantifying the cooling and anti-flooding benefits of green infrastructure. Available at: http://www.sed.manchester.ac.uk/architecture/research/ecocities/news/documents/UoM_Roland_Ennos.pdf
[279] Hölzinger, O. (2011) The Value of Green Infrastructure in Birmingham and the Black Country. The Total Economic Value of Ecosystem Services provided by the Urban Green Infrastructure. The Wildlife Trust for Birmingham and the Black Country.
[280] See Gill et al. (2007) Gill, S.E., Handley, J.F., Ennos, A.R. and Pauleit, S. (2007) Adapting cities for climate change: the role of the green infrastructure. Built Environment 33: 115-133.
[281] Nisbet, T., Silgram, M., Shah, N., Morrow, K., and Broadmeadow, S. (2011) Woodland for Water: Woodland measures for meeting Water Framework Directive objectives. *Forest Research Monograph*, 4, Forest Research, Surrey

habitats)[282]. The management of linear features and corridors (e.g. river corridors, and road, railway and canal verges) for species movement may become increasingly important. Features oriented north-south may aid species movement, whereas east-west features could act as barriers unless appropriately designed[283]. Providing further evidence of these issues a Natural England study assessed and mapped the vulnerability of the Northwest's natural environment to climate change according to character areas. It found that protected landscapes are often the most resilient, whilst areas of highest risk correspond with built up areas and act as a barrier to movement of species through the Northwest[284]. The natural areas of Liverpool City Region and Warrington are identified as having high vulnerability to climate change[285]. Green infrastructure and NBS can help other species to adapt to climate change as it provides existing habitats. In addition, action should be taken in areas deemed to be vulnerable to climate change; this could be by creating new habitat to connect fragmented areas, or by increasing the wider landscape permeability through, for example, the planting of appropriate species and management of linear corridors[286].

1.4 Biodiversity

Moving towards a more biodiverse and ecological city requires us to think about how we value and make best use of our Natural Capital to measure our progress toward being the first generation in the UK's history to actually manage and improve the quality of the natural landscape and not degrade or damage its provisioning, servicing, supporting and cultural services.

282 MONARCH (Modelling Natural Resource Responses to Climate Change) was a seven year phased programme to assess impacts of projected climate change on wildlife in Britain and Ireland. www.ukcip.org.uk/images/stories/Pub_pdfs/Monarch_summary.pdf
http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Monarch1_summary.pdf
283 Gilchrist A (2011) Climate change, species range expansion and the institutional response. Unpublished PhD thesis, University of Manchester.
284 Natural England (2010). An Assessment of the vulnerability of the Natural Environment in the Northwest to climate change at the National Character Area scale. See http://www.naturalengland.org.uk/regions/north_west/ourwork/climatechangeproject.aspx
285 The Mersey Forest (2010) Liverpool Green Infrastructure Strategy. Risley Moss, Mersey Forest.
286 Ahern, J. (2011) Urban landscape sustainability and resilience: the promise and challenges of integrating ecology with urban planning and design. Landsacpe Ecology, 28, 9, 1203-1212.

Urban landscapes provide key habitats for a range of flora and fauna both within cities and across their urban/rural boundaries[287]. A number of factors influence the value of green infrastructure for biodiversity including the area of habitat available, the type and diversity of green spaces, and proximity to other sites[288]. A study of four urban areas on Merseyside revealed that the greatest influence on their ecology was the proportion of green space, particularly trees[289]. Sites where many species most commonly occur include city parks, cemeteries, rail tracks and previously developed land[290]. Sufficient levels of green space of relevant ecological quality in urban landscapes may even allow the presence of specialist forest or endangered species[291,292]. Furthermore, a survey of 15 parks in highly urbanised Flanders (Belgium) revealed that they contained 30% of wild plant species, 50% of breeding birds, 40% of butterflies, and 60% of the amphibians occurring in Flanders[293]. A range of evidence therefore suggests that, generally, the larger the parks or other habitat patches, the higher the species richness[294]. However, parks that are between 10-35ha in size are likely to contain every species that can be recorded in any urban area of a given region[295]. The diversity of land use types and adjacent green space in urban areas in the UK has been found to be crucial for supporting richness of bird[296] and butterfly species[297].

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[287] Countryside Agency & Groundwork (2005) The Countryside in and around towns: A vision for connecting town and county in the pursuit of sustainable development. Weatherby, Countryside Agency.

[288] Beneduct, MA. & McMahon, E. (2006) Green Infrastructure: Linking Landscapes and Communities. Washington, DC. Island Press.

[289] Whitford V, Ennos AR & Handley JF (2001) 'City form and natural process' – indicators for the ecological performance of urban areas and their application to Merseyside, UK. Landscape and Urban Planning 57: 91-103.

[290] Kendle T & FORBES S (1997) Urban nature conservation. E&FN Spon, London.

[291] Park C-R & Lee WS (2000) Relationship between species composition and area in breeding birds of urban woods in Seoul, Korea. Landscape and Urban Planning 51: 29-36.

[292] Alvey AA (2006) Promoting and preserving biodiversity in the urban forest. Urban Forestry and Urban Greening 5: 195-201.

[293] Cprnelis J & Hermy M (2004) Biodiversity relationships in urban and suburban parks in Flanders. Landscape and Urban Planning 69: 385–401.

[294] Davies L, Kwiatkowski L, Gaston KJ, Beck H, Brett H, Batty M, Scholes L, Wade R, Sheate WR, Sadler J, Perino G, Andrews B, Kontoleon A, Bateman I & Harris JA (2011) Urban In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge

[295] Fernández-Juricic E & Jokimäki J (2001) A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe. Biodiversity and Conservation 10: 2023–2043.

[296] Young CH & JARVIS PJ (2001) Assessing the structural heterogeneity of urban areas: An example from the Black Country (UK). Urban Ecosystems 5: 49-69.

1.4.1 Connectivity of habitats

Wildlife corridors are important in helping to overcome habitat fragmentation and to ensure that species can reach the different resources they need, and that populations of species do not become isolated or die out due to inbreeding[298]. Also, as the climate changes, the range of species may shift northwards and upwards to higher altitudes as they seek new "climate spaces". Their ability to do this is affected by the fragmentation of existing habitats and the permeability of the landscape between habitats[299]. A study of butterflies' migration in the North West of England suggests that features oriented north-south (such as grass verges along major roads) may aid species movement, whereas east-west features could act as barriers unless appropriately designed[300]. To help biodiversity move and survive in urban areas, change in the management of close-mown amenity grass and encouraging wildlife friendly gardening are needed[301]. Ecological networks can therefore be designed into cities across the UK to ensure that links, hubs and nodes are accessible and available to species. For instance, in Birmingham, the management of wildlife in the city has relied heavily on corridors as strategic planning tools since development of the wildlife conservation strategy in 1997 explicitly built around the corridor concept[302]. In London, the South East London Green Chain extends over 40 miles linking 300 open spaces, combining nature conservation and other benefits[303].

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[297] Hardy PB & Dennis RLH (1999) The impact of urban development on butterflies within a city region. Biodiversity and Conservation 8: 1261-1279.
[298] O'Brien E (2006) Habitat fragmentation due to transport infrastructure: Practical considerations. Environmental Pollution 10: 191-204.
[299] Niemelä, J. (2014) Ecology of urban green spaces: The way forward in answering major research questions. Landsacpe and Urban Planning, 125, 298-303.
[300] Gilchrist A (2011) Climate change, species range expansion and the institutional response. Unpublished PhD thesis, University of Manchester.
[301] Mitchell R J, Morecroft MD, Acreman M, Crick HQP, Frost M, Harley M, Maclean IDM, Mountford O, Piper J, Pontier H, Rehfisch MM, Ross LC, Smithers RJ, Stott A, Walmsley CA, Watts O & Wilson E (2007) *England Biodiversity Strategy - towards adaptation to climate change.* Department for Food, Environment and the Rural Affairs.
[302] Birmingham City Council (1997), Nature Conservation Strategy for Birmingham. Birmingham, Birmingham City Council.
[303] London Assembly (2011) South East London Green Chain Plus Area Framework - All London Green Grid. London, Greater London Authority.

Appendix 4 Valuing our vital green infrastructure

Why put a price tag on green infrastructure?

The role green infrastructure plays in the quality of place and quality of life and so the economy and society, is finally becoming more widely understood. Even so,-project managers, funders and client teams often need to provide robust evidence that environmental and economic development projects that include new green infrastructure deliver economic benefits.

Existing green infrastructure can also be under threat without an economic case for its preservation. Whilst the intrinsic value of a rare species, a cultural landscape or a tranquil area in the heart of a town or city may be considered as “priceless”, there is a danger that priceless can then lead to them effectively becoming “valueless” in economic assessment terms.

There has been a great deal of work carried out to try to value the benefits of the natural environment using a wide range of techniques. Many of these are academic and not accessible to project managers who need to be able to rely on sound data from easily accessible sources to provide a robust valuation that they can employ as justification to funders and/or developers.

To enable such a valuation to be carried out, the Mersey Forest has developed the Green Infrastructure Valuation Toolkit. The toolkit calculates monetary values for the social, economic and environmental benefits that green infrastructure provides.

History of the Toolkit

The toolkit was originally developed as part of a Natural Economy Northwest project, in conjunction with other regions across England and with national bodies such as DEFRA. A range of organisations pooled their expertise to aid the design of an easily accessible toolkit to enable GI valuation.

The toolkit has been released as a prototype, in a 'Creative Commons' format that means it can be used by all interested parties at no cost. It i's not yet complete and still in active development, with a network of users who share information and ideas. Repeated use of the toolkit by the Mersey Forest and other organisations is helping us to refine and modify its contents to make it more suitable for analysing a wider range of projects. The aim is that over time the toolkit will become an increasingly robust model, recognised by decision makers and funders.

The toolkit and an explanatory guide can be downloaded from http://www.merseyforest.org.uk/services/gi-val/.

How does the toolkit work?

The toolkit provides a set of calculator tools, to help assess an existing green asset or proposed green investment. They are organised under eleven key benefits of green infrastructure:

Climate change adaptation and mitigation | Flood alleviation and management | Place and communities | Health and wellbeing | Land and property values | Investment | Labour productivity | Tourism | Recreation and leisure | Biodiversity | Land management.

The toolkit looks at how the range of green infrastructure benefits derived from an asset or investment can be shown:

- **in monetary terms** – applying economic valuation techniques where possible
- **quantitatively** – for example with reference to jobs, hectares of land, visitors
- **qualitatively** – referencing case studies or important research where there appears to be a link between green infrastructure and economic, social or environmental benefit but where the scientific basis for quantification and/or monetisation is not yet sufficiently robust.

The toolkit uses standard valuation techniques to assess the potential benefits provided by green infrastructure within a defined project area. These benefits are assessed in terms of the functions that the green infrastructure may perform, support or encourage, depending upon the type of project.

For example, Figure 23 shows how an urban tree planting scheme can result in improved air quality, carbon sequestration and reduced health costs, thereby illustrating green infrastructure function, benefit and potential monetisation.

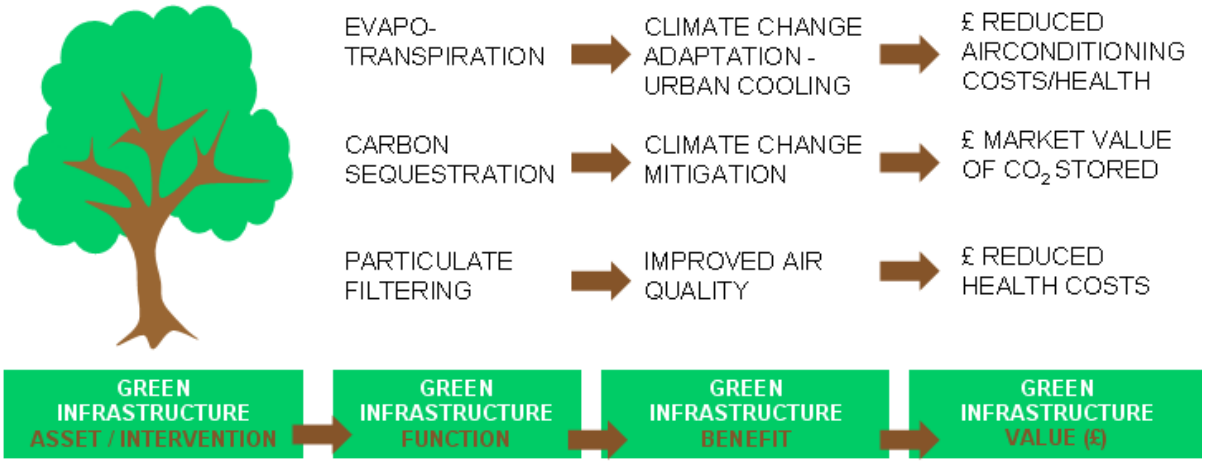


Figure 23 Green Infrastructure chain - asset - value

Once data is entered into the toolkit, it generates financial values for many of the green infrastructure benefits. The toolkit identifies the marginal benefit[304], the additional value of the green infrastructure, and also tries to ensure that there is no "double counting" of value.

Current limitations

The toolkit remains in development and this means there are some green infrastructure benefits for which it cannot calculate a direct financial value. While there is a rich body of evidence that illustrates and demonstrates the different types of benefits deriving from quality green infrastructure, robust valuation techniques do not yet exist for all benefits. Therefore, some valuations come with detailed caveats as they are based on limited evidence at this stage.

The toolkit's calculation is designed to be useful for initial, indicative project appraisal, providing a range of figures indicating the potential impact of a green infrastructure intervention or the value of an existing green infrastructure asset. The toolkit does not assess the quality of the design or detailed management requirements of green infrastructure. It does not replace a full cost benefit analysis, but it provides a basic, indicative valuation at a much lower cost.

Valuations such those made with a toolkit or cost benefit analysis also need to be seen as part of a much bigger picture. The valuation should not replace community engagement and local dialogue about what is valued about a place. Calculating economic value of green assets will

[304] Marginal benefit: this is a way to measure change in benefits over the change in quantity. For example, it could refer to the value of the benefits of an additional recreational visit for a tourist site.

always be a controversial technique and financial value should only be seen as one factor in decision-making.

Data used in the production of the valuation data for Cheshire East's green infrastructure is described in Technical Appendix 2 – Data sources for the green infrastructure valuation toolkit – GI-V

Appendix 5 Valuing Cheshire East's Green Infrastructure using GI-Val

In recent years there has been an increasing focus on developing methods to place a monetary value on the services and benefits provided by green infrastructure. This approach can be controversial. Green infrastructure has an intrinsic value, not dependent on the goods and services that we might receive as a society.

Current policy, as set out in the 25 Year Plan for the Environment aims for no net loss of natural capital or green infrastructure, highlights the intrinsic value of nature and points to the need to value the green infrastructure benefits that are provided by, for example, trees and woodland.

Putting a value on these assets owned by the council enables informed decisions to be made about future funding and management of green infrastructure and the plans and policies that may be needed to safeguard the asset and ensure that the benefits provided are sustained in the long term.

The Green Infrastructure Valuation Toolkit has been used to arrive at a valuation of the benefits of green infrastructure in Cheshire East[305].

Data for green infrastructure in Cheshire East

Using GI-Val and datasets from recognised sources (see Technical Appendix 2 for information on these datasets) we can identify values against the eleven benefits that are assessed. Values are discounted, as appropriate, to give a present-day value. The figure is indicative. For example, the water management function of green infrastructure in Cheshire East is potentially very valuable. However, poor land management that may cause soil sealing, will reduce infiltration capacity of the land and so increase run-off resulting increased costs for water management and less value for water management being attributable to green infrastructure.

[305] http://www.merseyforest.org.uk/services/gi-val/

SUMMARY OF ECONOMIC VALUE

BENEFITS Benefits groups	BENEFIT MONETISATION GVA value	Land and property value	Other economic value
1 Climate Change Adaptation & Mitigation	£2.8m	n.a.	£32.4m
2 Water management & Flood Alleviation	£642m	n.a.	n.a.
3 Place & communities	£0	n.a.	£21.8m
4 Health & Well-being	£8.3m	n.a.	£171m
5 Land & Property Values	n.a.	£594m	n.a.
6 Investment	n.a.	n.a.	n.a.
7 Labour Productivity	£13.3m	n.a.	n.a.
8 Tourism	£257m	n.a.	n.a.
9 Recreation & leisure	n.a.	n.a.	£73.6m
10 Biodiversity	n.a.	n.a.	£31.3m
11 Land management	£0	n.a.	n.a.
TOTAL ECONOMIC VALUE OF BENEFITS	£924m	£594m	£257m
	These three figures should not be added together, as they represent different kinds of value		

The value of recreation & leisure benefits has not been included in the other economic value total because of the risk of double counting

Figure 24 GI valuation for Cheshire East green infrastructure

The values produced show both the wide range of benefits delivered by green infrastructure and the high economic value that is delivered.

The data for Cheshire East is not typical. In most areas and projects, the wider economic values are much higher, highlighting the value of green infrastructure beyond direct impact on the economy in terms of Gross Value Added (GVA). Health benefits are often greater than the total GVA value.

In Cheshire East, GVA is estimated at nearly £1bn, nearly four times greater that the wider economic value benefits. This is mainly driven by the water management benefits, reflecting both the importance of the issue and the need to sustain and improve water management functionality of green infrastructure in Cheshire East.

Other tools

GI-Val is not the only tool available for valuing green infrastructure. An appraisal of the various tool has been carried out by the Ecosystem Knowledge Network. This assessment includes GI-Val.

The new ORVal[306] valuation tool is a useful and relatively simple to use online resource. Orval looks at a more restricted set of benefits than GI-Val and used the national Monitor of Engagement with the Natural Environment dataset to derive welfare values for green spaces. ORVal gives a lower has less local data/context and looks at fewer benefits.

The ORVal welfare value for Cheshire East from accessible green spaces is estimate to be £78,908,179/annum

[306] http://leep.exeter.ac.uk/orval/

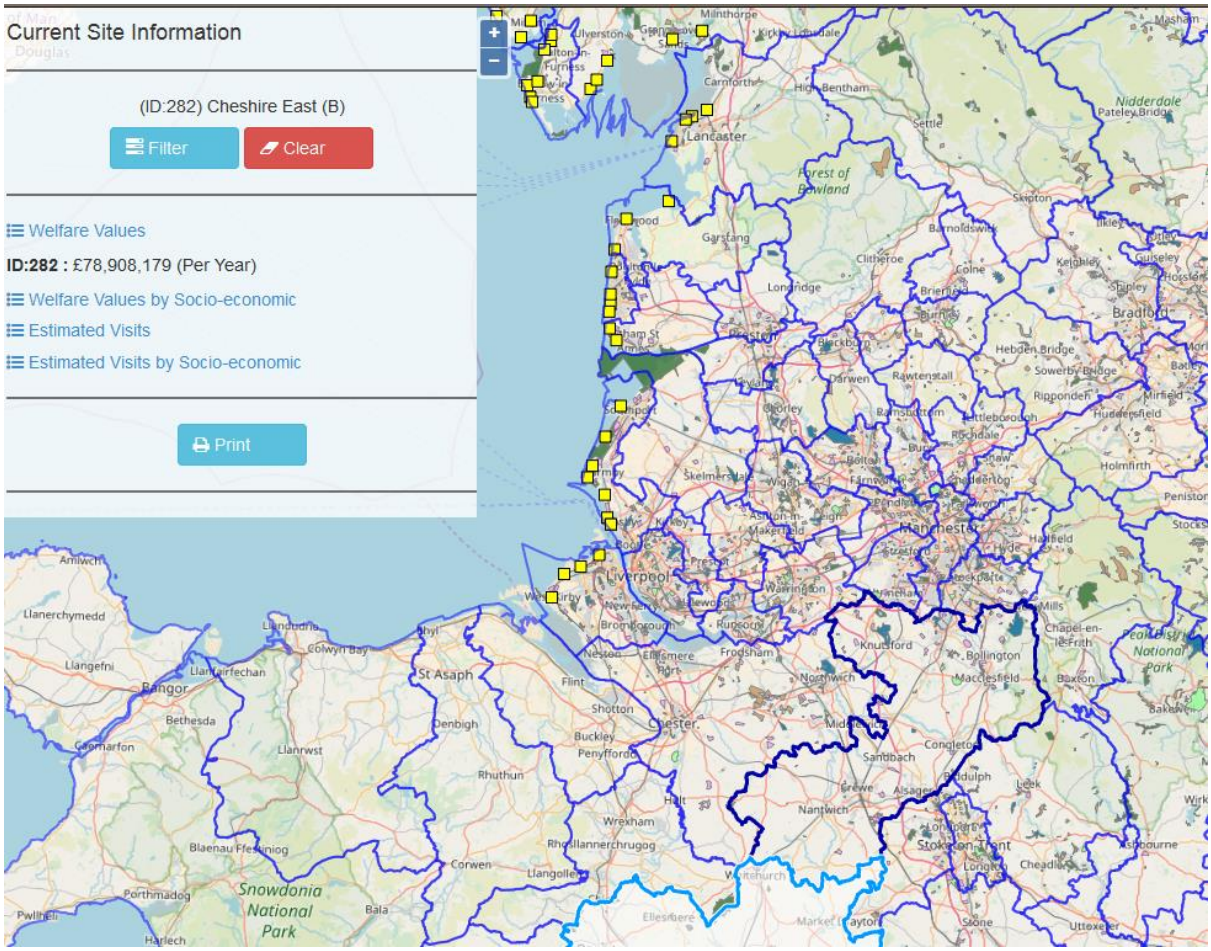


Figure 25 image from the ORVal online tool for Cheshire East

Appendix 6 Funding sources

This is possibly the least attractive option for a strategic, sustainable programme of green infrastructure development. However, it is likely to continue to be an important mechanism for capital interventions and for short terms projects and programmes.

The uncertainty over EU funding adds to the pressure from applicants to UK-based funds. In addition, as government agencies now regularly apply for some of the larger funds, the competition for funding from UK based funds continues to increase.

Lottery has been a significant source of funds for environmental projects and parks and green spaces in particular. However, recent announcements indicate that there will be less lottery funding available in future, putting even greater pressure on other grant sources.

Several grant databases exist to identify funding opportunities and notify organisations who have signed up to alerts.

https://www.idoxgrantfinder.co.uk/

Some of the funds that could be accessed for specifc projects are shown below. It is likely that Cheshire East officers are already is aware of these funding opportunities. We have identified:

1. Funding source
2. Indicative scale of funding – what is the likely scale of funding that might be secured
3. Risk – an assessment of the liklehood of success, on average, of bids. Larger bids tend to be more risky, but obvioulsly offer significant reward if succcessful.
4. Assessment of whether the fund will support capital or revenue programmes
5. How long is funding for? – the average duration of the funding source

DRAFT Table being updated

Funding source	Indicative Scale (£)	Risk	Capital/Revenue	How long is funding for? (indicative - years)
S106 Funding	10 – 100,000	Low	Capital/Revenue	3-5
CIL	10-100000	High	Capital/Revenue	3-5
HLF Transition Fund	90,000	medium	Revenue	1
LEADER	5,000	medium	Capital	1
Natural Capital Financing Fund	1000000	high	Capital/Revenue	10
Landfill Communities Fund	100,000	medium	Capital	3
Local Trusts	20,000	medium	Capital/Revenue	1
National Trusts	50,000	medium	Capital/Revenue	3
Arts Council England - Small Capital Grants	250,000	high	Capital/Revenue	3
Arts Council England - Large Capital Grants	2,500,000	high	Capital/Revenue	3
Heritage Lottery Fund - Heritage Grants	2,000,000	medium	Capital/Revenue	3
Big Lottery	150,000	medium	Capital/Revenue	3
Big Lottery Awards for All	10,000	medium	Revenue	1

Funding source	Indicative Scale (£)	Risk	Capital/Revenue	How long is funding for? (indicative - years)
Children in Need	20,000	high	Capital/Revenue	2
Carrier bag schemes (funding distributes the 5p charged for plastic bags by retailers)	5,000	medium	Capital	1
Postcode Dream Trust - Dream Fund	500,000	high	Capital/Revenue	2
Postcode Local Trust	15,000	medium	Capital/Revenue	1

Figure 26 Funding sources

Whilst external funds can provide useful project income, they require investment.

- There is a “hit rate” – not all bids are successful, competition is becoming greater and the investment in bid writing is not insignificant. For some funds, the hit rate can be less than 5%. There is a trade off between the cost of bididng and the likelehood of success. This should be considered when developing the green infrastructure funding strategy
- There is also a cost to management of any successful bids, which again can be relatively high. Without management of the funds there is a risk of clawback.

Capturing the value of the benefits

Whilst bidding for funding will enable some elements of green infrastructure delivery, a more sustainable programme is needed. A "value capture framework" needs to be developed, that includes potential payments for the benefits by the beneficiaries and development of bonds or endowments that enable investment in the delivery of the benefits for commercial, policy or philanthropic purposes.

Offering new solutions to potential beneficiaries of services

As described above, Cheshire East's green infrastructure provides a wide range of benefits to local communities that help to deliver not only Cheshire East's corporate objectives but also help to achieve others' business goals and objectives too.

However, it is challenging to capture that value that is provided. For example, the health benefits provided by Green Infrastructure are more than £170m. Expecting this benefit to be paid for by the NHS is, given current funding challenges, unrealistic. However, identifying the saving that could be made by reducing the number of GP visits or visits to A&E centres might be the basis for a conversation with Clinical Commissioning Groups and Public Health.

Based on the benefits that Cheshire East green infrastructure provides, the following potential beneficiaries have been identified. The scale of possible annual payment for the services and the likelihood of a successful outcome to discussion is rated to provide a score that perhaps points to the initial targets for the discussions.

Benefit	Organisation	Scale £000s	Likelihood (1-5)	Score
Flood risk reduction	United Utilities	100	2	200
Health and wellbeing	Public Health	100	4	400
Flood risk reduction	Environment Agency	100	3	300
Health and wellbeing	CCGs	100	3	300
Flood risk reduction	Insurers	100	2	200
Products	Stobart	10	4	40
Biodiversity	Developers	10	3	30
Biodiversity	Natural England	10	3	30

Benefit	Organisation	Scale £000s	Likelihood (1-5)	Score
Green Travel	Mersey Travel	10	3	30
Labour productivity	City Region/LA	10	3	30
Labour productivity	RSLs	10	3	30
Land management	Developers	10	3	30
Land management	RSLs	10	3	30
Quality of place	City Region/LA	10	3	30
Quality of place	Developers	10	3	30
Flood risk reduction	NW Coast and Flood Board	10	2	20
Flood risk reduction	SABs	10	2	20
Health and Wellbeing	Employers	10	2	20
Labour productivity	Employers	10	2	20
Reducing urban heat island /climate change adaptation	NHS	10	2	20
Reducing urban heat island / climate change adaptation	Public health	10	2	20
Green travel	Employers	1	3	3
Products	Communities - food, fuel	1	3	3
Products	Grazing	1	3	3

Benefit	Organisation	Scale £000s	Likelihood (1-5)	Score
Quality of place	RSLs	1	3	3
Recreation and leisure	RSLs	1	3	3
Tourism	Businesses	1	3	3
Land management	Land owners	1	2	2
Recreation and leisure	Businesses	1	2	2
Tourism	Visitors	1	2	2

Figure 27 CSR benefits

Based on the top five as scored above, the table below suggests data that would be needed to open the discussions. All of the discussions are based on the idea that budget cuts reduce or take away completely the benefits enjoyed at present, at no cost, by the beneficiary.

Benefit	Organisation	What are the key facts and figures
Flood risk reduction	United Utilities	How much water stored, impacts on water quality, how many homes affected?
Health and wellbeing	Public Health	How many people involved, JSNA
Flood risk reduction	Environment Agency	How much water stored, impacts on water quality, how many homes affected?
Health and wellbeing	CCGs	How many fewer GP visits, fewer drugs, fewer visits to A&E
Flood risk reduction	Insurers	How many homes affected? How many more could have risk reduced?

Figure 28 Benefits - Key data

In total we have identified 21 possible purchasers of the types of benefit provided by Cheshire East Green Infrastructure.

Potential PES Partners
Businesses
CCGs
City Region/LA
Local communities - food growing/ fuel
Developers
Employers – wider than private businesses
Environment Agency
Farmers looking for grazing land
Insurers
Land owners
Mersey Travel
NE
NHS
NW Coast and Flood Board
Public Health
RSLs
SABs
Stobart
United Utilities
Visitors

Figure 29 Potential partners

We have also looked at the basic, necessary elements that would need to be in place for each of the potential benefits to enable marketing of the benefits to the target audience. A green box indicates:

1. A possible link to a CSR programme or similar, which might unlock or help to unlock some of the funds
2. An assessment that the condition is already in place, i.e. that Cheshire East already have this agreement or evidence available

	Benefit	Who benefits?	Possible CSR	Necessary Conditions	In Place
1	Health and wellbeing	Public Health		High quality sites and products to support good health	
	Health and wellbeing	CCGs		Evidence of impact in reducing costs and keeping people well, professional approach to service delivery for health	
	Health and wellbeing	Employers		Evidence of impact for businesses	
2	Flood risk reduction	Environment Agency		Long term ownership and management of sites, site use agreement	
	Flood risk reduction	United Utilities		Long term ownership and management of sites, site use agreement	
	Flood risk reduction	NW Coast and Flood Board		Long term ownership and management of sites, site use agreement	
	Flood risk reduction	Insurers		GI Plan to reduce flood risk	
	Flood risk reduction	SABs (If they ever come into being)		Long term ownership and management of sites, site use agreement	
3	Labour productivity	Employers		Evidence of impact for businesses	
	Labour productivity	City Region/LA		Evidence of impact for businesses	

	Labour productivity	RSLs	Evidence of impact
4	Quality of place	Developers	Plans for integration of parks and greenspacs into regeneration and other strategic plans
	Quality of place	City Region/LA	Evidence of impact
	Quality of place	RSLs	Evidence of impact
5	Land management	Land owners	Management agreements and clear management objectives for each site
	Land management	Developers	Management agreements and clear management objectives for each site
	Land management	RSLs	Management agreements and clear management objectives for each site
6	Reducing urban heat island/climate change adaptation	Public Health	Plans for heatwave risk reduction - evidence of impact
	Reducing urban heat island/climate change adaptation	NHS	Plans for heatwave risk reduction - evidence of impact
7	Products	Stobart	Woodland resource management plan in place
	Products	Grazing	Management agreements and clear management objectives for each site
	Products	Communities - food, fuel	Management agreements and clear management objectives for each site

8	Biodiversity	NE	Management agreements and clear management objectives for each site
	Biodiversity	Developers	Offset policy
9	Tourism	Businesses	Strategy and pricing policy
	Tourism	Visitors	Strategy and pricing policy
10	Recreation and leisure	RSLs	Evidence of impact
	Recreation and leisure	Businesses	Evidence of impact
11	Green Travel	Local Transport Plan	Evidence of impact, active travel routes
	Green Travel	Employers	Evidence of impact, active travel routes

Figure 30 CSR benefits

New funding models, bonds and endowments, developing new, long term funding streams

Bonds and endowment models are being looked at by public bodies across the country. They offer the potential for entirely new and sustainable sources of funding. However, a capital sum needs to be identified to provide the endowment.

The model that we (Mersey Forest) are developing looks at using the LGPS as the investment vehicle for the endowment or bond. This became possible in April 2018. LGPS offers an opportunity to realise greater returns on investment than other fund managers, is "known" to the local authority and has local involvement, with an interest in the area.

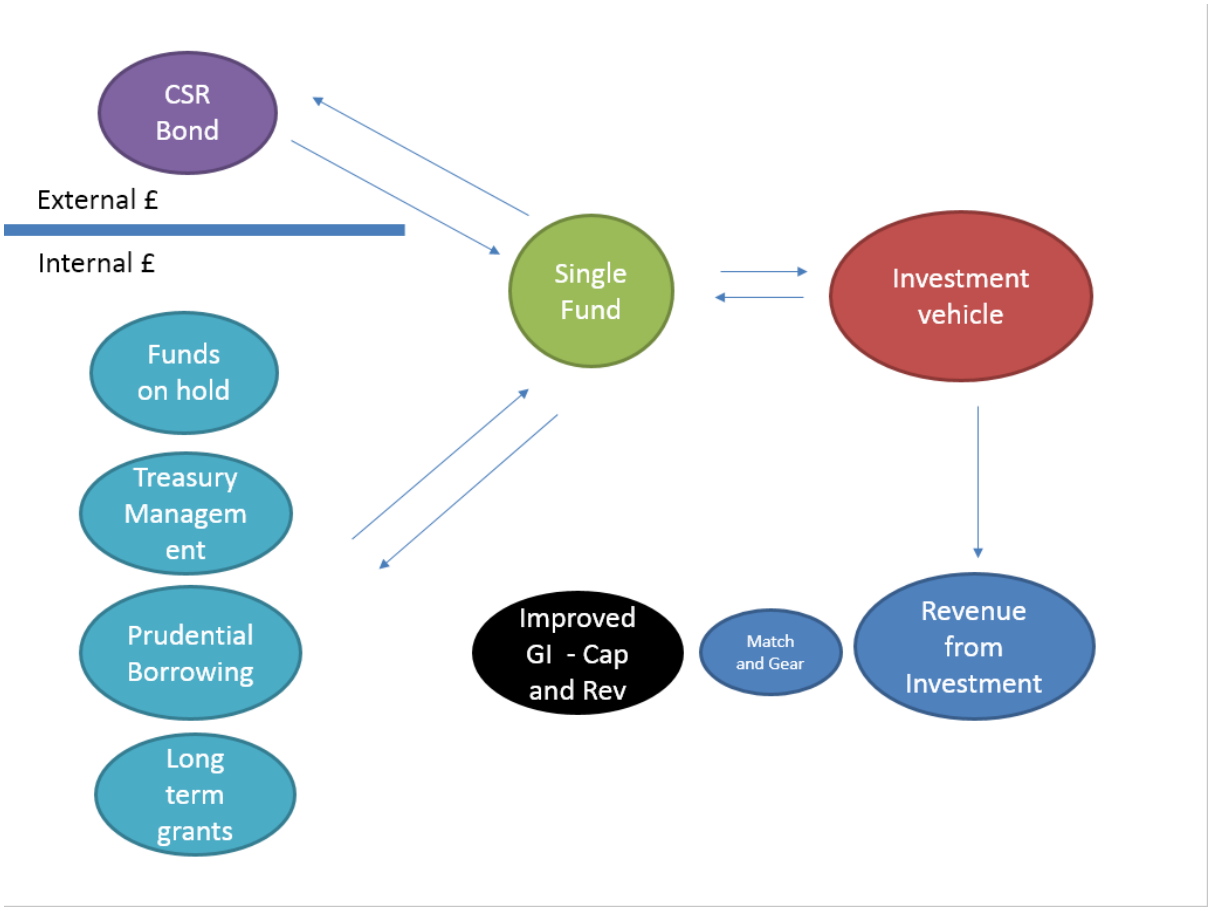


Figure 31 Innovative funding models

More details on the mechanisms, flow of funds, risk and how this model can be developed for Cheshire East.

Appendix 6a Northern Forest

The “Northern Forest” has been developed by the Woodland Trust and the Community Forests and is included as a priority action in the 25 YEP. The Northern Forest spans the M62 Corridor, from Chester and Liverpool to Hull. It builds on the existing partnership between the Trust and five Community Forests. It takes its inspiration from the Community Forest Plans and strategies in the area, such as The Mersey Forest Plan

Over the next 25 years £75bn of investment in housing and transport infrastructure is planned across the M62 Corridor.

There are already 13 million people living in the project area. 650,000 new homes are projected to be built and the population is due to rise by 9 percent over the next 20 years.

The 25 Year Plan, the Industrial Strategy[307], and the Clean Growth Strategy308 each calls for integrated infrastructure investment, including green infrastructure, to secure increases in natural capital.

The Northern Forest aims to secure significant green infrastructure and natural capital gains through the creation of a new ‘Northern Forest. It can deliver national, regional and local policy and strategy.

The target is to plant 50 million new trees over the next 25 years. The estimate is that it will the cost £500m. It will create a productive forest across the Northern Powerhouse that not only provides biomass and future timber, but also helps to deliver wider social and environmental benefit to improve health, reduce flood risk, tackle poor air quality, improve water quality, provide opportunities for recreation, tourism and leisure, and create attractive places to live, work and invest. The estimated economic benefit is £2.5bn.

Cheshire East is included in the “halo” area for Northern Forest, with over 2m trees targeted for planting in the borough.

[307] https://www.gov.uk/government/policies/industrial-strategy
[308] https://www.gov.uk/government/publications/clean-growth-strategy

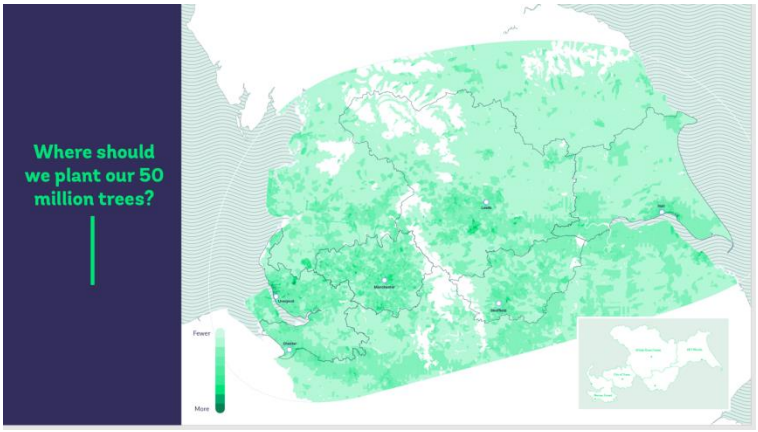
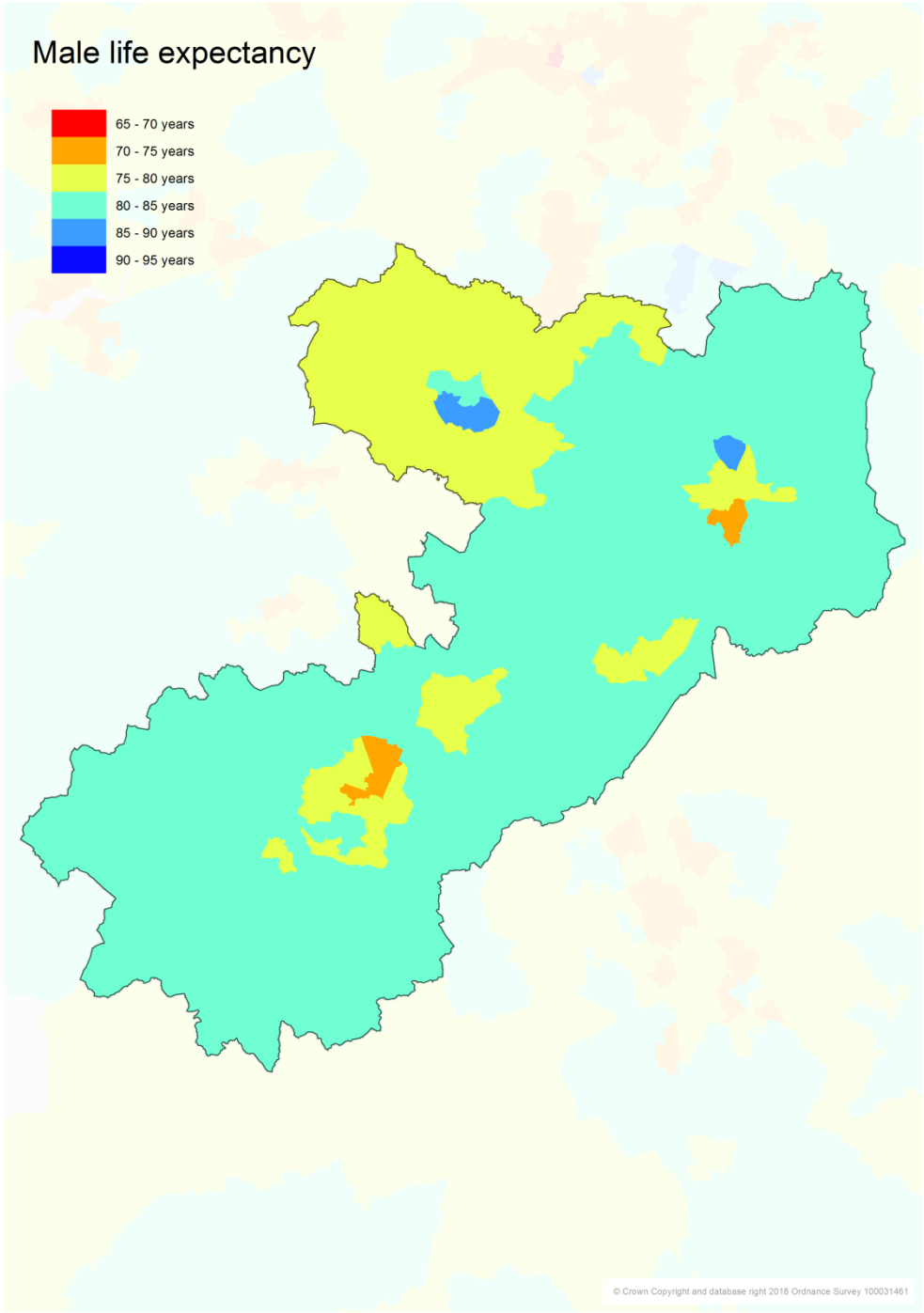
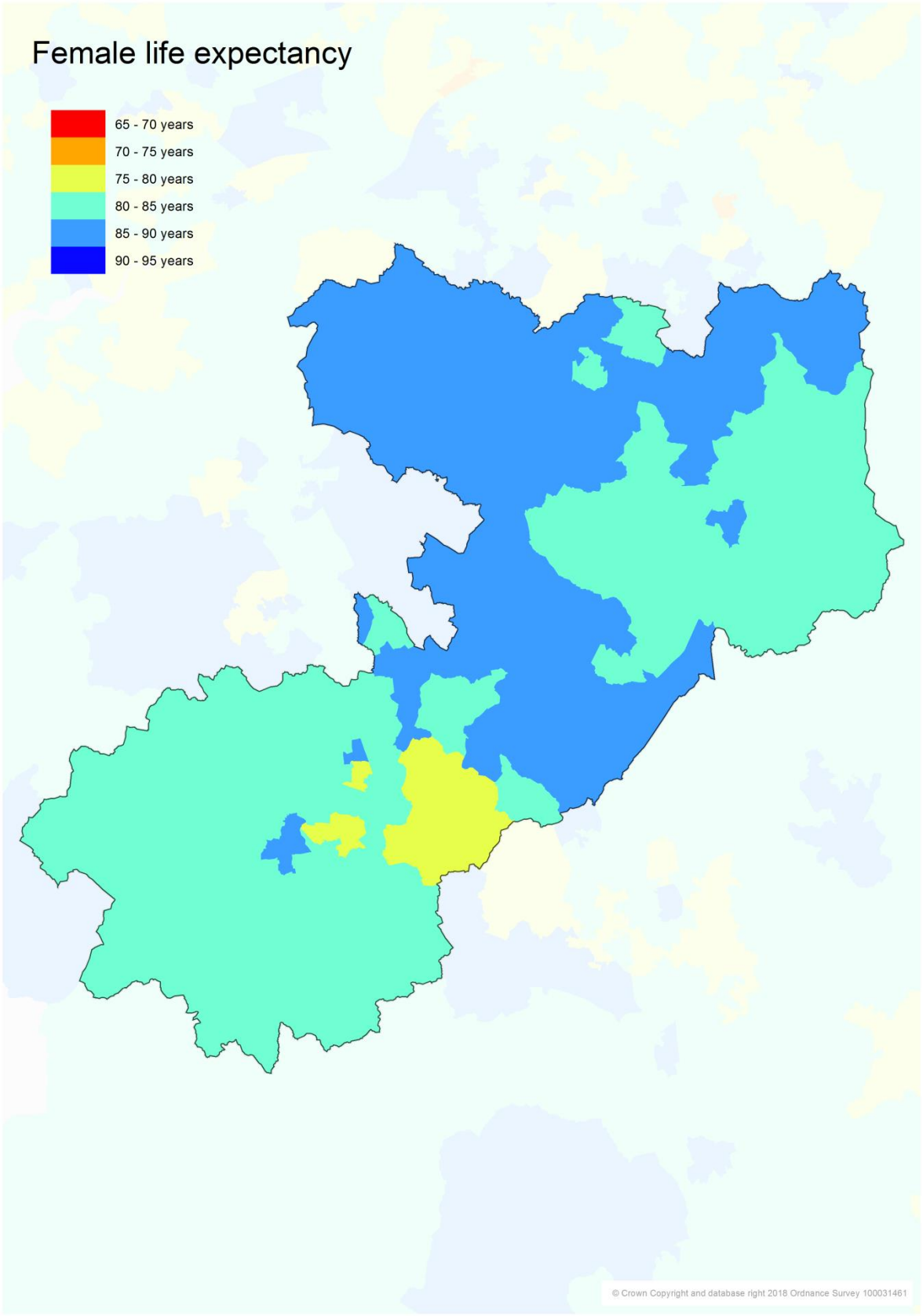


Figure 32 Planting 50 million trees north England

Appendix 7 Additional mapping of health issues in Cheshire East

The following maps show the distribution of health issues across Cheshire East. The issues selected are those for which there is evidence that green infrastructure interventions can have a positive impact (see page 69 for evidence). Future development of a Green Infrastructure Plan for Cheshire East can develop the links and possible interventions required.


Male life expectancy
65 - 70 years
70 - 75 years
75 - 80 years
80 - 85 years
85 - 90 years
90 - 95 years
© Crown Copyright and database right 2018 Ordnance Survey 100031461



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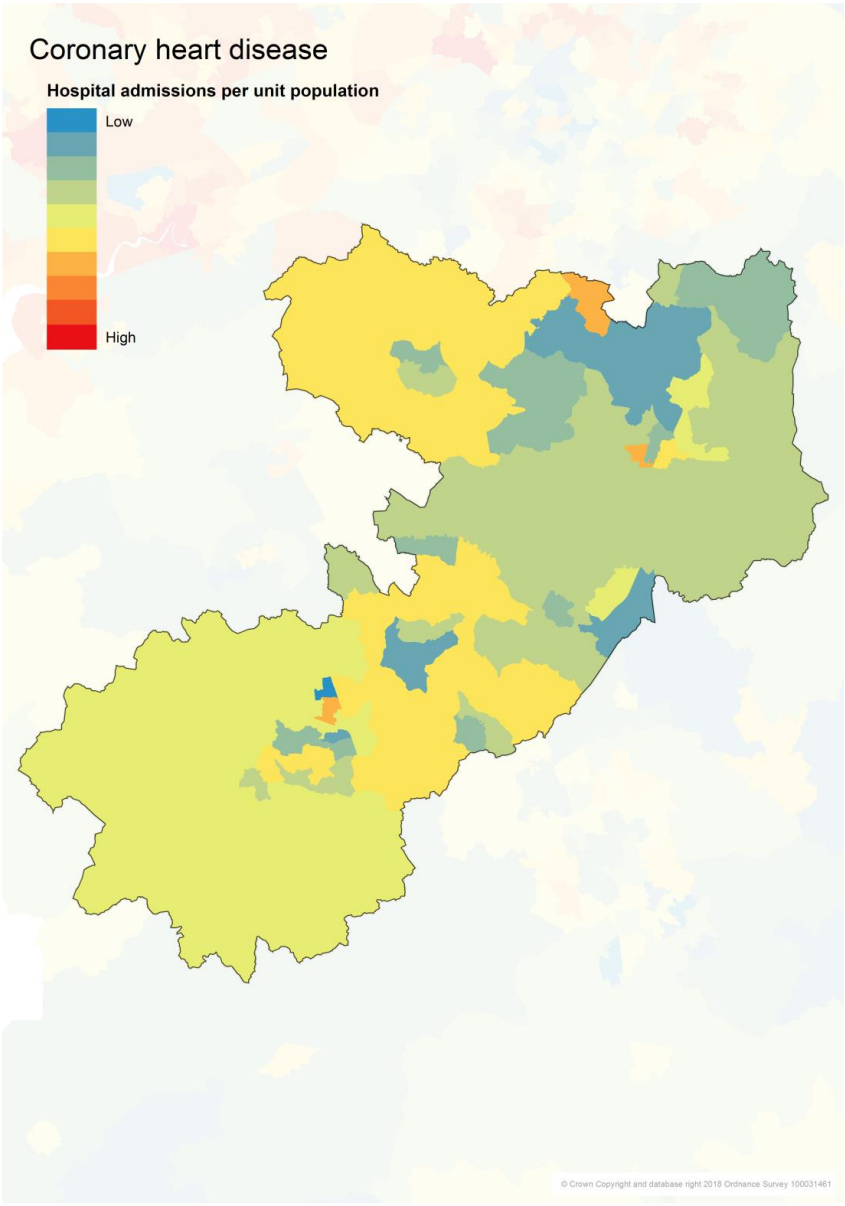

Figure 33 Coronary heart disease in Cheshire East

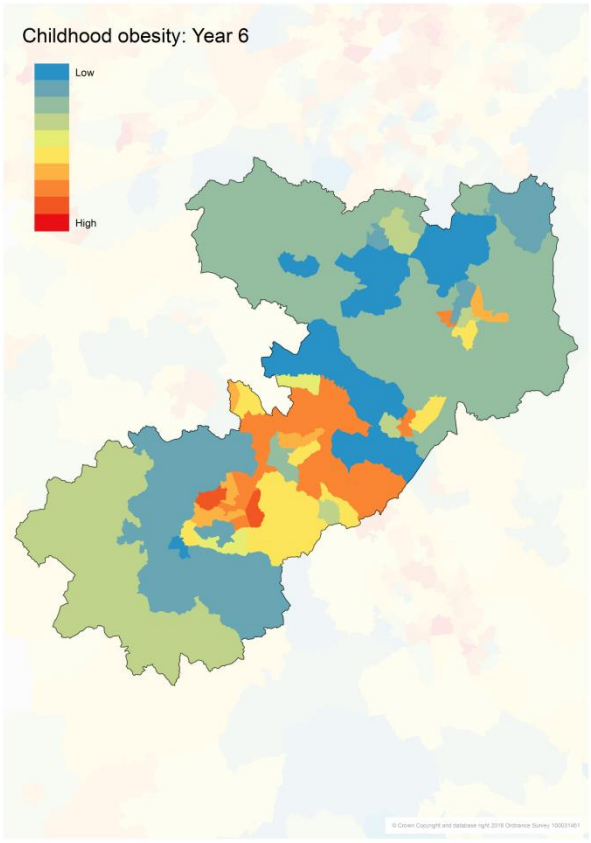

Figure 34 Childhood obesity (Year 6) in Cheshire East

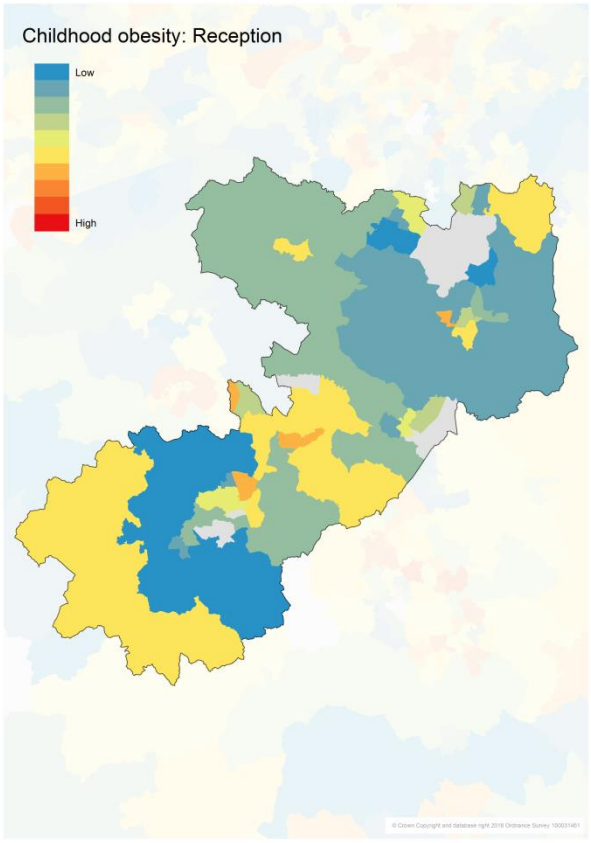

Figure 35 Childhood obesity (Reception age) in Cheshire East

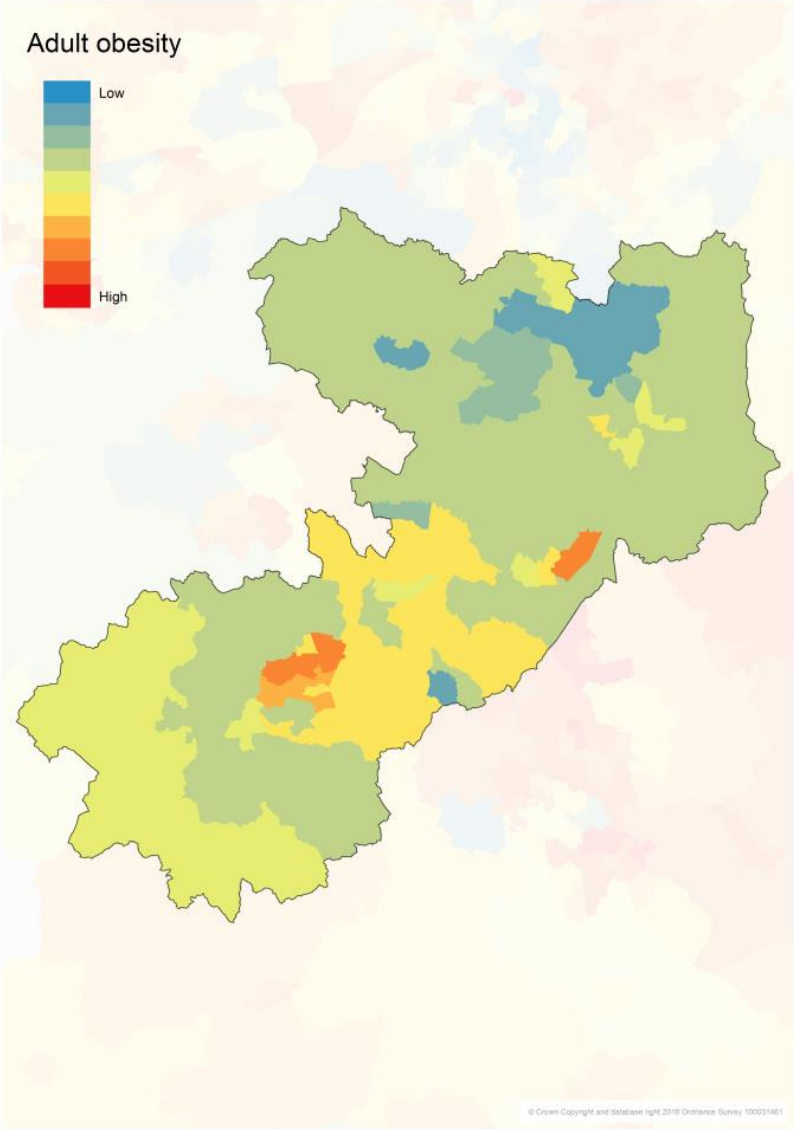

Figure 36 Adult obesity in Cheshire East

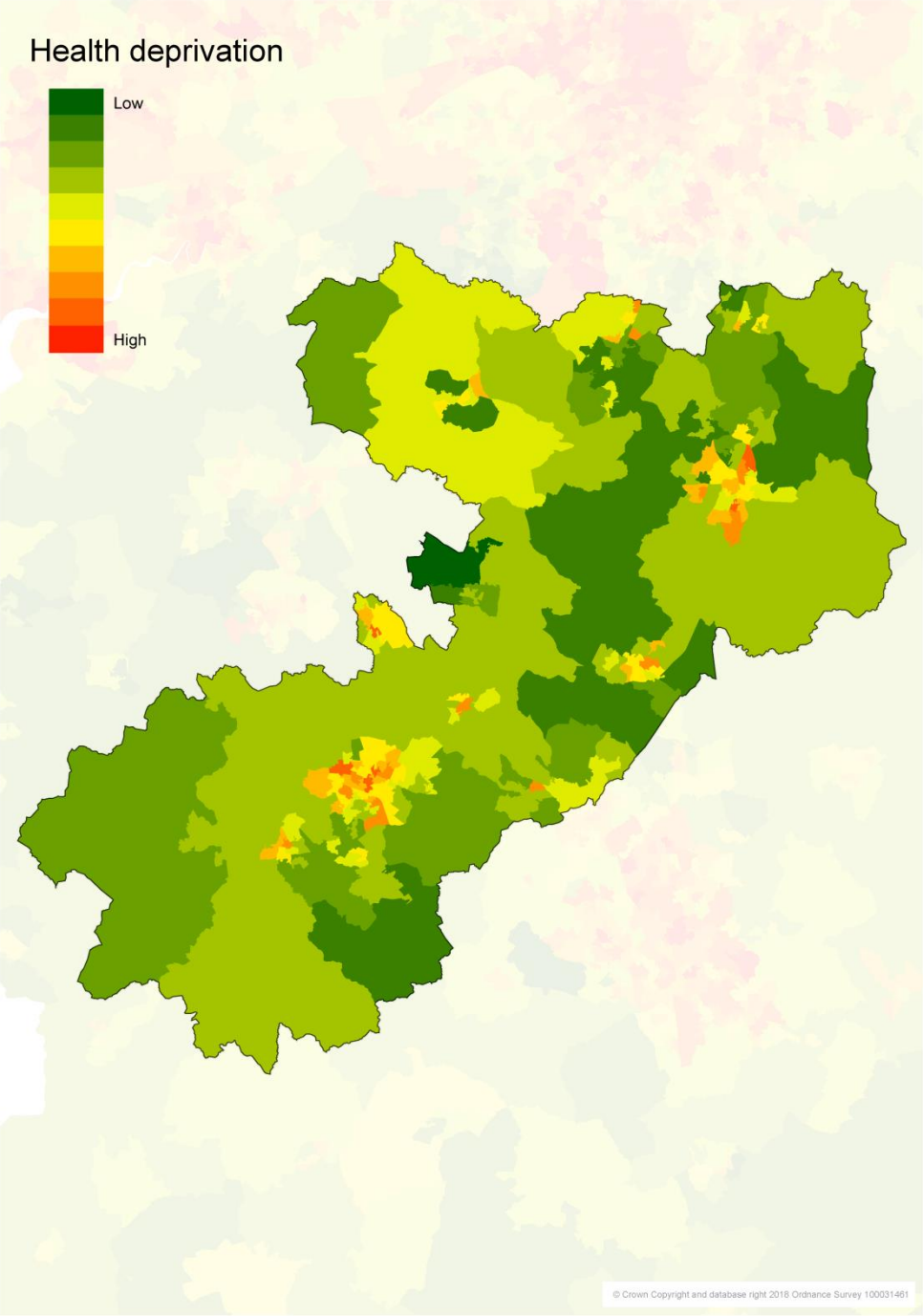

Figure 37 Health deprivation

Appendix 8 Pinch Points

The idea of Pinch Points for key socio-economic or environmental issues, for which there may be green infrastructure solutions, has been developed for other Green Infrastructure Plans. The following provides an overview of the approach, and how it can help to target limited resources to best effect.

Assets –the term "asset" has been used to describe green infrastructure that is delivering a function or functions in an area of identified need. For example, woodland that is intercepting and storing water in an area of flood risk is a water management asset; it is providing functions that help to reduce the risk of flooding.

Pinch Points - Pinch Points are identified as areas where a "need" has been identified, for which green infrastructure functionality could provide a solution, but where that functionality is not provided at the moment AND that pinch may prevent planned investment from taking place or reduce its return or likelihood of success or add significant cost to the investment.

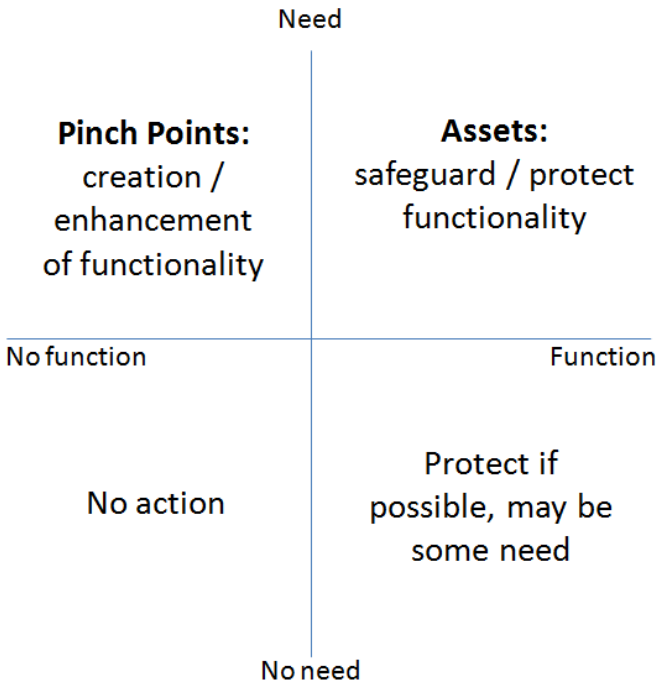

Figure 38 Assets and Pinch Points

The lack of functionality may be because there is no green infrastructure or perhaps because the existing type of green infrastructure does not provide the functionality that is needed.

For example, in an area of high flood risk a lack of water management functionality creates a pinch point. Future growth, existing quality of life and a range of other issues are adversely affected by these pinch points. They act as constraints.

The options available to tackle pinch points include changing the existing green infrastructure typology so as to provide the necessary functionality or where this is not possible to create additional green infrastructure where resources, space and tenure allow.

For example, options for incorporating green infrastructure to intercept and store water locally and upstream of the flood area can help to mitigate flood risk.

Pinch points are closely related to the idea of environmental limits and actions to improve functionality in an area of need can both directly address "pinch point" issues and also create headroom within an environmental limit, providing capacity for future sustainable development.

Investment in regeneration or major housing or business development that does not take into account the impacts of pinch points will be more likely to underperform.

It is also important to recognise and highlight the GI assets; these already meet existing and projected future needs. Safeguarding these functions helps to reduce the risk of future problems in an area where investment is targeted.

Technical Appendix 1 – Data sources for green infrastructure mapping of Cheshire East

Green infrastructure typology

1. The latest version of Ordnance Survey's MasterMap Topography Layer was downloaded
2. Polygon features intersecting a 1km buffer of the Cheshire East Council boundary were extracted
3. Features where DescGroup like 'Landform%' were deleted, as these overlap other features
4. A figure called *E* was calculated for each feature, which is a measure of how intricate it is, or conversely how similar to a circle of the same area (for example, a long thin shape such as a river will have a higher *E* than a round or square shape such as a pond)
5. The result was unioned with Ordnance Survey's MasterMap Greenspace Layer and Cheshire East Council's Greenspace data
6. Features were classified according to MasterMap Topography attributes as follows (in the order given, only classifying at each step features not previously classified)

Attribute	Value	Type
Make	Manmade	Not GI
DescTerm	Orchard	Orchard
DescTerm	Marsh%	Wetland
DescTerm	%Trees% and not %Trees (Scattered)%	Woodland
DescTerm	Foreshore	Coastal habitat
DescTerm	%Scrub% or %Heath% or %Rough Grassland%	Grassland, heathland, moorland or scrubland
DescTerm	Coppice Or Osiers	Woodland
DescTerm	%Mineral Workings (Inactive)% or %Spoil Heap (Inactive)%	Grassland, heathland, moorland or scrubland
DescTerm	Multi Surface	Private domestic garden
DescGroup	Rail%	Grassland, heathland, moorland or scrubland
DescGroup	Roadside%	General amenity space
DescGroup	Tidal Water	Water course
DescGroup	Unclassified	Not GI
DescGroup	Road Or Track%	Not GI
DescTerm	Agricultural Land	Agricultural land

DescTerm	%Rock% and not %Rock (Scattered)%	Not GI

7. Features identified by MasterMap Topography or Greenspace attributes as inland water were classified as follows
    - *E* < 3.5: w*ater body*
    - *E* between 3.5 & 5 and area < 1ha: *water course*
    - *E* between 3.5 & 5 and area > 1ha: *water body*
    - *E* > 5: *water course*
8. Features were classified according to the Council's Greenspace data attributes as follows (in the order given, only classifying at each step features not previously classified)

Attribute	Value	Type
Typology	01 – Parks & gardens	Park or public garden
Typology	02 – Natural & semi natural urban green spaces	Grassland, heathland, moorland or scrubland
Typology	04 – Outdoor sports facilities	Outdoor sports facility
Typology	05 – Amenity greenspace	General amenity space
Typology	06 – Provision for children & teenagers	General amenity space
Typology	07 – Allotments, community gardens & urban farms	Allotment, community garden or urban farm
Typology	08 – Cemeteries & churchyards	Cemetery, churchyard or burial ground

9. Features were classified according to MasterMap Greenspace attributes as follows (in the order given, only classifying at each step features not previously classified)

Attribute	Value	Type
priForm	Beach Or Foreshore	Coastal habitat
priForm	Manmade Surface	Not GI
priForm	Woodland	Woodland
priFunc	Allotments Or Community Growing Spaces	Allotment, community garden or urban farm
priFunc	Amenity - Transport	General amenity space

priFunc	Bowling Green	Outdoor sports facility
priFunc	Cemetery	Cemetery, churchyard or burial ground
priFunc	Golf Course	Outdoor sports facility
priFunc	Institutional Grounds	Institutional grounds
priFunc	Other Sports Facility	Outdoor sports facility
priFunc	Play Space	Park or public garden
priFunc	Playing Field	General amenity space
priFunc	Private Garden	Private domestic garden
priFunc	Public Park Or Garden	Park or public garden
priFunc	Religious Grounds	Institutional grounds
priFunc	School Grounds	Institutional grounds
priFunc	Tennis Court	Outdoor sports facility
priForm	Open Semi-Natural	Grassland, heathland, moorland or scrubland
priFunc	Camping Or Caravan Park	Institutional grounds
priFunc	Land Use Changing	Institutional grounds
priFunc	Amenity – Residential Or Business	Institutional grounds

10. Features were classified according to the Council's Greenspace data attributes as follows (in the order given, only classifying at each step features not previously classified)

Attribute	Value	Type
Typology	03 – Green corridors	General amenity space
Typology	09 – Accessible countryside in urban fringe areas	Grassland, heathland, moorland or scrubland
Typology	10 – Civic spaces	Not GI

11. Features were classified according to MasterMap Topography attributes as follows (in the order given, only classifying at each step features not previously classified)

Attribute	Value	Type
DescGroup	%Natural Environment%	Grassland, heathland, moorland or scrubland
DescGroup	%Rail% or %Structure%	Not GI

12. Remaining features were classified as institutional grounds
13. Some incorrectly classified features were fixed by visual comparison with aerial photography and Ordnance Survey background mapping
14. The result was updated with street tree features identified using the process described below

Tree canopy

Bluesky/Getmapping's colour infrared aerial imagery (now available under the APGB agreement) was used to calculate the normalized difference vegetation index (NDVI)[309]. The digital terrain model and digital surface model available under the same agreement were used to calculate the height difference between the ground and objects upon it (such as trees). Locations where the height difference was greater than 5m and the NDVI was greater than the tile mean were picked out as tree canopy.

Street trees

The tree canopy was clipped to a 10m buffer of polygon features from Ordnance Survey's MasterMap Topography Layer with DescGroup like '%Roadside%'. Resulting features larger than 10m^2 were counted as street trees.

Businesses per square kilometre

Local Units 2017 at Middle Layer Super Output Area level (Office for National Statistics)

Index of risk of poor mental health

As suggested by Moscone et al (2006)[310], the following regressors were used to calculate the index. All are taken from Census 2011 statistics except for the last, which are Office for National

[309] https://en.wikipedia.org/wiki/Normalized_difference_vegetation_index
[310] Moscone, F, Knapp, M and Tosetti, E, Mental Health Expenditure in England: A Spatial Panel Approach (2006). Available at SSRN: https://ssrn.com/abstract=898474 or http://dx.doi.org/10.2139/ssrn.898474

Statistics model-based estimates for 2007-8. The index is simply the sum of the percentages at Lower Layer Super Output Area level.

- Percentage of population aged 0-15
- Percentage of population aged 65+
- Percentage of females in the population
- Percentage of population living alone
- Percentage of population with no qualifications
- Percentage of population with a long-term health problem or disability
- Percentage of households in poverty (below 60% of median income)

Coronary Heart Disease

Hospital admissions for Coronary Heart Disease per unit population 2007-8 at Middle Layer Super Output Area level (Office for National Statistics)

Childhood obesity

Prevalence of obesity in children at Reception and Year 6, 2012/13 to 2014/15, at Middle Layer Super Output Area level (Public Health England)

(Note that some values are missing for confidentiality reasons)

Adult obesity

Prevalence of obesity in adults 2003-5 at Middle Layer Super Output Area level (The NHS Information Centre)

Respiratory diseases

Deaths from respiratory diseases per unit population 2006-10 at Middle Layer Super Output Area level (Public Health England)

Potential for working with natural processes to reduce flood risk

Mapping of the potential for Working with Natural Processes 2018 (Environment Agency)[311]

Catchments smaller than 10km² of communities at risk of river flooding

Communities at risk: provided by the Environment Agency for Greater Manchester, Merseyside and Cheshire

The number of properties at risk is the number of addresses (from Ordnance Survey's AddressBase) within Flood Zone 2 and within the community at risk, for all communities at risk including those provided by the Environment Agency

Digital terrain model: Ordnance Survey Terrain 5

Catchments were calculated using ArcGIS hydrology tools:

The Fill tool was used to remove any sinks from the digital terrain model

The Flow Direction tool was used to generate a flow direction raster from the result

The Flow Accumulation tool was used to generate a flow accumulation raster

The Arc Hydro Stream Definition tool was used to generate a stream definition raster

The Arc Hydro Stream Segmentation tool was used to generate a stream link raster

The Arc Hydro Catchment Grid Delineation tool was used to generate a catchment raster

The Arc Hydro Catchment Polygon Processing tool was used to convert the catchment raster to vector

The Arc Hydro Drainage Line Processing tool was used to generate drainage lines

The Arc Hydro Adjoint Catchment Processing tool was used to generate adjoint catchments

The Arc Hydro Batch Watershed Delineation tool was used to calculate the catchments of the communities at risk centroids

The catchments of the communities at risk were filtered to show only those smaller than 10km² and larger than 10ha

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311 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/677592/Working_with_natural_processes_mapping_technical_report.pdf

Improved image

Local (Business) Units 2017 at Middle Layer Super Output Area level (Office for National Statistics)

HS2 Phase 2a proposed route March 2018 (High Speed 2 Limited)

HS2 Phase 2b proposed route July 2017 (High Speed 2 Limited)

Proposed Development Sites (Cheshire East Council)

Housing Sites May 2018 (Cheshire East Council)

Health deprivation

Indices of Deprivation 2015 Health Deprivation and Disability domain at Lower Layer Super Output Area level (Ministry of Housing, Communities & Local Government)

Accessible Natural Greenspace Standards

Greenspace (Cheshire East Council)

Countryside and Rights of Way Act 2000 open access land (Natural England)

Country Parks (Natural England)

Doorstep Greens (Natural England)

Millennium Greens (Natural England)

Woods for People (Woodland Trust)

Accessible greenspace and PRoWs

Greenspace (Cheshire East Council)

Countryside and Rights of Way Act 2000 open access land (Natural England)

Country Parks (Natural England)

Doorstep Greens (Natural England)

Millennium Greens (Natural England)

Woods for People (Woodland Trust)

Public Rights of Way (Cheshire East Council)

Air quality

National Air Quality Archive estimated background air pollution maps (2010)

Life expectancy

Life expectancy at birth by sex 2009-2013 at Middle Layer Super Output Area level (Office for National Statistics)

Technical Appendix 2 – Data sources for the green infrastructure valuation toolkit – GI-Val

The following provides information about the sources of data that have been used to complete the valuation toolkit.

Sheet	Input value	Method
Project Data	Project area	Cheshire East boundary
Project Data	Total area of greenspace	Total area of green infrastructure as determined by typology mapping
Project Data	Tree cover	As per tree canopy mapping
Project Data	Area of new woodland created	Area of woodland as determined by typology mapping
Project Data	Cycle routes	Public Rights of Way for cycling, National Cycle Network
Project Data	Footpaths	Ordnance Survey MasterMap Integrated Transport Network Urban Paths, Public Rights of Way
Project Data	Number of residents within 300m	OpenPopGrid within buffer
Project Data	Number of residents within 1200m	OpenPopGrid within buffer
Project Data	Number of households within 300m	Addresses from OS AddressBase without an organisation name (a proxy for residential buildings) within buffer
Project Data	Number of households within 450m	Addresses from OS AddressBase without an organisation name (a proxy for residential buildings) within buffer
Project Data	Number of households within 1200m	Addresses from OS AddressBase without an organisation name (a proxy for residential buildings) within buffer
Project Data	Number of visits from local visitors	90% of estimated visits according to ORVal (http://leep.exeter.ac.uk/orval/)
Project Data	Number of visits from tourist visitors	10% of estimated visits according to ORVal (http://leep.exeter.ac.uk/orval/)
Project Data	Estimate of working population	Census 2011 data for OAs within 300m
Project Data	Is the area serviced by a	United Utilities data shows that it is (partially)

	combined sewer system?	
Project Data	Area designated for nature and wildlife conservation (local designation)	Total area of Local Nature Reserves and Local Wildlife Sites within study area
Project Data	Area designated for nature and wildlife conservation (national designation)	Total area of Special Areas of Conservation, Special Protection Areas, National Nature Reserves, Sites of Special Scientific Interest, Ancient Woodlands and Priority Habitats within study area
Project Data	Number of jobs created/safeguarded for management/maintenance of site	Unknown
Project Data	Average residential property price in the area	According to zoopla.co.uk, average price in Macclesfield is £311,000, in Crewe is £205,000, and in Wilmslow is £460,000
1 Climate	Residential buildings with large trees < 10m	Addresses from OS AddressBase without an organisation name (a proxy for residential buildings) within 10m of areas of tree canopy larger than 70 sq m
2 Water	Daily precipitation figures	North West England & Wales figures for 1981-2010 from http://www.metoffice.gov.uk/hadobs/hadukp/data/download.html
4 Health	Average distance covered by walkers	Changed to 1.4km instead of 40% of total length of paths; since two lots of 300m are added on to represent travel to and from the 'site', this comes to an average walk length of 2km
4 Health	Average distance covered by cyclists	Changed to 4.4km instead of 60% of total length of cycling routes; since two lots of 300m are added on to represent travel to and from the 'site', this comes to an average trip length of 5km
4 Health (cont'd)	What type of location is the project in?	Rural seems most representative
4 Health (cont'd)	What is the existing land use type?	Agricultural seems most representative
5 Property	Of which quality 'local park'	Area of parks and gardens according to Greenspace Audit 2012

7 Lab Prod	Average gross daily wage of walker / cyclist	Based upon http://www.theguardian.com/news/datablog/2011/nov/24/wages-britain-ashe-mapped
8 Tourism	Of which day visits	Ratio as per https://www.liverpoollep.org/wp-content/uploads/2016/02/Tourism-Digest-February-2015-2.pdf
8 Tourism	Of which overnight visits	Ratio as per https://www.liverpoollep.org/wp-content/uploads/2016/02/Tourism-Digest-February-2015-2.pdf