Cheshire and Warrington Natural Capital Audit and Investment Plan

1. Natural capital audit and policy analysis

Authors:

Alison Holt[1], Mark Ashby[1], Jim Rouquette[1], Karl Busdieker[2], Colm Bowe[2], Teresa Fenn[3], Lillian Lochner[3], Imogen Shapland[3], Mark Anderson[3] and Joe Morris[4]

[1]Natural Capital Solutions, [2]Liverpool John Moores University, [3]RPA and [4]Morris Resource Economics

Contact details:

Dr J.R. Rouquette

Natural Capital Solutions Ltd

www.naturalcapitalsolutions.co.uk

jim.rouquette@naturalcapitalsolutions.co.uk

Report prepared for:

Cheshire and Warrington LEP

Version: Final

September 2021

Executive summary

The Cheshire and Warrington Local Enterprise Partnership (C&W LEP) have identified the need for an assessment of the interrelationship between natural capital and its economic and social development ambitions. The C&W LEP have commissioned this project team to produce a Natural Capital Audit, and support development of a Natural Capital Investment and Implementation Plan for the area. Technical Report 1 communicates the results of the first steps of the project, the natural capital mapping and valuation, and the policy analysis by sector.

The spatial natural capital asset register for the Cheshire and Warrington region shows that almost half of the land area is dedicated to improved grassland for livestock grazing, with smaller but significant areas of arable. Although the area of woodland is a much smaller proportion of the total area (7.8%), the woodland asset is integral to the capacity of the area to provide a wide range of services. The maps show the spatial pattern in provision of 10 ecosystem services. The woodland asset delivers high levels of provision, in comparison to other land covers, of carbon storage and sequestration, air quality, noise, local climate and water flow regulation benefits across all of the local authorities. However, due to the dominance of agriculture in the region, the associated GHG emissions outweigh the ability of the natural assets to sequester carbon.

Overall the natural capital assts of Cheshire and Warrington deliver £465 million annually, with a present value of £13.4 billion over 50 years. The most valuable ecosystem services are air quality regulation, recreation, physical health benefits and angling, delivering annual benefits between £55.4 and £146 million in value, with a present value (over 50 years) of between £2.1 and £5.4 billion. Mineral extraction, is also valuable, but there are associated environmental impacts that we have not been able to value here. Agriculture is one of the least valuable services (once subsidies are removed), although it is dominant, and the associated emissions cause a cost to society of £30.5 million annually.

Each of the local authorities have a different capacity for provision of ecosystem services and related value. Warrington is a smaller area and has a higher coverage of buildings and urban infrastructure than the other local authorities, so its baseline provision of all services is lower. However, on a per hectare basis, some of the values for Warrington are very high, particularly for recreation and physical health. Cheshire East has the largest area of woodland and other assets, and therefore, is able to deliver a greater natural capital value.

The policy analysis focused on eight sectors: agriculture; skills and education; energy, clean growth, housing and construction; manufacturing, logistics and services; minerals and waste management; environmental management; health, wellbeing and tourism; and transport. At the same time quality of place has been identified as an important cross-cutting aspect of all sectors, and key to attracting and retaining talent in the Cheshire and Warrington region. The sector analysis shows that there are opportunities across all sectors that could enhance natural capital and help deliver the LEP's economic and social targets. Key opportunities include the development of forests and urban green spaces, the transition to clean growth and supporting local communities to develop digital skills.

The analysis also highlights some policies and plans that could lead to negative effects on natural capital. The most significant threats are housing developments on the green belt, the stimulation of the economy attracting more workers and putting additional pressure on services and emphasising road development. Now the opportunities and threats have been identified, the policy analysis, along with the natural capital baseline, provides an evidence-based approach to assessing where future interventions need to be targeted to ensure opportunities can be maximised while threats are minimised.

Contents

1. Introduction

The Cheshire and Warrington Local Enterprise Partnership (C&W LEP) have identified the need for an assessment of the interrelationship between natural capital and its economic and social development ambitions for the area. Natural Capital is defined as:

> *"..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"* (Natural Capital Committee 2014[1]).

It is the stock of natural assets (e.g. soils, water, biodiversity) that produces a wide range of ecosystem services that provide benefits to people. These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities.

Natural capital supports all other forms of capital on which human systems depend, whether man-made, human or social. However, many of the outputs produced by natural capital, such as the regulation of flooding and atmospheric gases by forest lands, are not included in the decisions of private individuals or organisations. This is because they often involve non-priced public goods that are not traded in the market place and are not subject to formal property rights and entitlements (TEEB, 2010[2]). Elements of natural capital are therefore liable to be overused, degraded, depleted and eventually lost, with consequences for long term welfare and the sustainability of economic systems. There is now much greater awareness of the role of natural capital in the design and achievement of economic and social development strategies, with strong links to business and enterprise[3]. The C&W LEP's interest in natural capital assessment is also set within its commitment to develop quality of place as a platform for sustained growth.

The C&W LEP have commissioned this project to produce a Natural Capital Audit, and support the development of a Natural Capital Investment Plan for the area. This is driven by the need not only to manage risks to the natural environment associated with economic development that could undermine successful achievement, but also to explore the opportunities to tap into new funding sources and mechanisms for innovative investments that can achieve substantial gains for people and the natural world. In this respect, there is a need to develop a strategic network of natural capital oriented projects to support and extend C&W LEP's strategy through to 2040, engaging key stakeholder interests in the process. The investment plan covers the three local authority areas of Cheshire West and Chester, Cheshire East, and Warrington.

An extensive evidence base has been built-up to support the development of the **Natural Capital Audit and Investment Plan** (NCAIP). The evidence is summarised in the main NCAIP report, but is presented in much greater detail in the form of five technical reports:

1. **Natural capital audit and policy analysis** – a baseline assessment of the natural capital assets currently present across Cheshire and Warrington, the benefits that flow from those assets and their monetary value, together with an analysis of policies at the local and national scale that effect natural capital, and an identification of priority themes and sectors.

[1] Natural Capital Committee 2014. Towards a Framework for Defining and Measuring Changes in Natural Capital. Working Paper 1, Natural Capital Committee.
[2] TEEB. 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, Oxford & NY.
[3] TEEB. 2012. The Economics of Ecosystems and Biodiversity in Business and Enterprise. Earthscan. London; New York.

2. **Intervention and investment opportunities report** – habitat opportunity mapping to identify the best locations to deliver specific or multiple objectives, along with mapping of strategic themes based on local policies, to prioritise locations for investment.
3. **Workshop report** – write-up of stakeholder workshop to present the approach used to map natural capital opportunities, and to discuss key priorities across C&W.
4. **Future financing report** – review of emerging financing options, including a typology of different funding opportunities, the ecosystem services and habitats covered by each, and an approach to identifying the most appropriate funding mechanism for different projects.
5. **Case studies report** – presentation of five case studies to demonstrate how the opportunity maps can be used to identify habitat creation potential based on different objectives, to highlight the benefits of such projects, and to show how funding requirements and potential funding sources can be identified.

Another key output from this project are the numerous GIS maps and layers. These are being supplied to project partners as a data package.

This report is the first of these technical reports; the natural capital audit and policy analysis. The aims of this report are to:

a) Produce, drawing on existing and new data, a map-based register of natural capital assets and associated services flows in the study area, together with economic values where possible. This will form a baseline from which future development and change can be assessed.
b) Identify existing and potential interactions between the above natural capital assessment and development initiatives and plans, and emerging polices at the local and national scale.
c) Identify priority themes and geographic areas where actions can be taken to safeguard natural capital and maximise its potential contribution to economic and social development.

Figure 1 shows the structure and components that make up the overall Natural Capital Audit and Investment Plan and how the NC audit and policy analysis workstreams fit into the rest of the project.

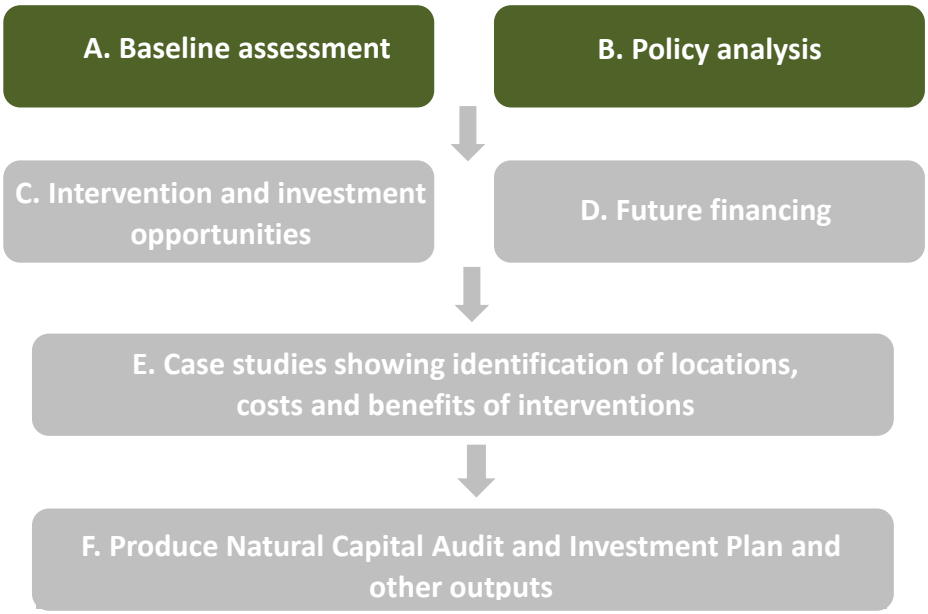

Figure 1 Overview of the overall project. The green box highlights the work reported here and shows how it fits into the other components of the overall project (grey boxes).

1.1 Approach to policy analysis

Work package B involved collating and analysing existing initiatives, plans, policies and strategies that are relevant to the identification and selection of priority areas. We reviewed the national and local policy and institutional frameworks that will drive investment in the priority areas to be identified in the GIS mapping task (Work Package A) and the stakeholder workshop. The importance of the natural environment is increasingly promoted through national and local planning policy, such as the UK Government 25 Year Environment Plan, and the National Planning Policy Framework. A structured approach was adopted to extract important information from each policy document summarising the key aspects required for the natural capital assessment. The following key aspects were considered for each policy document during the policy analysis:

- **Policy type** (e.g. Strategic Economic Plan)
- **Policy area** (objectives/examples/explanation)
- **Sub-policy area** (e.g. rail, road)
- **LEP competence** (Y/N)
- **Who has competence** (e.g. Local Authority)
- **Stakeholders** (who is involved/has invested interests in this policy)
- **Key policy document** (name of policy)
- **Key legislation and strategies** (national policy, e.g. Climate Change Act 2008, Industrial Strategy White Paper)
- **Relevant webpage**
- **Funding** (by whom, amount)
- **Relevant economic sector**
- **Relevant ecosystem services**
- **Investment drivers/pressures** (enablers and barriers to natural capital)
- **Positive/negative effect** (do enablers/barriers affect natural capital negatively or positively)
- **Level of impact** (scale 1-3)
- **Current policy situation** (life cycle of policy)
- **Current environmental situation** (state of the environment)
- **Keywords during search**
- **Comments**
- **Maps** (does the policy include maps? - important for GIS)

The development plans and strategies with the key elements of natural capital, and associated service flows, were aligned in order to determine important two-way interactions and interdependencies, both positive and negative. This was done by overlaying the development plans on the map-based outputs from the natural capital assessments in order to provide a spatial perspective. The analysis provides an overview of main policy strategies in each relevant sector. While a wide range of similar policies and initiatives was reviewed, only the impact on ecosystem services and the relevant sector of the main strategies were assessed.

The review of documents also identified drivers and pressures that could affect the type, source and magnitude of investment in the priority areas. Drivers and pressures that were identified from the existing policy and institutional framework were linked to the ecosystem services to which they are relevant. This study focuses on broad groupings of ecosystem services: provisioning, regulating, cultural and supporting since the analysis shows that the main differences are between these groups. The identification of impacts on ecosystem services in this way will help with the determination of any unintended impacts of investing in an area (either a sector or a specific geographical location) when considering specific opportunities and priorities in Work Package C.

2. Baseline natural capital assets

2.1 Creating a natural capital basemap

Before the flow or value of ecosystem services can be calculated and mapped, it is necessary to obtain an accurate assessment of the natural capital assets currently present in the study area. The most important component of this is to create a habitat basemap for the Cheshire and Warrington region.

The habitat basemap was created using EcoServR, a toolkit developed at Liverpool John Moores University (in collaboration with Natural Capital Solutions and Forest Research) and based on the original EcoServ GIS toolkit developed by the Wildlife Trusts, with a number of modifications. This approach uses OS MasterMap polygons as the underlying mapping unit, and then uses a series of different data sets to classify each polygon to a detailed habitat type and to associate a range of additional data with each polygon. The data that was used to classify habitats is shown in Box 1.

Box 1: Data used to classify habitats in the basemap:

- OS Mastermap topography layer
- OS VectorMap District data
- OS Open Greenspace data
- CORINE European land cover data
- CROME crop data
- Digital Terrain Model

Polygons were classified into Phase 1 habitat types and were also classified into broader habitat groups. Multiple modifications were made to the EcoServ programme code to enable improved classification of habitats. Furthermore, upon initial completion, the basemap was carefully checked and manual alterations were made in a number of places where misclassifications had occurred. Note, however, that the final map was not ground truthed for accuracy, hence some misclassifications are inevitable. The basemap was produced to cover the whole of the wider Cheshire and Warrington area, plus an additional buffer zone of 1km to ensure that all maps were accurate right to the edge of the main study area.

2.1 Broad habitats

Figure 2 shows the key habitats across the Cheshire and Warrington region. A breakdown of the broad habitats found in Cheshire and Warrington, along with their area and percentage cover, is also presented in the natural capital asset register below (Table 1). The Cheshire and Warrington area covers approximately 229,500 ha, and provides a diversity of broad habitats, but is dominated by improved grassland that covers 47.3% of the area along with significant regions of arable land (17.4%). In total 4.0% of the region is classified as amenity grassland, with another 3.0% comprised of other types of grassland (mostly semi-natural or marshy grassland). Built-up areas and infrastructure make up around 8.5% of the area, with gardens occupying another 6.0%. Woodland, parkland and tree habitats comprise 7.8% of the total area, which is below the national average.

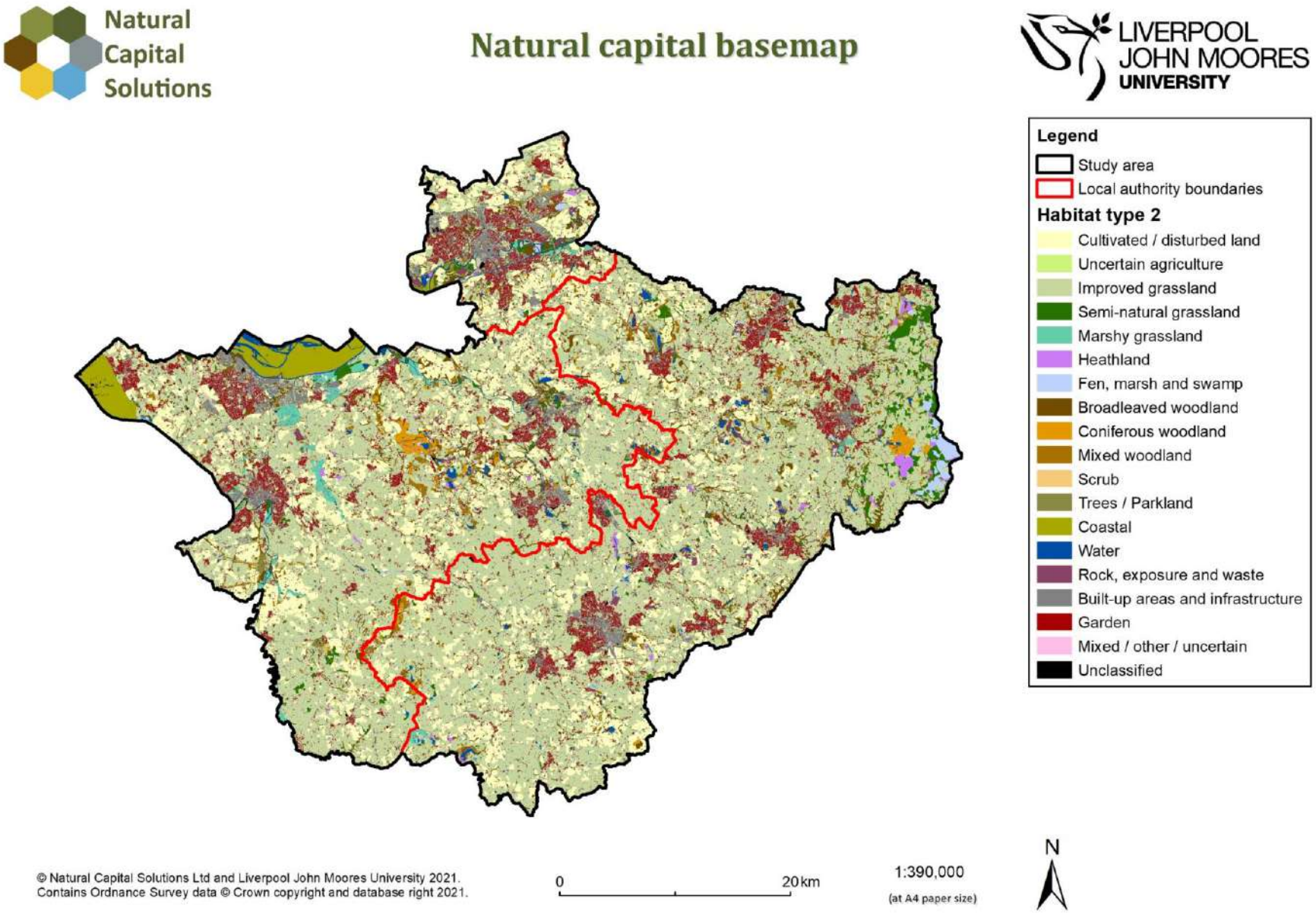

Figure 2 Cheshire and Warrington natural capital asset map, broken down by broad habitat categories.

Table 1 Natural capital asset register showing the area and percentage cover of broad habitat types for each of the Local Authority areas within Cheshire and Warrington and for the region as a whole.

Broad Habitat Category	Cheshire East		Cheshire West		Warrington		All Cheshire and Warrington	
	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area
Cultivated / disturbed land	18,035	15.4	17,328	18.4	4,589	25.1	39,951	17.4
Improved grassland	62,448	53.4	42,854	45.4	3,323	18.2	108,626	47.3
Amenity grassland	3,669	3.1	3,859	4.1	1,608	8.8	9,136	4.0
Semi-natural grassland	2,969	2.5	1,041	1.1	269	1.5	4,292	1.9
Marshy grassland	405	0.3	1,526	1.6	184	1.0	2,115	0.9
Unknown grassland	228	0.2	215	0.2	61	0.3	503	0.2
Heathland	378	0.3	15	0.0	0	0.0	393	0.2
Bog	892	0.8	8	0.0	67	0.4	967	0.4
Fen and swamp	107	0.1	115	0.1	44	0.2	265	0.1
Broadleaved woodland	5,696	4.9	3,753	4.0	1,353	7.4	10,802	4.7
Coniferous woodland	854	0.7	832	0.9	63	0.3	1,749	0.8
Mixed woodland	1,820	1.6	1,770	1.9	186	1.0	3,776	1.6
Scrub	180	0.2	101	0.1	69	0.4	351	0.2
Trees / Parkland	674	0.6	373	0.4	115	0.6	1,163	0.5
Hedgerows	1,416	1.2	1,233	1.3	104	0.6	2,753	1.2
Intertidal	7	0.0	1,805	1.9	78	0.4	1,890	0.8
Saltmarsh	0	0.0	1,980	2.1	61	0.3	2,041	0.9
Shingle	0	0.0	0	0.0	0	0.0	0	0.0
Water	1,848	1.6	1,681	1.8	433	2.4	3,962	1.7
Natural rock	14	0.0	1	0.0	0	0.0	15	0.0
Artificial exposure and waste	261	0.2	117	0.1	127	0.7	506	0.2
Built up areas	4,650	4.0	4,586	4.9	2,007	11.0	11,243	4.9
Roads	2,753	2.4	2,405	2.5	953	5.2	6,111	2.7
Railway	232	0.2	163	0.2	67	0.4	462	0.2
Pavement	487	0.4	479	0.5	287	1.6	1,253	0.5
Path	194	0.2	184	0.2	122	0.7	500	0.2
Garden	6,458	5.5	5,331	5.6	1,931	10.6	13,720	6.0
Unclassified (under development)	184	0.2	618	0.7	148	0.8	950	0.4
Total	**116,859**	**100**	**94,372**	**100.0**	**18,251**	**100.0**	**229,496**	**100.0**

3. Modelling and mapping ecosystem services (physical flows)

Once a detailed habitat basemap had been created for Cheshire and Warrington region, it was then possible to quantify and map the benefits that these habitats (natural capital) provide to people. The following benefits (ecosystem services) have been assessed for this project:

- Carbon storage
- Carbon sequestration
- Air purification
- Noise regulation
- Local climate regulation
- Water flow regulation
- Water quality
- Agricultural production
- Timber production
- Accessible nature

The list of services assessed was considered to capture all of the most important services provided by the natural environment, supported by expert knowledge from within the project team. A variety of methods were used, and these are described for each individual ecosystem service in the sections below. In all cases the models were applied at a 10m by 10m resolution to provide fine scale mapping across the area. The models are based on the detailed habitat information determined in the basemap, together with a variety of other external data sets (e.g. digital terrain model, UK census data 2011, open space data, and many other data sets and models mentioned in the methods for each ecosystem service). Note, however, that many of the models are indicative (showing that certain areas have higher capacity or demand than other areas) and are not process-based mathematical models (e.g. hydrological models). In all cases the capacity and demand for ES is mapped relative to the values present within the study area.

For every ecosystem service listed, the capacity of the natural environment to deliver that service – or the current supply – was mapped. For air purification, noise regulation, and local climate regulation, it was also possible to map the local demand (the beneficiaries) for these services. The importance and value of ecosystem services can often be dependent upon its location in relation to the demand for that service, hence capturing this information and how it changed under the proposed masterplan, provided useful additional insight. Mapping demand was not, however, possible, for the other services where there was no obvious method to apply, or local demand is not relevant, such as food or timber production.

3.1 Carbon storage capacity

What is it and why is it important?

Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation. Carbon storage and sequestration is seen as increasingly important as we move towards a low-carbon future. The importance of managing land as a carbon store has been recognised by the UK government, and land use has a major role to play in national carbon accounting. Changing land use from one type to another can lead to major changes in carbon storage, as can restoration of degraded habitats.

How is it measured?

Carbon storage capacity was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. This model estimates the amount of carbon stored in the vegetation and top 30cm of soil. It applies average values for each habitat type taken from a review of a large number of previous studies in the scientific literature. As such it does not take into account habitat condition or management, which can cause variation in amounts of carbon stored. It is calculated for each 10m by 10m cell across the study area. Scores are scaled on a 0 to 100 scale, relative to values present within the mapped area.

In all the ecosystem services maps that follow, the highest amounts of service provision and demand (hotspots) are shown in red, with a gradient of colour to blue, which shows the lowest amounts (coldspots).

Results for Cheshire and Warrington

Figure 3 (overleaf) shows baseline carbon storage capacity across the study area. The score is out of a maximum possible of 100 (in this case, if the whole area was covered in sphagnum bog habitat).

Carbon storage capacity in the region is clustered in areas of habitats such as broadleaved woodland, which is particularly efficient at carbon storage. There are some clusters of extremely high carbon storage capacity to the north and east of the region, which are characterised by sphagnum bog habitats – the most efficient at storing carbon.

However, most green spaces of the region support some level of carbon storage, with much lower levels in urban areas dominated by buildings and sealed surfaces.

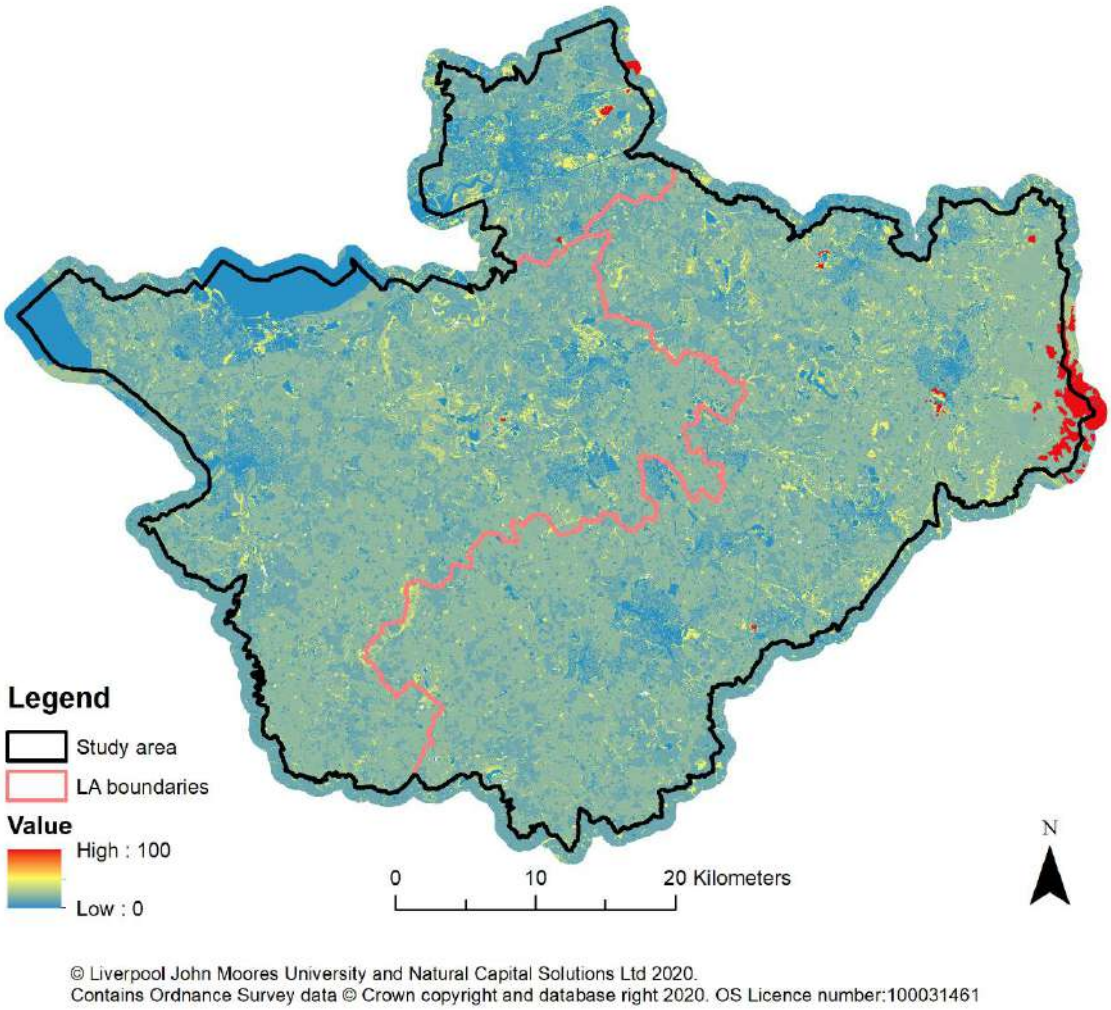

Figure 3 Carbon storage capacity across the Cheshire and Warrington region, and by local authority.

3.2 Carbon sequestration

What is it and why is it important?

Carbon is sequestered (captured) by growing plants. Plants that are harvested annually (e.g. arable crops, improved grassland) will be approximately carbon neutral over the course of a year as the sequestered carbon is immediately harvested. There is very little information about sequestration in other habitats (apart from woodland), but these are likely to be very low. Therefore, estimates are solely based on woodland carbon sequestration.

How is it measured?

Carbon sequestration from woodland and street trees were calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2018[4]). Coniferous woodland sequestration rates were averaged over a 60-year period and deciduous woodland sequestration rates were averaged over a 100-year period, as this is the length of a typical forestry cycle for for these woodland types. Information on species composition was taken from the Forestry Commission's National Inventory of Woodland and Trees County Report for Cheshire (2002[5]). Yield classes for each tree species in Cheshire were derived from Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). The annual sequestration rate for each woodland type were then multiplied by the area of each and added together to give the total annual sequestration estimate for woodland at the site. Maps of the sequestration rate scaled from 0 to 100 were produced.

Results

The baseline carbon sequestration rate map (Figure 4) shows high areas of carbon sequestration (in red) scattered across the Cheshire and Warrington areas. These are areas of broadleaved woodland. In terms of ability to sequester carbon at a high rate, Cheshire East has the largest area of broadleaved woodland. Areas in orange tend to be mixed woodland. Coniferous woodland plantation shows up as light green, Delamere Forest in Cheshire West, and Macclesfield Forest in Cheshire East.

[4] Woodland Carbon Code (2018) Carbon calculation guidance v2. March 2018. Forestry Commission.
[5] Forestry Commission (2002) National Inventory of Woodland and Trees County Report for Cheshire. Forestry Commission.

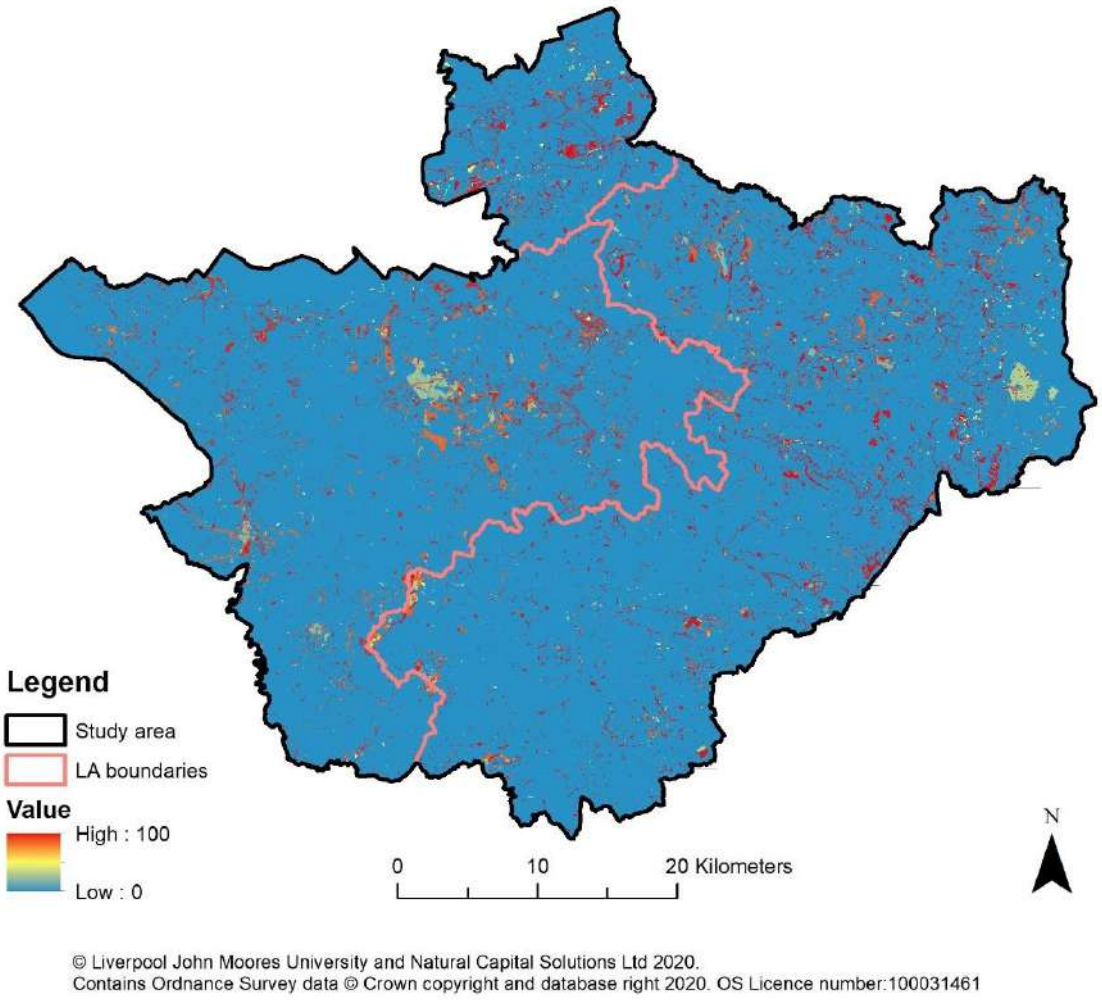

Figure 4 Carbon sequestration capacity across the Cheshire and Warrington region, and by local authority.

3.3 Air purification capacity (air quality regulation)

What is it and why is it important?

According to the World Health Organisation, air pollution is the greatest environmental health risk in Western Europe and globally. In the UK alone, it is estimated to have an effect equivalent to 29,000 deaths each year and is expected to reduce the life expectancy of everyone in the UK by 6 months on average, at a cost of around £16 billion per year (Defra 2016[6]). Air pollution also contributes to climate change, reduces crop yields, and damages biodiversity.

Air purification capacity estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Vegetation can be effective at mitigating the effects of air pollution, primarily by intercepting airborne particulates (especially PM_{10} and $PM_{2.5}$) but also by absorbing ozone, SO_2 and NO_X. Trees provide more effective mitigation than grass or low-lying vegetation, although this varies depending on the species of plant. Coniferous trees are generally more effective than broadleaved trees due to the higher surface area of needles and because the needles are not shed during the winter.

How is it measured?

Local climate regulation capacity was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. The model assigns a score to each habitat type representing the relative capacity of each habitat to ameliorate air pollution. The cumulative score in a 20m and 100m radius around each 10m by 10m pixel was then calculated and combined. The benefits of pollution reduction by trees and greenspace may continue for a distance beyond the greenspace boundary itself, with evidence that green area density within 100m can have a significant effect on air quality. Therefore, the model extends the effects of greenspace over the adjacent area, with the maximum distance of benefits set at 100m. **Note that the model does not take into account seasonal differences or differences in effect due to prevailing wind direction**.

The final capacity score was calculated for each 10m by 10m cell across the study area, and was scaled on a 0 to 100 scale, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to trap airborne pollutants and ameliorate air pollution.

Results for Cheshire and Warrington

Woodland is by far the best habitat at intercepting and absorbing air pollution, with the very highest scores from coniferous forests. The lowest scores (dark blue) are from man-made sealed surfaces and water features which effectively have zero capacity to ameliorate air pollution.
Of particular note are the densely forested areas, apparent as dark red patches of high air purification capacity in Figure 5. These include sites such as Macclesfield Forest and Delamere Forest, which provide disproportionately high levels of air purification capacity compared to surrounding areas. Urban areas display much lower levels of air purification capacity in general.

[6] Defra (2016) Air pollution in the UK 2015. Crown Copyright.

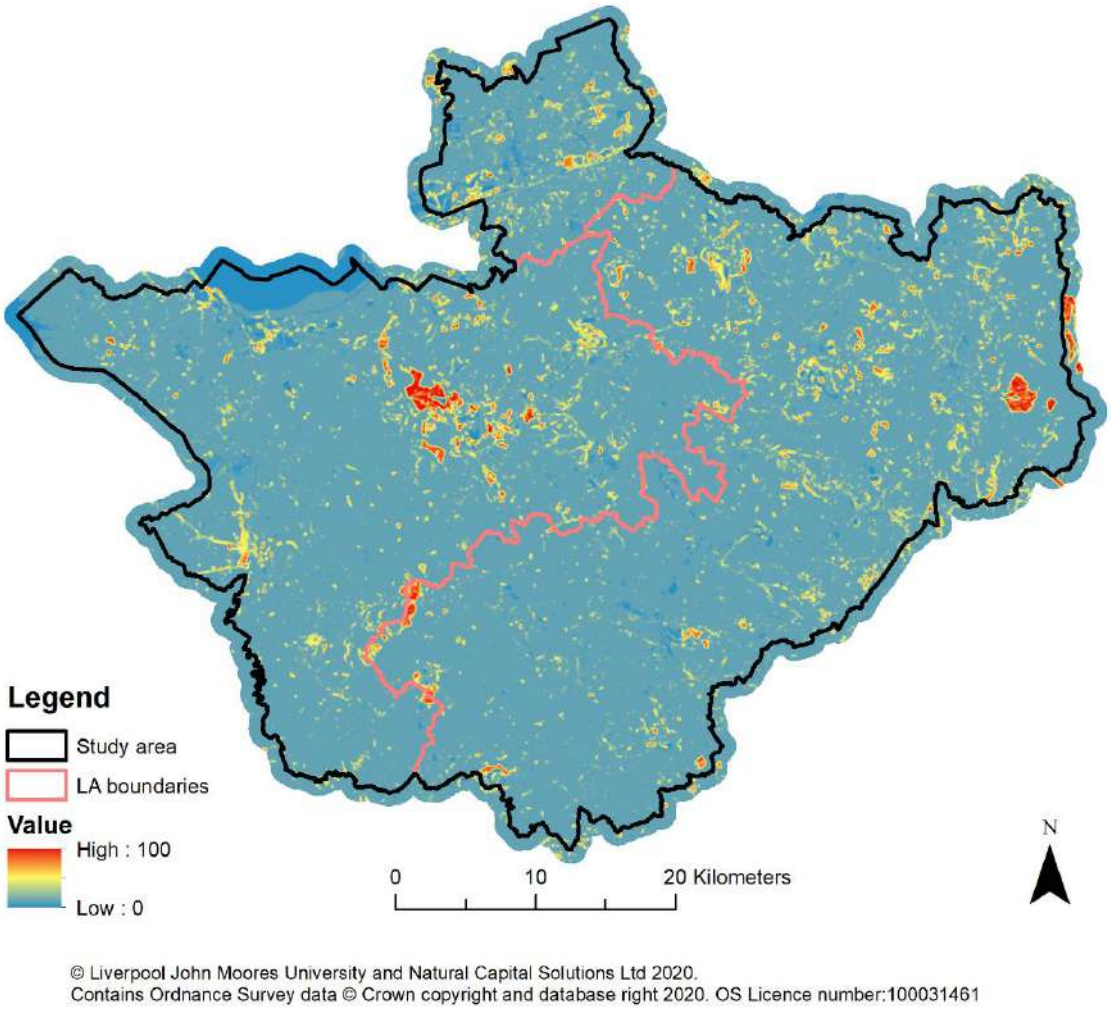

Figure 5 Air purification capacity across the Cheshire and Warrington region, and by local authority.

3.4 Air purification demand

What is it and why is it important?

Air purification demand estimates societal and environmental need for ecosystems that can absorb and ameliorate air pollution. Demand is assumed to be highest in areas where there are likely to be high air pollution levels and where there are lots of people who could benefit from the air purification service.

How is it measured?

Air purification demand was mapped using a bespoke EcoservR model, originally adapted from coServ GIS. The model combines two indicators of air pollution sources (log distance to roads, and % cover of sealed surfaces) and two indicators of societal need for air purification (population density, and Index of Multiple Deprivation health score).

The scores for each indicator were normalised and combined with equal weighting. The final score was then projected on a 0 to 100 scale, relative to values present within the study area. High values (red) denote areas with the greatest demand for air purification as a service.

Results for Cheshire and Warrington

Air purification demand is highest in urban centres as these have both higher air pollution levels and higher populations that would benefit from better air quality. The main road network is also clearly visible as a major pollution source, and where these main roads pass through built up areas, there is increased demand for air purification. On Figure 6, the areas of highest demand are clustered around major towns and cities in the region, particularly in Chester, Warrington and Crewe. Outside of these clusters, demand is relatively low across the study region.

Balancing supply and demand for air purification services

By considering both the air purification capacity and demand maps (Figures 5 and 6), it is clear that there is a significant spatial disparity in air purification capacity and demand, with the former being higher in rural areas and the latter higher in urban areas. Planting (or maintaining) trees and woodland close to main roads and other pollution sources in built-up areas would be highly beneficial, with considerable benefits to society possible. Air pollution can be very localised, hence it is also important to consider the specific location of trees to gain the maximum benefit of this service.

Trees are very effective at mitigating the effects of air pollution. However, there are major differences in the ability of different species to intercept pollution. The location of trees relative to pollution sources also determines how effective they are at removing pollutants, with trees close to sources being the most effective. Urban woodland is particularly effective as it has high capacity to absorb pollution and is also situated in locations likely to have high demand for the service.

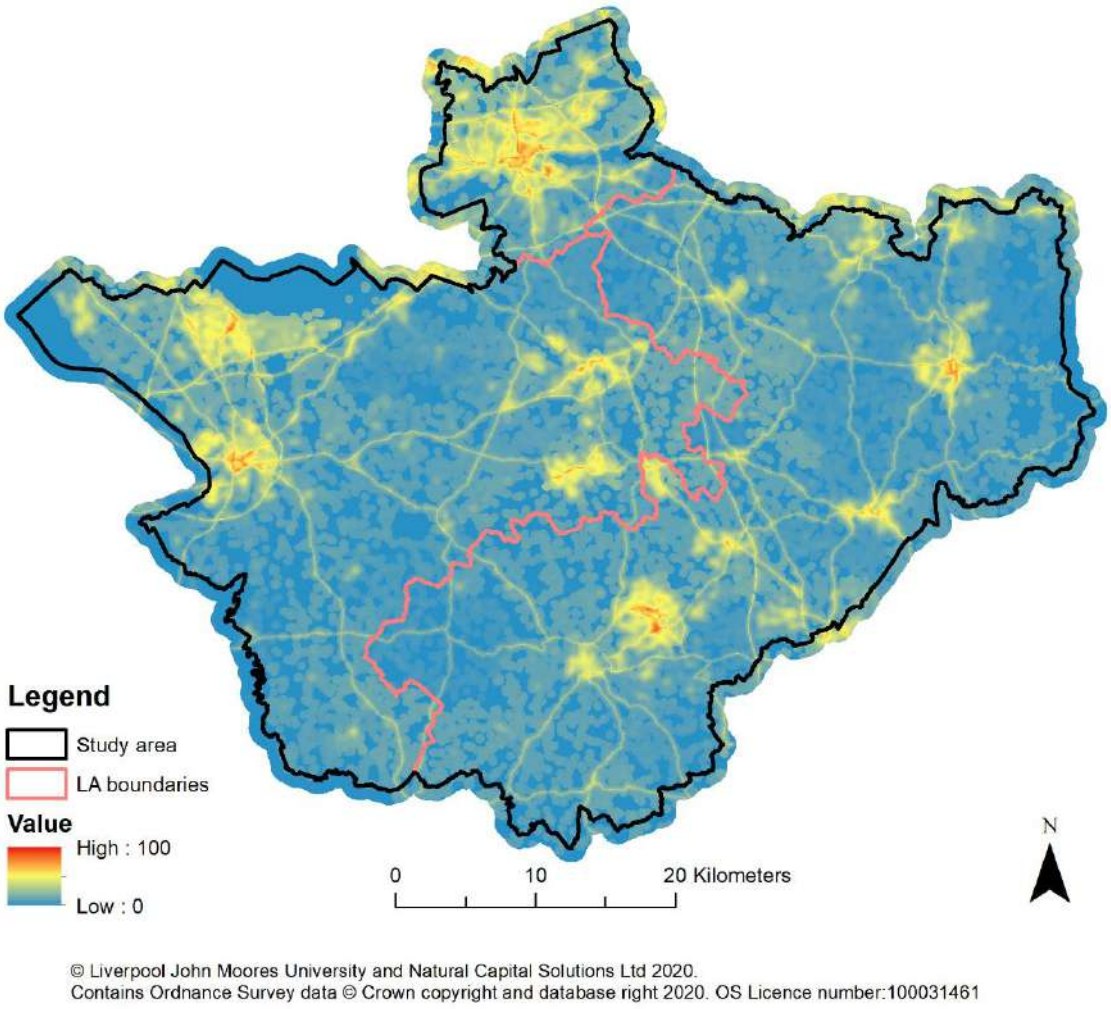

Figure 6 Air purification demand across the Cheshire and Warrington region, and by local authority.

3.5 Noise regulation capacity

What is it and why is it important?

Noise regulation capacity is the capacity of the land to diffuse and absorb noise pollution. Noise can impact on health, wellbeing, productivity and the natural environment and the World Health Organisation (WHO) have identified environmental noise as the second largest environmental health risk in Western Europe (after air pollution). It is estimated that the annual social cost of urban road noise in England is £7 to £10 billion (Defra 2013[7]). Major roads, railways, airports and industrial areas can be sources of considerable noise, but use of vegetation can screen and reduce the effects on surrounding neighbourhoods. Complex vegetation cover such as woodland, trees and scrub is considered to be most effective, although any vegetation cover is more effective than artificial sealed surfaces, and the effectiveness of vegetation increases with width.

How is it measured?

Noise regulation capacity was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. First, the capacity of the natural environment is mapped by assigning a noise regulation score to vegetation types based on height, density, permeability and year round cover. Next, the noise absorption score in 30m and 100m radii around each point was modelled and the scores combined, which results in wider belts of vegetation receiving a higher score. The score was calculated for each 10 m by 10m cell across the study area, and is scaled on a 0 to 100 scale, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to absorb noise pollution.

Results for Cheshire and Warrington

Woodland is by far the most effective habitat at absorbing noise. However, the effects are modest, with reductions of 2-4 dB typically recorded across dense tree belts. Figure 7 shows a broadly similar spatial pattern to Figure 5, air purification capacity. Noise regulation capacity is relatively low in urban areas, and highest in forested areas such as Delamare and Macclesfield forests, and Pennsylvania Wood to the southeast. Outside of these major areas, noise regulation capacity is variable and occurs mainly in clusters around green spaces across the region.

[7] Defra (2013) Noise pollution: economic analysis. Crown Copyright.

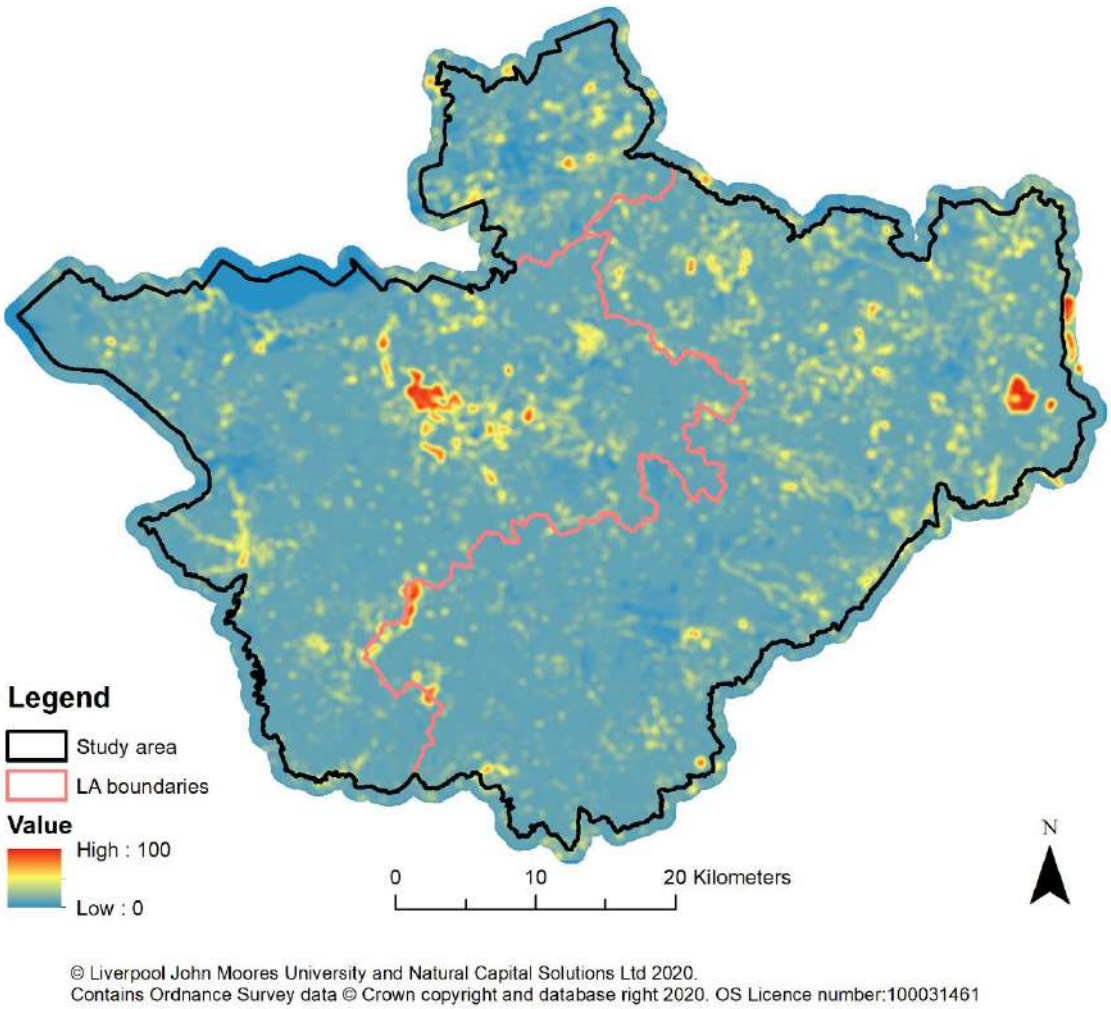

Figure 7 Noise regulation capacity across the Cheshire and Warrington region, and by local authority.

3.6 Noise regulation demand

What is it and why is it important?

Noise regulation demand estimates societal and environmental need for ecosystems that can absorb and reflect anthropogenic noise.

How is it measured?

Noise regulation demand was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. The model combines one indicator that maps noise sources (inverse log distance to different road classes and railways, custom built for the study area) and two indicators of societal demand for noise abatement (population density, and Index of Multiple Deprivation health scores).

Scores are on a 1 to 100 scale, relative to values present within the study area. High values (red) indicate areas that have the highest demand for noise regulation as a service.

Results for Cheshire and Warrington

Figure 8 shows noise regulation demand across the Cheshire and Warrington region. Demand is greatest in urban areas close to major roads, as these contain large populations, with potentially poor health scores, that would benefit from noise abatement from the main roads. The main areas include Chester, Warrington and Crewe. Railways are also a major noise source in Cheshire and so demand in the areas directly surrounding these is high, as is demand surrounding major roads and motorways.

Balancing supply and demand for noise regulation services

The pattern of supply and demand for this service is rather similar to that of air purification, with a spatial disparity between capacity and demand - capacity is concentrated in more rural areas and demand is clustered around urban areas, as well as roads and railways. Again, planting trees close to main roads and other noise sources would be the most effective mitigation.

Studies in many countries have shown that densely planted tree belts can reduce noise levels, but the effects are modest, with reductions of 2-4 dB typically recorded. Note however, that there is some evidence to suggest that the presence of vegetation blocking views of a noise source such as a road can enhance the perception of noise reduction. Densely planted and complex vegetation cover such as trees mixed with scrub is considered to be most effective, although any vegetation cover is more effective than artificial sealed surfaces.

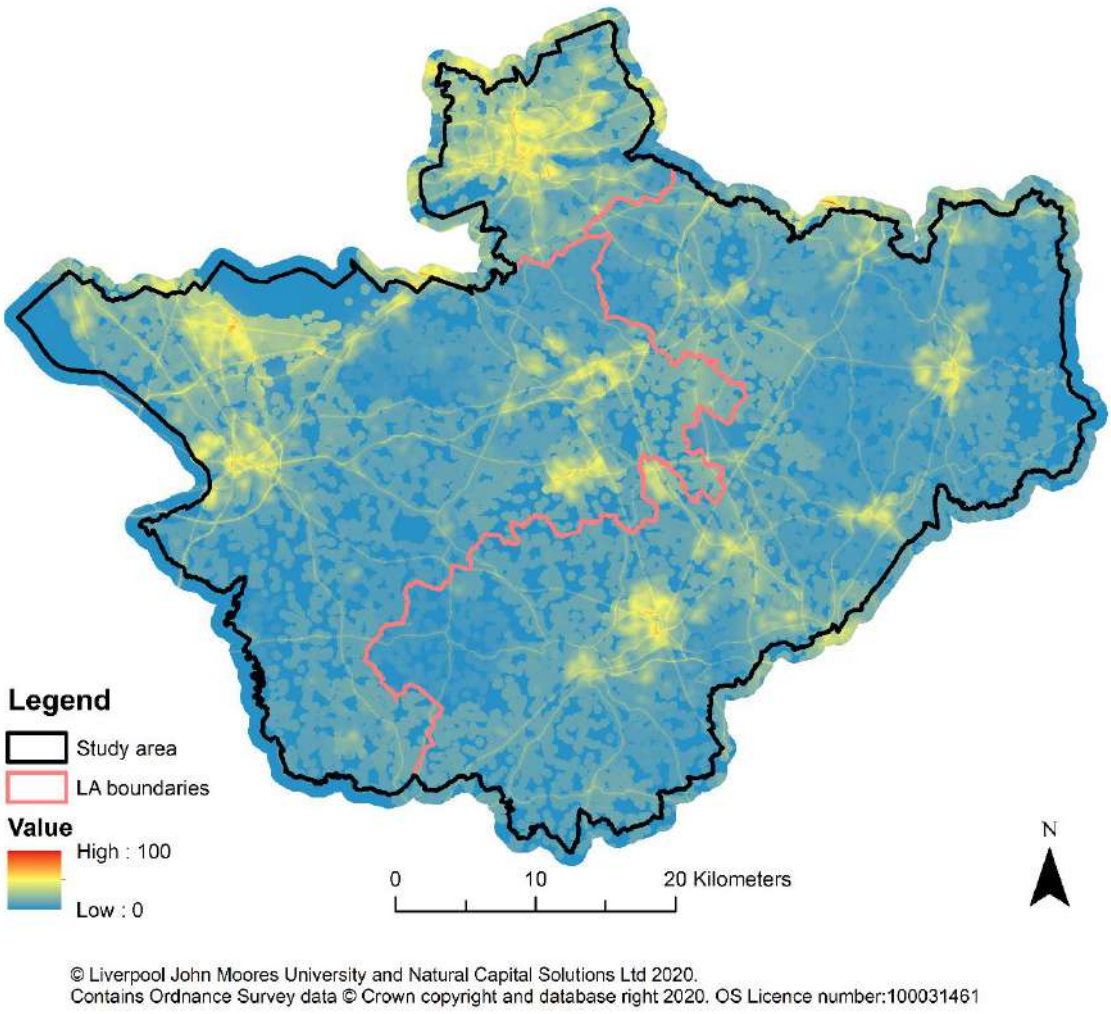

Figure 8 Noise regulation demand across the Cheshire and Warrington region, and by local authority.

3.7 Local climate regulation capacity

What is it and why is it important?

Land use can have a significant effect on local temperatures. Urban areas tend to be warmer than surrounding rural land due to a process known as the "urban heat island effect". This is caused by urban hard surfaces absorbing more heat, which is then released back into the environment, coupled with energy released by human activity such as lighting, heating, vehicles and industry. Climate change impacts are predicted to make the overheating of urban areas and urban buildings a major environmental, health and economic issue over the coming years. Natural vegetation, especially trees / woodland and rivers, are able to have a moderating effect on local climate, making nearby areas cooler in summer and warmer in winter. Local climate regulation capacity estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima.

How is it measured?

Local climate regulation capacity was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. The model calculates the proportion of the landscape that is covered by woodland / scrub and water features within a 200m radius around each 10m by 10m cell across the study area. However, temperature regulating effects of woodland and water will also occur in nearby adjacent areas, with the distance of the effect dependent on the patch size of the natural area. To incorporate this effect, a buffer was applied around each woodland / water patch, with wider buffers modelled around larger natural sites. Note that this model only includes woodland / scrub and water features which provide the most significant effects. All green space is beneficial compared to artificial sealed surfaces, so a future iteration of the model could include all natural surfaces.

The final capacity score was calculated for each 10m by 10m cell across the study area, and was scaled from 0 to 100, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to regulate temperatures, keeping them cool in the summer and warmer in the winter.

Results for Cheshire and Warrington

Figure 9 shows local climate regulation capacity across the Cheshire and Warrington region. In the absence of large bodies of water, areas of woodland provide some of the highest local climate regulation capacity in the region. For this reason, Figure 9 shows a similar capacity pattern to Figures 5 and 7, with Delamere and Macclesfield forests providing significant amounts of local cooling. Capacity is significantly lower around urban centres and throughout much of the region outside of woodland and water bodies.

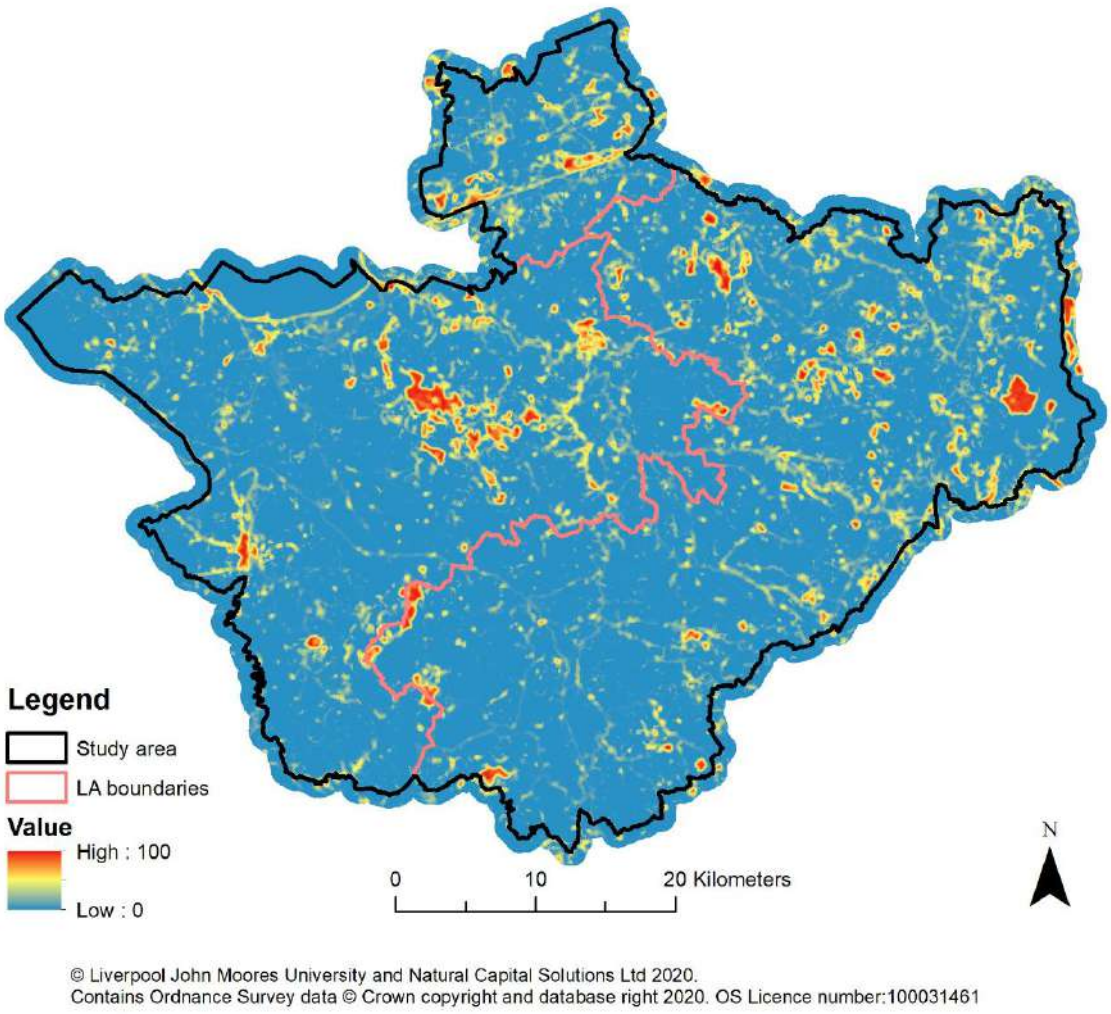

Figure 9 Local climate regulation capacity across the Cheshire and Warrington region, and by local authority.

3.8 Local climate regulation demand

What is it and why is it important?

Local climate regulation demand estimates societal and environmental need for ecosystems that can regulate local temperatures and reduce the effects of the urban heat island.

How is it measured?

Local climate regulation demand was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. The model combines one indicator showing the location of areas suffering from the urban heat island effect (the proportion of sealed surfaces), with two indicators showing societal need for local climate abatement (population density, and proportion of the population in the highest risk age categories – defined as under 10 and over 65).

Scores are on a 0 to 100 scale, relative to values present within the study area. High values (red) indicate areas that have the highest demand for local climate regulation as a service.

Results for Cheshire and Warrington

Figure 11 shows local climate regulation demand across the Cheshire and Warrington region. By removing areas of zero demand, it is immediately clear that demand is heavily clustered around urban centres, with Warrington providing a particularly large area of high demand. Demand for local climate regulation is effectively zero outside of these centres, and so interventions looking to reduce the disparity between capacity and demand in this service would benefit heavily from investing in capacity in urban areas to meet this concentrated demand.

Balancing supply and demand for local climate regulation services

Demand for this service is focussed around the larger, more densely populated communities. Large water bodies, and large areas of woodland in or adjacent to towns are particularly beneficial to local climate regulating services as they can bring moderating conditions into the heart of these urban areas. Further promoting water features and planting trees would be the most effective way to extend these benefits to other areas, particularly when these are installed close to or within built-up areas.

Although regulating local climate and moderating the impacts of the urban heat island effect may be considered to be a relatively low priority at present, its importance is likely to increase over time due to climate change and an increasing (and ageing) population.

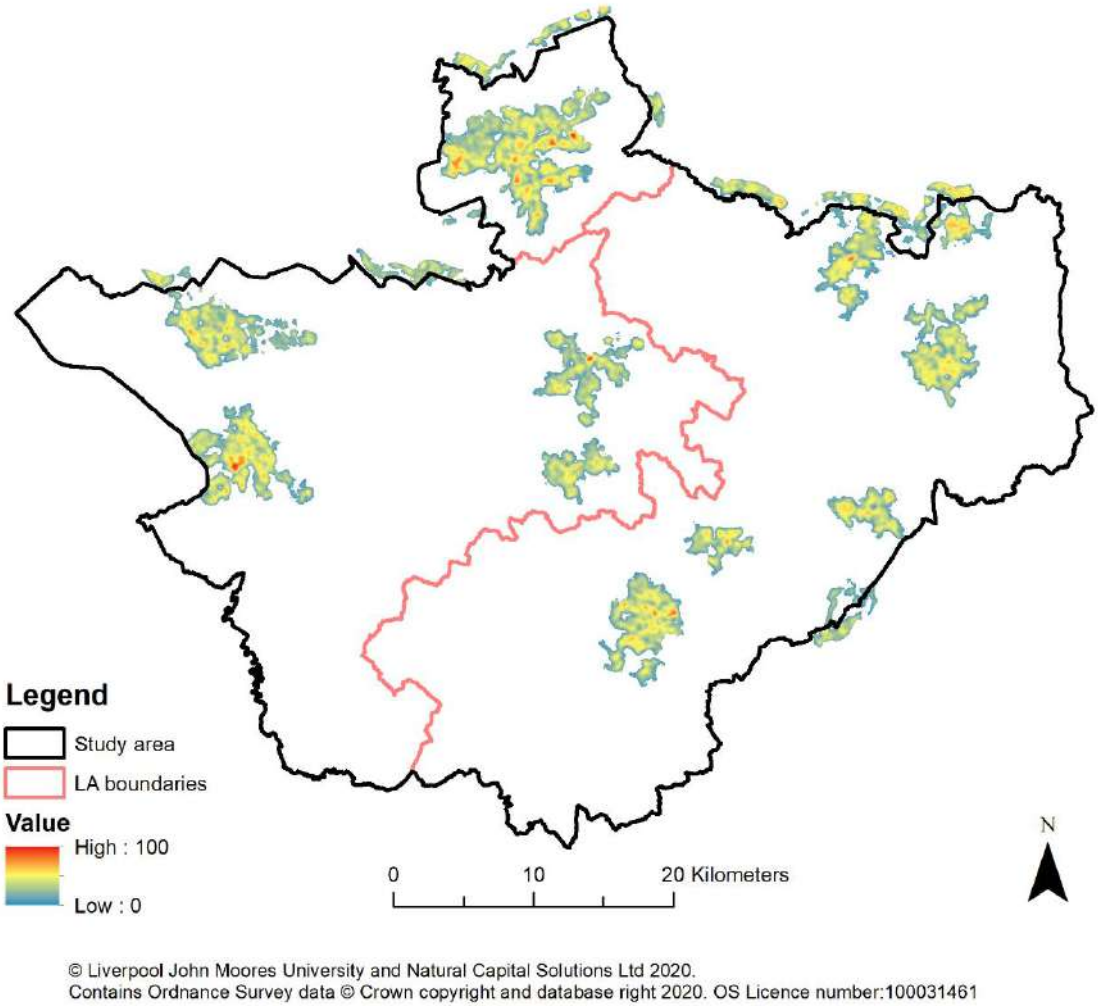

Figure 10 Local climate regulation demand across the Cheshire and Warrington region, and by local authority. Areas with zero demand have been excluded for to improve map legibility.

3.9 Water flow capacity

What is it and why is it important?

Water flow capacity is the capacity of the land to slow water runoff and thereby potentially reduce flood risk downstream. Following a number of recent flooding events in the UK and the expectation that these will become more frequent over the coming years due to climate change, there is growing interest in working with natural process to reduce downstream flood risk. These projects aim to "slow the flow" and retain water in the upper catchments for as long as possible. Maps of water flow capacity can be used to assess relative risk and help identify areas where land use can be changed.

How is it measured?

Water flow capacity was mapped using a bespoke EcoservR model, which builds on an existing EcoServ model and incorporates many of the features used in the Environment Agency's catchment runoff models used to identify areas suitable for natural flood management. Runoff can generally be assessed based on three factors: land use, slope and soil type, and so the following indicators were developed and mapped for each 10m by 10m cell across the Cheshire and Warrington region:

- **Roughness score** – Manning's Roughness Coefficient provides a score for each land use type based on how much the land use will slow overland flow.
- **Slope score** – based on a detailed digital terrain model, slope was re-classified into a number of classes based on the British Land Capability Classification and others.
- **Standard % runoff** – was obtained from soil data and modified to reflect soil hydrological properties and their sensitivity to structural degradation from agricultural use. This was integrated with a layer showing impermeable areas where no soil was present (sealed surfaces, water and bare ground).

Each indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale, as for the other ecosystem services. Note that this is an indicative map, showing areas that have generally high or low capacity and is not a hydrological model. High values (dark orange and red) indicate areas that have the highest capacity to slow water runoff.

Results for Cheshire and Warrington

The best locations for slowing water runoff are areas of woodland on flat land and permeable soils (Figure 11). The worst areas are areas of impermeable surface. Though not particularly visible at a regional scale, impermeable sealed surfaces are prominent in urban areas, where water flow regulation capacity is quite poor.

In comparison, areas such as Delamere Forest, characterised by gentle slopes, permeable soils and woodland which slows surface water flow, have excellent water flow regulation capacity. Similarly, flatter areas lacking in woodland such as the arable land surrounding Warrington Airstrip in Birchwood also provide significant water flow regulation capacity.

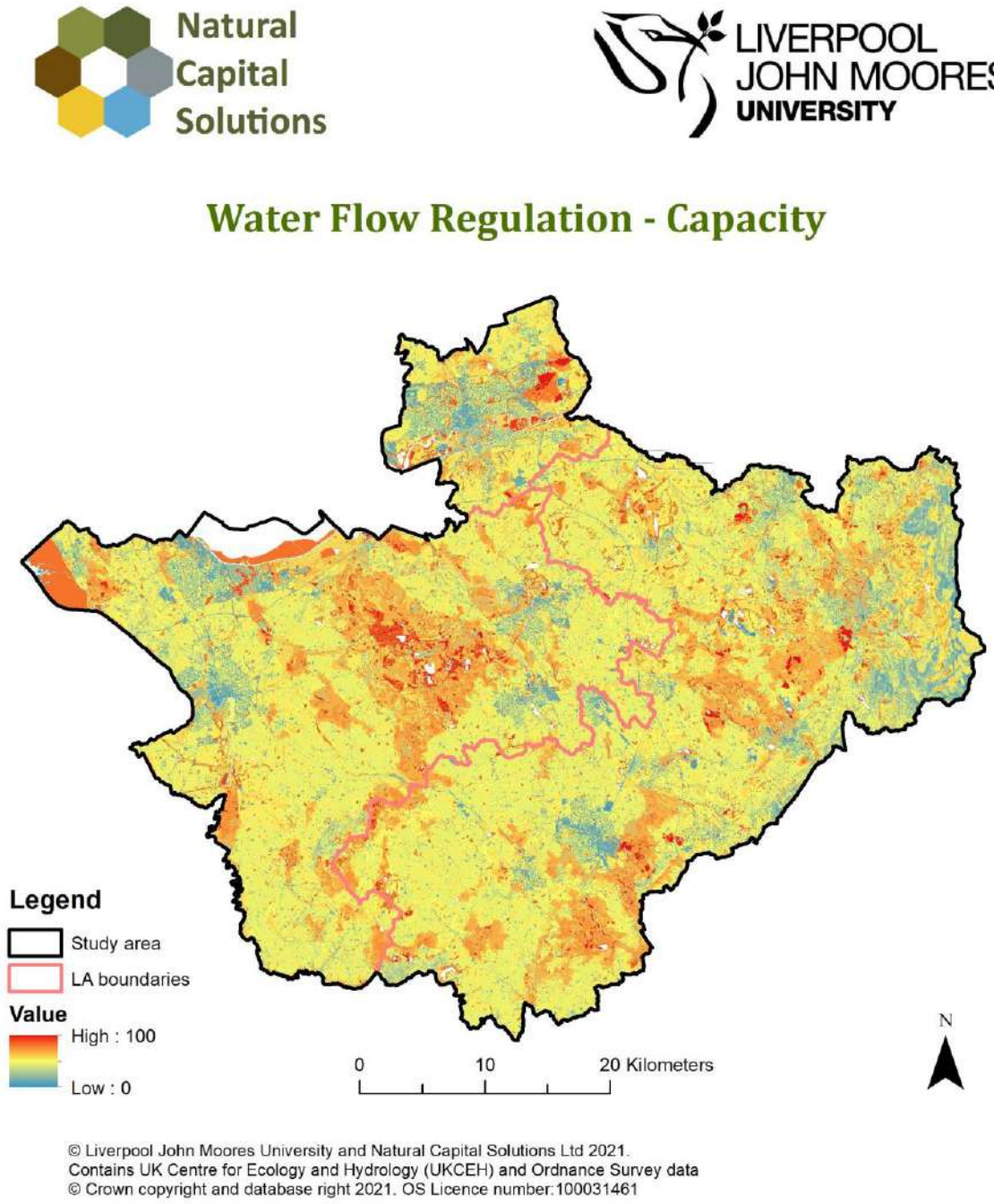

Figure 11 Water flow regulation capacity across the Cheshire and Warrington region, and by local authority. Blank (white) areas are areas of water.

3.10 Water quality (soil erosion reduction) capacity

What is it and why is it important?

Water quality capacity maps the risk of surface runoff becoming contaminated with high sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. Note that although diffuse urban pollution is partially captured in the model at the catchment scale, the focus is on sedimentation risk from agricultural land; hence built-up areas are not particularly well accounted for in the existing model.

How is it measured?

A modified version of an EcoServ GIS model was developed, which combines a coarse and fine-scale assessment of pollutant risk.

At a coarse scale, catchment land use characteristics were used to determine the overall level of risk. The percentage cover of sealed surfaces and arable farmland in each sub-catchment (EA Waterbody catchment) was calculated, and the values were re-classified into a number of risk classes. There is a strong link between the percentage cover of these land uses and pollution levels, with water quality susceptible to the percentage of sealed surfaces in the catchment.

At a fine scale, a modification of the Universal Soil Loss Equation (USLE) was used to determine the rate of soil loss for each cell. This is based on the following three factors:

- **Distance to a watercourse** – using a least-cost distance analysis, taking topography into account.
- **Slope length** – using a flow accumulation grid and equations from the scientific literature. Longer slopes lead to greater amounts of runoff.
- **Land use erosion risk** – certain land uses have a higher susceptibility to erosion, and standard risk factors were applied from the literature. Bare soil is particularly prone to erosion.

Each of the three fine-scale indicators and the catchment-scale indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale. As previously, this is an indicative map, showing areas that generally have high or low capacity and is not a process-based model. High values (red) indicate areas with the greatest capacity to deliver high water quality (least sedimentation risk).

Results for Cheshire and Warrington

Scores are generally lowest (blue areas in Figure 12) within arable fields, with those parts close to watercourses scoring least well. Scores are generally higher in areas away from watercourses with woodland land covers.

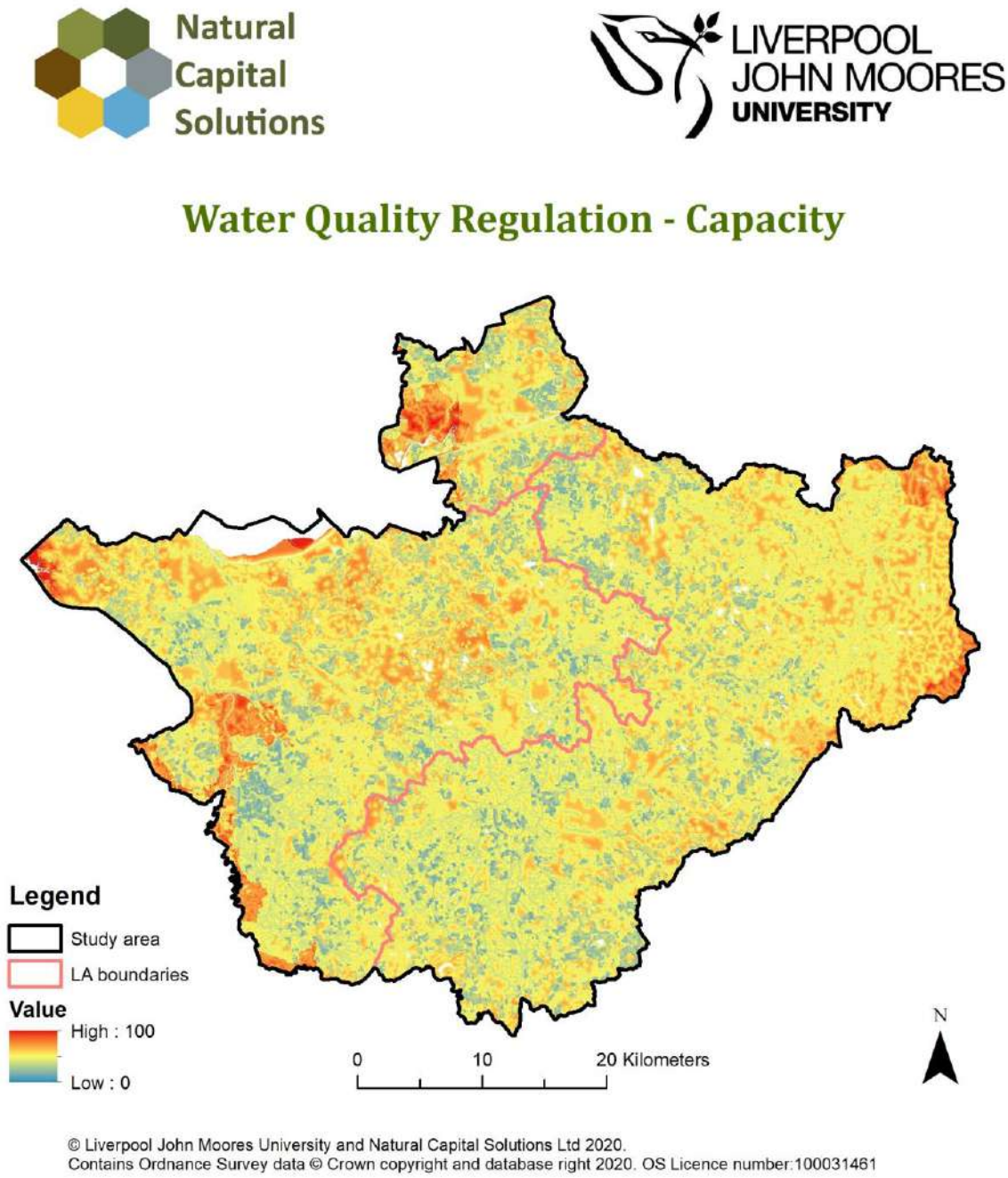

Figure 12 Water quality (soil erosion) regulation capacity across the Cheshire and Warrington region, and by local authority. Blank (white) areas are areas of water.

3.11 Agricultural production capacity

What is it and why is it important?

Agricultural production models the capacity of the land to produce food under current farming practices. Farming is the dominant land-use in Cheshire. Much of the this is grazing pasture for livestock (dairy), with some arable. These land covers provide the largest proportion of food, however, food is produced from a range of other habitats, albeit to a lesser extent. The ability of habitats to provide food, accounting for Agricultural Land Classification, was mapped.

How is it measured?

Broad habitats in Cheshire were assigned a score based their relative ability to provide food:

- Arable, horticulture, improved grassland, intensive orchard - 10
- Allotments – 7
- Semi-natural rough grassland – 6
- Wood pasture, traditional orchard – 5
- Marshy grassland – 4
- Bog/heath, domestic gardens, woodland - 1

This was then weighted by the Agricultural Land Class in which it occurred:

Grade 1 – 3.03
Grade 2 – 2.40
Grade 3 – 1.33
Grade 4 – 0.67
Grade 5 – 0.50

These multipliers are only applied to arable fields, horticulture and rough grazing, as these are habitats where the Agricultural Land Class could make a significant difference to the amount of food produced. The lower scores applied to habitats used for rough grazing (e.g. semi-natural grassland) already reflect their low productivity. This was then mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores were scaled on a 0 to 100 scale, relative to values present within the mapped area. This methodology follows that outlined in Smith, A. (2019) Natural Capital in Oxfordshire.

Results

The majority of the Cheshire and Warrington area has a medium food production capacity (yellow/green Figure 13). This is due to the predominant Agricultural Land Classification for the region being Grade 3, and therefore it is used as improved grassland for livestock production. The mid and high (orange to red) food production areas are arable land. Much of Warrington is urban so scores 0 for food production, but it does have almost equal areas of livestock production and arable production. Cheshire East and West's food production capacity is predominantly livestock with pockets of arable.

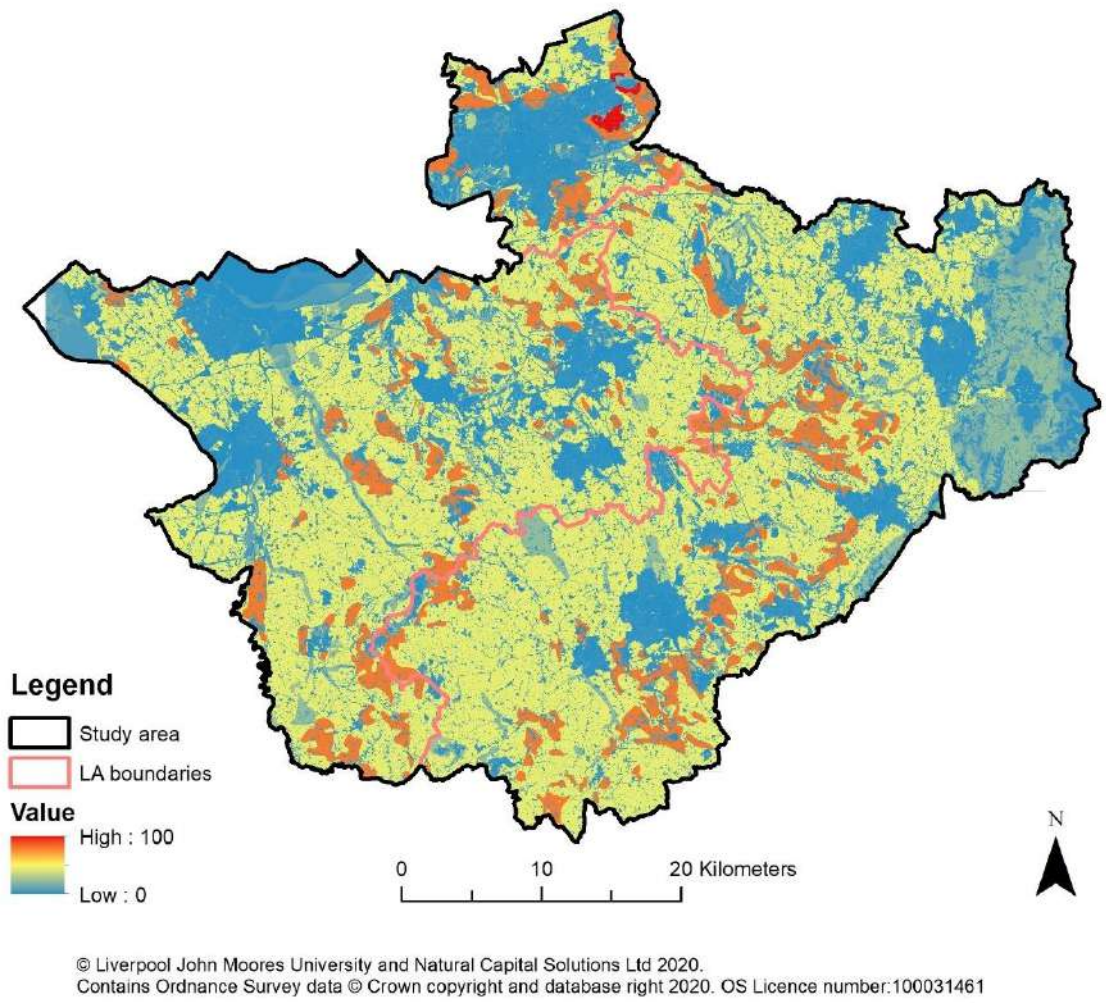

Figure 13 Food production capacity across the Cheshire and Warrington region, and by local authority.

3.12 Timber / woodfuel capacity

What is it and why is it important?

Forestry remains an important component of the rural economy and many areas of woodland are still valued primarily on their timber value. Timber is an important product of woodlands and is the raw resource of the timber industry. Sustainably managed woodland produces timber that is important in contributing to processing mills and factories that produce wood-based products, and also produces wood fuel for the generation of renewable heat and electricity.

How is it measured?

Information on the species mix and yield class was obtained from the Forestry Commission's National Inventory of Woodland and Trees Regional Report for the North West (2002), and Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). This was used to determine the average yield of timber (m^3) per hectare per year. This was then mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores were scaled on a 0 to 100 scale, relative to values present within the mapped area.

Results

There are patches of high timber and woodfuel production capacity scattered throughout the Cheshire Warrington region (Figure 14). High capacity is shown in red, and is mainly broadleaved woodland. Much of the area is red and orange. Cheshire East has the largest area of broadleaved woodland, and therefore the most capacity of the region for timber and woodfuel production. Delamere Forest in Cheshire West, and Macclesfield Forest in Cheshire East dominated by coniferous woodland show a lower timber and woodfuel capacity (yellow/green and yellow/orange).

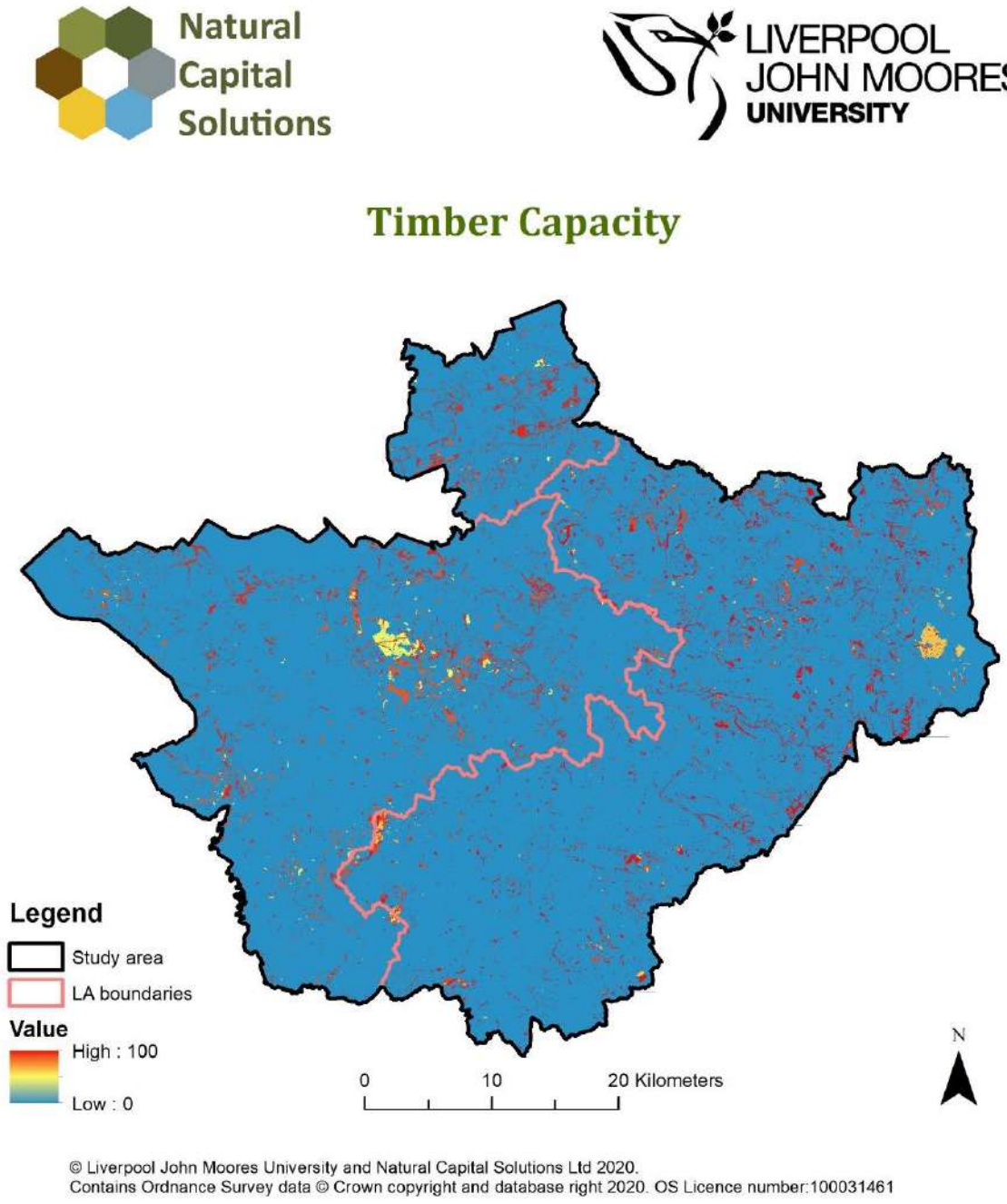

Figure 14 Timber / woodfuel capacity across the Cheshire and Warrington region, and by local authority.

3.13 Accessible nature capacity

What is it and why is it important?

Access to greenspace is being increasingly recognised for the multiple benefits that it can provide to people. In particular there is strong evidence linking access to greenspace to a variety of health and wellbeing measures. Research has also shown that there is a link between wellbeing and perceptions of biodiversity and naturalness. Natural England and others have published guidelines that promote the enhancement of access, naturalness and connectivity of greenspaces.

The two key components of accessible nature capacity are therefore public access and perceived naturalness. Both of these components are captured in the model, which maps the availability of natural areas and scores them by their perceived level of "naturalness".

How is it measured?

Accessible nature capacity was mapped using a bespoke EcoservR model, originally adapted from EcoServ GIS. In the first step, accessible areas are mapped. These are defined as:

- Areas 10m either side of linear routes such as Public Rights of Way, pavements and Sustrans routes.
- Publicly accessible areas such as country parks, CRoW access land, local nature reserves and accessible woodlands.
- Areas of green infrastructure marked as accessible, including parks, playgrounds, and other amenity greenspaces.

These areas were then scored for their perceived level of naturalness, with scores taken from the scientific literature. Naturalness was scored in a 300m radius around each point, representing the visitors experience within a short walk of each point.

The resulting map shows accessible areas, with high values representing areas where habitats have a higher perceived naturalness score. Scores are on a 1 to 100 scale, relative to values present within the study area. White space shows built areas or areas with no public access.

Larger continuous blocks of more natural habitat types will have higher scores than smaller isolated sites of the same habitat type. One consequence is that linear routes, such as footpaths, that pass through land with no other access will not score highly.

Results for Cheshire and Warrington

Figure 15 shows accessible nature capacity for publicly accessible land only. Accessible nature capacity is highest in some of the fringe areas of the region, particularly in some of the woodland habitats around Macclesfield Forest and Errwood Reservoir to the east. Hotspots also occur around much of central Northwich, Delamere Forest, and Lyme Park near Macclesfield.

Accessible nature capacity is moderate around the outskirts of major urban centres, probably due to existing right of way networks allowing easy access to public greenspaces. Access is lowest in more rural areas due to decreased availability of transport, and also potentially due to increased private land ownership for agriculture in these areas.

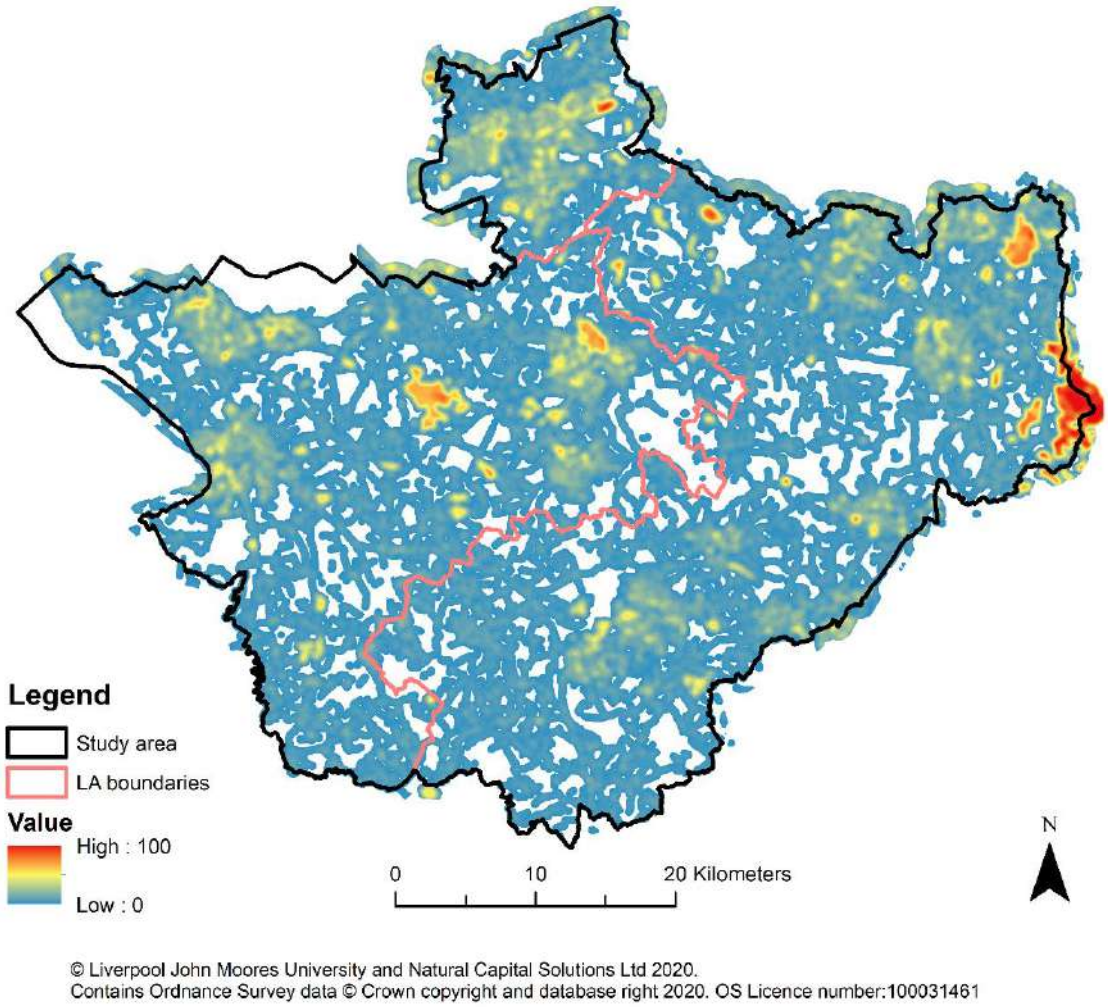

Figure 15 Accessible nature capacity across the Cheshire and Warrington region, and by local authority.

3.14 Accessible nature demand

What is it and why is it important?

This indicates where there is the greatest demand for accessible nature, which is strongly related to where people live. Research, including large surveys such as the Monitor of Engagement with the Natural Environment (MENE), have shown that there is the greatest demand for accessible greenspace close to people's homes, especially for sites within walking distance.

How is it measured?

This model maps sources of demand, taking no account of habitat, based on three indicators: population density (based on 2011 census data), health scores (from the Index of Multiple Deprivation), and distance to footpaths and access points. The three indicators are calculated at three different scales as demand is strongly related to distance. The Monitor of Engagement with the Natural Environment (MENE) survey and other literature on visit distance was used to determine appropriate distances. The distances chosen (and rationale) were: 600m (10 minutes walking distance), 3.2 km (67% of all visits and 90% of visits by foot occur within this distance), and 16 km (90% of all visits travelled less than this distance).

The three indicators were normalised from 0-1, then combined with equal weighting at each scale and then the three different scales of analysis were combined and projected on a 0 to 100 scale. High values (red) indicate areas (sources) that generate the greatest demand for accessible nature.

Results for Cheshire and Warrington

Demand for accessible nature (Figure 16) is focussed on where people live. Hence, most of the demand across the study area is centred on the larger urban areas, particularly Warrington, Chester, Ellesmere Port, Crewe, Macclesfield, Northwich and Winsford. Demand is much reduced in the more rural parts of the region, especially in the south=west of Cheshire and in the Peak District, although is still apparent from some of the larger villages.

Balancing supply and demand for accessible nature

Numerous researchers have shown that people travel most frequently to greenspaces very close to their homes, and Natural England recommends that everyone should have access to at least some greenspace within 300m (5 minutes walk) and larger sites within 2 km. Furthermore, surveys have shown that most people will typically travel less than 3.2 km to visit greenspace. Any new accessible greenspace being created should therefore be close to housing areas. New housing areas will also create increased demand for accessible greenspace, so this demand must be met on-site.

There is now a vast amount of evidence showing the benefits of greenspace, particularly in built-up areas. Furthermore, research has shown that people gain greater well-being from visiting sites that they perceive to be more natural and richer in biodiversity. This shows that as well as providing access to greenspace, it is important that the greenspace is of high quality and as natural as possible.

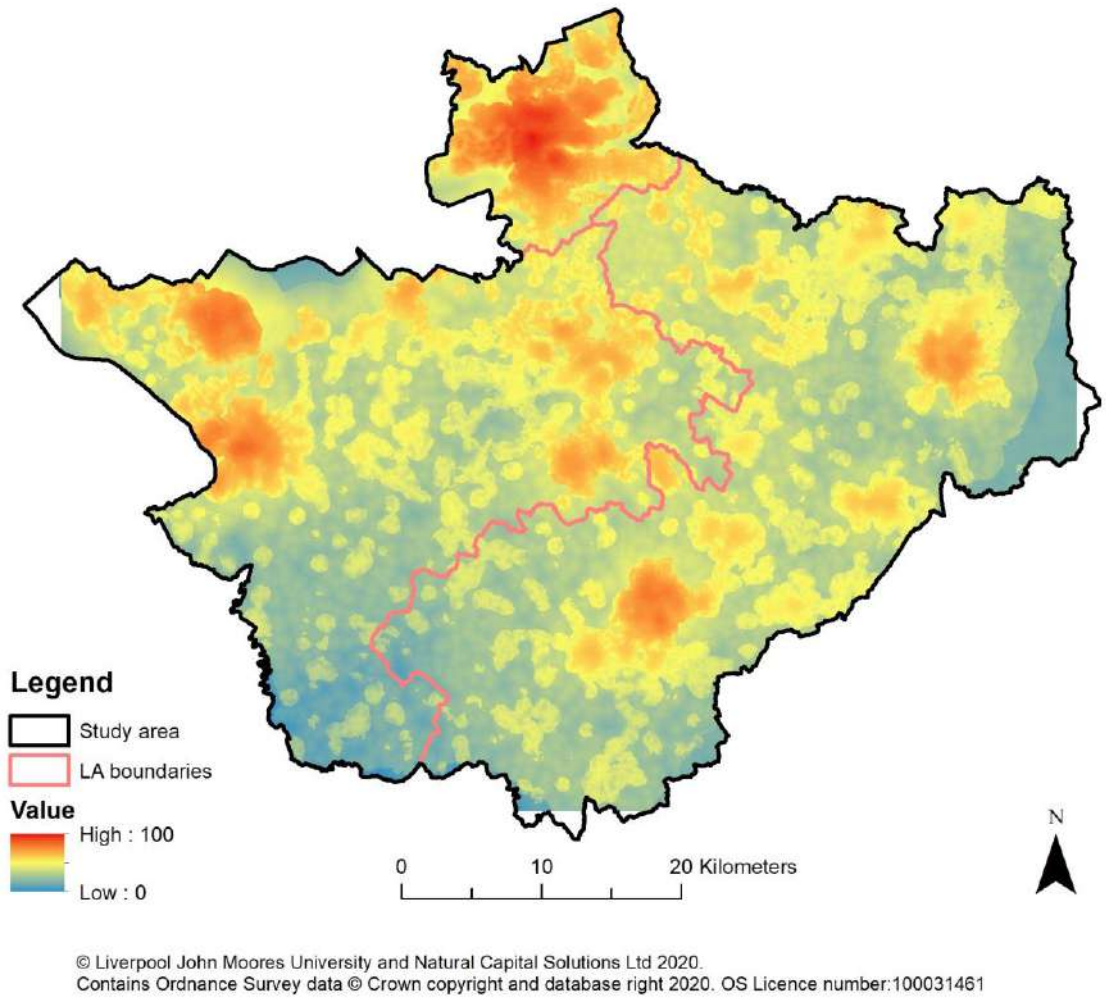

Figure 16 Accessible nature demand across the Cheshire and Warrington region, and by local authority.

4. Baseline ecosystem service valuation (monetary flows)

We estimate the annual monetary flow of some of the mapped ecosystem services (air quality regulation, carbon sequestration, timber production, and agricultural production). It was also possible to value a range of ecosystem services that were not mapped (recreation, physical health, GHG emissions from agriculture, mineral extraction, angling and visual amenity). Table 2 outlines the indicators used to quantify both the physical and monetary flows of these services.

Table 2 Ecosystem services and indicators for physical and monetary measurement.

Ecosystem service	Physical flow	Valuation
Air quality regulation	Tonnes of $PM_{2.5}$ and SO_2 absorbed	Costs avoided £/tonne of $PM_{2.5}$ and SO_2 /year
Carbon sequestration	Quantity of CO_2 sequestered	£/tonne of CO_2
Greenhouse gas emissions from agriculture	GHG/ha	£/ha/year
Recreation	Number of visits	Welfare value/visit/year
Physical health	Active visits	£/QUALY/year
Agricultural production	ha	£/ha/year
Timber/woodfuel production	m^3/ha	£/m^3/year
Mineral extraction	Tonnes extracted	£/year
Recreational fisheries (angling)	Generic estimates of no. of angling trips	£/trip/year
Visual amenity	No. of houses within proximity of greenspaces	£ and % increase in house prices

Annual monetary flows of ecosystem services have been calculated based on the latest valuation techniques available in the scientific literature and approaches adopted by the Office for National Statistics (ONS 2017[8]) and recent Defra guidance to standardise approaches to the valuation of ecosystem services[9]. The physical and monetary flows of the ecosystem services are presented below for each of the three local authorities separately, and for Cheshire and Warrington as a whole. The methods used to calculate these are outlined in the Technical Appendix at the end of the report (Section 8).

Vegetation can be effective at contributing to **air quality regulation**, with surface area being the most important determinant of capacity. Trees are much more effective than grass at this, and capacity increases significantly as trees grow and their surface area increases. The woodland and grass vegetation across Cheshire and Warrington is estimated to absorb 884 tonnes of $PM_{2.5}$ (particulate matter 2.5 micrometres of less in diameter) annually, at an annual value of £146 million with a present value (over 50 years) of £5.4 billion (Tables 3 & 4). Cheshire East has the highest rate of absorption of $PM_{2.5}$ across the local authorities at 50% of the total annual absorption. Cheshire West accounts for 41% of the regional absorption, and then Warrington the remaining 9%.

[8] ONS (2017) Principles of Natural Capital Accounting. Office for National Statistics
[9] Defra (2020). Enabling a Natural Capital Approach (ENCA).

Carbon sequestration is the uptake of carbon by plants as they grow, with woodlands being much the most effective habitat at this in the Cheshire and Warrington area. Carbon sequestration capacity for woodland (including trees in parkland and scrub) is highest in Cheshire East (Table 3) with a total average annual sequestration of 64,000 tonnes of carbon per year (tCO_2e) at an annual value of £4.4 million and a present value (over 50 years) of £259 million. This is followed by Cheshire West at 45,600 tCO_2e, with an annual value of £3.2 million, and a present value of £184 million, and Warrington at 12,700 tCO_2e, an annual value of £879,000, and a present value of £51.3 million. This makes the total average annual sequestration of carbon across the Cheshire and Warrington region 122,000 tCO_2e, with an annual value of £8.5 million and a present value of £494 million. By comparing the emissions from agriculture with the amount of carbon sequestered by woodland, it is possible to calculate an overall **carbon budget**, or **GHG balance** for the region and each of the local authorities. The emissions from agriculture outweigh the carbon sequestered in all local authorities and, therefore, the region has net emissions of 441,000 tCO_2e per year, at a **cost** of £30.5 million annually, and a present value of £1.8 billion (Tables 3 & 4). This high figure is driven by the large amount of dairy and other livestock across the area. This greenhouse gas balance is an important figure as it represents the agriculture and land use, land use change and forestry (LULUCF) sector for which national emissions information is collected. Note that this does not include greenhouse gas emissions from other sectors, such as transport, manufacturing and construction.

The Cheshire region has high recreational value with country parks such as Macclesfield Forest, Errwood Reservoir, Delamere Forest and Lyme Park, along with a network of public rights of way. Using the ORVal tool (see Technical Appendix) we were able to estimate the number of **recreational visits** made to publicly accessible greenspaces in each of the local authorities (Tables 3 & 4). Across the Cheshire and Warrington region there are an estimated 49.7 million recreational visits per year. The same tool estimates the welfare value derived from these visits, and these are valued at £159 million annually, with a present value (over 50 years) of £4.1 billion. A subset of these visitors will also receive **physical health** benefits through making regular active visits that meet national physical activity guidelines (20 minutes of moderate intensity exercise every day). It is estimated that there are 109,000 active visitors every year to publicly accessible greenspaces in the Cheshire and Warrington region, which is equivalent to 3,720 Quality Adjusted Life Years (QALY). This delivers an annual value of £55.4 million, and a present value of £2.1 billion (Tables 3 & 4). The local authorities contribute to this to different extents. Forty three percent of the active visitors occur in Cheshire East, 36% in Cheshire West and 21% in Warrington (Table 3).

Another form of recreation in the area is **angling**. We have focused on freshwater fishing here, river, stream, lake and reservoir fishing. The numbers are derived from rod licence purchases in the NW of England by postcode, and from an Environment Agency survey of freshwater fishing in England and its associated economic activity. From this we estimated that there are 799,000 fishing visits annually to rivers, streams, lakes and canals in the Cheshire and Warrington region. This has an estimated annual value of £55.7 million, with a present value of £1.4 billion.

The total area of land in **agricultural production** in the Cheshire and Warrington region is approximately 133,000 ha (Table 3). This is predominantly improved and rough grasslands (111,000) for grazing livestock (mainly cattle), with 22,600 ha of arable. Warrington has a relatively even split between the two types of agriculture, Cheshire East has arable but 78% of the farmland is for livestock production, whereas Cheshire West is mostly livestock production. The annual value of agricultural production in the Cheshire and Warrington region is £9.4 million after subsidies are stripped out, with a present value (over 50 years) of £239 million.

Table 3 Annual physical flows of ecosystem services for Cheshire East, Cheshire West and Warrington local authorities, and across the whole region.

Ecosystem service	Annual physical flow			
	Cheshire East	Cheshire West	Warrington	Full region Cheshire
Air quality regulation ***tPM2.5***	446	362	77	884
Carbon sequestration ***tCO2e***	64,000	45,600	12,700	122,000
GHG emissions from agriculture ***tCO2e***	-343,000	-186,000	-33,800	-563,000
Recreation ***Visits***	21.2M	17.9M	10.6M	49.7M
Physical health ***QALY***	1580	1340	796	3,720
Agricultural production (*ha*) ***Arable*** ***Grazing***	 18,000 62,800	 39 44,300	 4,540 3,510	 22,600 111,000
Timber/woodfuel production **m^3**	69,900	49,500	12,700	132,000
Mineral extraction ***Million tonnes*** ***Sand and gravel*** ***Crushed rock***	 0.71 0.04	 0.8 -	 0.43 1.32	 1.94 1.36
Recreational fisheries (angling) ***Fishing trips***	-	-	-	799,000
Visual amenity ***Number of properties within 500m of a greenspace over 2.5 ha in size***	17,600	24,500	18,900	61,100

NB. All figures displayed to 3 significant figures; any discrepancies due to rounding.

Table 4 Annual monetary flows of ecosystem services and the present value calculated across 50 years for Cheshire East, Cheshire West and Warrington local authorities, and across the whole region.

Ecosystem service	Annual monetary flow (2020) and present value over 50 years (£ million)							
	Cheshire East		Cheshire West		Warrington		Full region C&W	
Air quality regulation	71.3	2,640	57.9	2,140	16.3	603	146	5,380
Carbon sequestration	4.44	259	3.16	184	0.879	51.3	8.48	494
GHG emissions from agriculture	-23.8	-1,390	-12.9	-751	-2.34	-136	-39.0	-2,270
Recreation	67.0	1,710	56.3	1,440	35.7	912	159	4,060
Physical health	23.3	862	20.1	744	11.9	441	55.4	2,050
Agricultural production	5.71	146	3.09	78.9	0.562	14.3	9.37	239
Timber/woodfuel production	1.29	32.9	0.918	23.4	0.221	5.64	2.43	62
Mineral extraction	-	-	-	-	-	-	68.0	1,740
Recreational fisheries (angling)	-	-	-	-	-	-	55.7	1,420
Visual amenity	-	83.6	-	99.1	-	63.1	-	246
TOTAL VALUE	**149**	**4,340**	**129**	**3,960**	**63.3**	**1,950**	**465**	**13,400**

NB. All figures displayed to 3 significant figures; any discrepancies due to rounding.

We have also looked at the woodland asset from a **timber and woodfuel** production perspective. This does not mean that the woodland is necessarily being harvested for these purposes, rather it is another way of exploring the value of woodland in the region. If the woodlands in the Cheshire and Warrington region were to be manged for timber and woodfuel production, they would be able to produce approximately 132,000 m^3 per year under their current management and averaged over a full woodland production cycle (Table 3). This has an annual value of £2.4 million, and a present value of £62 million (Table 4). The production capacity varies across the local authorities depending on the area of woodland they support. Cheshire East accounts for 53% of the capacity, Cheshire West 38%, and Warrington 9%.

There is **minerals extraction** activity in Cheshire and Warrington. This varies across the region with the highest quota for extraction of sand and gravel in Cheshire East, and the highest quota for extraction of crushed rock in Warrington. Cheshire West only extracts sand and gravel (Table 3). We did not have a breakdown of the value of this extraction for the local authorities separately, but the GVA value for the Cheshire and Warrington region is £68 million, with a present value over 50 years of £1.7 billion (Table 4).

We use the principle of hedonic pricing and evidence of increases in property values as a means of capturing **amenity value**. If homes are in close proximity to greenspace in the Cheshire and Warrington area, it will have a positive impact on the average house values of those homes. Across the region there are 61,100 residential buildings within 500 metres of a greenspace more than 2.5 hectares in size (Table 3). This increases asset values by £246 million (Table 4). The Cheshire West local authority has the highest amenity value of the region.

This means that the overall value of the benefits delivered by the natural capital assets across the Cheshire and Warrington region (that we were able to quantify) is £465 million annually, with a present value of £13.4 billion over 50 years. The total value delivered by the natural capital of each local authority ranges from £63.3 million to £149 million annually, with a present value over 50 years ranging from £1.95 billion to £4.3 billion. Overall values are larger for Cheshire East and Cheshire West and Chester, but if calculated on a per hectare basis are highest for Warrington, where publicly accessible greenspace will be providing benefits of high value, particularly for recreation and physical health.

Sensitivity analyses

A sensitivity analysis at the Cheshire and Warrington scale examined the low, central and high estimates of all benefits (Table 5). This demonstrates the overall sensitivity of the natural capital values. The overall natural capital value ranges from a present value (over 50 years) of £6.94 billion under the lowest benefits estimates up to £32.3 billion under the highest benefits estimates. This large difference highlights the challenges of placing a monetary value on some services. A key point, however, is that even under the low benefit estimate, the natural capital assets of the region will deliver a substantial benefit worth at least £257 million annually, which is £6.94 billion in present value terms.

This analysis shows the high levels of uncertainty inherent in valuing ecosystem service benefits. Valuation of ecosystem services should be seen as appropriate at indicating the approximate magnitude of benefits, but not their exact values. It has allowed the comparison of values for a broad suite of services to be compared across the local authorities and at the Cheshire and Warrington scale. It demonstrates the range of benefits that the natural environment can provide. However, these results need to be interpreted with care, and in the knowledge that whilst the highest quality and most readily available data and methods were used, there are limitations and assumptions that need to be borne in mind.

Table 5 Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets of Cheshire and Warrington.

Ecosystem service	Annual values (2020) (£ million)			Present value (over 50 years) (£ million)		
	Low	Central	High	Low	Central	High
Air quality regulation	30.7	146	448	1,140	5,380	16,600
Carbon sequestration	4.24	8.48	12.7	236	494	751
GHG emissions from agriculture	-19.5	-39.0	-58.5	-1,090	-2,270	-3,460
Recreation	119	159	199	3,040	4,060	5,070
Physical health	27.9	55.4	233	1,030	2,050	8,260
Agricultural production	-0.63	9.37	32.3	-16.1	239	823
Timber/woodfuel production	1.82	2.43	3.04	46.5	62.0	77.5
Mineral extraction	51.0	68.0	85.0	1,300	1,740	2,170
Recreational fisheries (angling)	41.8	55.7	69.6	1,070	1,420	1,780
Visual amenity				184	246	307
Total value:	**257**	**465**	**1,020**	**6,940**	**13,400**	**32,300**

NB. All figures displayed to 3 significant figures; any discrepancies due to rounding.

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. Some are highly location specific, for example water flow and impact on downstream flood risk. This can be quantified and valued by running detailed hydrological and flood risk modelling, but it is difficult to generalise. Others, such as water quality can be modelled, but are very difficult to value, while there are additional cultural services, such as aesthetic experiences, cultural heritage, spiritual experience and sense of place that are difficult to even quantify. It should, therefore, be borne in mind that the valuations presented in this section place values on several key benefits, but these are necessarily incomplete.

For the services that have been included here, a range of assumptions have been made, and these are outlined when describing the methodology (see Annes). In addition, a summary of the main uncertainties is provided for each service in Table 6 (below), along with a RAG rating highlighting the overall confidence in each estimate. For most ecosystem services these assumptions are minimal, as established production functions exist linking natural capital to ecosystem service production, and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for physical health, and this estimate should, therefore, be used with care.

Table 6 Summary of uncertainties in the calculation of physical flows and monetary values of each natural capital benefit, and an overall assessment of confidence, using a red, amber, green (RAG) rating.

Natural capital benefits	Assessment of uncertainties	RAG rating
Air quality regulation	Biophysical estimates based on averages for broadleaved and coniferous trees and grassland. Valuation follows ONS guidance.	
Carbon sequestration	Well studied, standardised carbon lookup tables available. Valuation uses UK Government non-traded carbon price.	
Agricultural emissions	Receiving increasing attention as part of climate change accounting. Valuation uses UK Government non-traded carbon price.	
Recreation	Welfare values from a welfare function model from the ORVal tool. This is a good model and based on a travel cost method, but it is nonetheless a model.	
Physical health	The most uncertain of the services measured. High uncertainty over who would make frequent and active visits to the green spaces and the monetary value of these benefits. There is also a potential here for double counting with the amenity service.	
Agricultural production	Based on extensive data collected by Defra annually and market prices.	
Timber production	Well studied over many years as part of forestry management. Valuation uses market prices.	
Mineral extraction	Based on county level GVA data and mineral quota data from each local authority from ONS.	
Recreational fisheries (angling)	Rod licence data was from the Environment Agency using postcode data. The postcode area data included may have been slightly out of the study area so may result in a slight overestimate.	
Visual amenity	Follows the latest ONS study on the effect on house values of proximity to greenspaces. This uses travel to work area estimates of impact on house values for Warrington and Chester only. These estimates may vary across the region. There is potential here for double counting with the physical health service (see Annex for discission).	

5. Key findings from the natural capital audit

The baseline natural capital assessment for Cheshire and Warrington has demonstrated that almost half of the area is dedicated to livestock production on improved grassland, with significant areas of arable land. There are pockets of woodland across the region which total an area slightly higher than that taken up by buildings (6,660 ha compared to 4,590 ha). The ecosystem service maps demonstrate the spatial pattern of provision of ten different ecosystem services, and the demand for four. The maps demonstrate that the woodland asset is important for high levels of provision of carbon storage but small areas of bog habitats also play an important role. The woodland delivers carbon sequestration, air quality, noise, local climate, water flow and water quality regulation benefits across all of the local authorities. Food production is clearly an important service in this region, although much of the area is providing a medium level of this service through livestock production, with slightly higher provision in arable areas. The mapping shows that the area has hotspots of access to nature, around the woodland parks in Cheshire West and East, and on the eastern edges where the Cheshire boundary meets the Peak District. The demand maps of air quality, noise, local climate regulation and accessible nature show clearly the importance of ecosystem service delivery to the urban centres in the Cheshire and Warrington region. It is clear that the capacity to provide these services is generally not high in the areas that demand it the most.

Overall the value of the natural capital assets of Cheshire and Warrington is £465 million annually, with a present value of £13.4 billion over 50 years. The most valuable ecosystem services are air quality regulation, recreation, physical health benefits and angling, delivering annual benefits between £55.4 and £146 million in value, with a present value (over 50 years) of between £2.1 and £5.4 billion. (Table 4). Mineral extraction is valuable, but has associated environmental impacts that we have not looked into here. Agriculture is one of the lower value services once subsidies are removed, and the magnitude of the associated GHG emissions, in comparison to the capacity of the area to sequester carbon, means that the area is a net emitter of GHG emissions at a cost of £30.5 million annually.

The spatial provision and value of the ecosystem services differs in each of the local authorities in the Cheshire and Warrington region. Cheshire East has the biggest woodland asset, and consequently it tends to have a slightly higher provision and value across a number of services than Cheshire West, and certainly in comparison to Warrington. Warrington is a smaller area, with a higher proportion of its area taken up with buildings and urban infrastructure, so it will have a lower capacity to provide services. However, on a per hectare basis, some of the values are very high, particularly for recreation and physical health.

The baseline assessment is important for understanding the potential areas that, with investment, could increase the provision of key ecosystem services. The maps of ecosystem demand also highlight the location and extent of the benefits required within the region, so these needs can be met. However, investment decisions will also depend on the priorities and policies in the region and across sectors. The following sections begin to look into these, applying a policy analysis by sector. The remainder of the project was a process by which the best opportunities were identified based on the evidence presented in this report, case studies developed to explore some of the possibilities, and a natural capital investment plan for Cheshire and Warrington created. Please see the other technical reports and the main Natural Capital Audit and Investment Plan for details.

6. Policy analysis by sector

6.1 Analysing the results of the policy review

Figure 17 summarises how we explored the linkages between natural capital and the C&W LEP development outcomes, underpinned by developing a spatially differentiated sense of quality of place. The figure is used as the basis for the sector summaries that follow with these setting out the relevant policies and the impacts these are expected to have on ecosystem services and the sector itself:

- the output produced by the sector;
- level of employment within the sector;
- the extent to which businesses are likely to be (and remain) economically sustainable; and
- the benefits that could flow along supply chains.

The opportunities and threats associated with the policies are next identified, together with those stakeholders who could benefit from opportunities and those who may lose out due to threats. This then informs the actions and interventions. For this report, these are limited to existing actions and interventions but will be supplemented by additional interventions identified through Work Package C (interventions and investment opportunities) that will feed into the stakeholder workshop to prioritise projects to take forwards. Finally, the policies are linked back to the LEP economic and social outcomes to ensure that the LEP's targets and aims would be met.

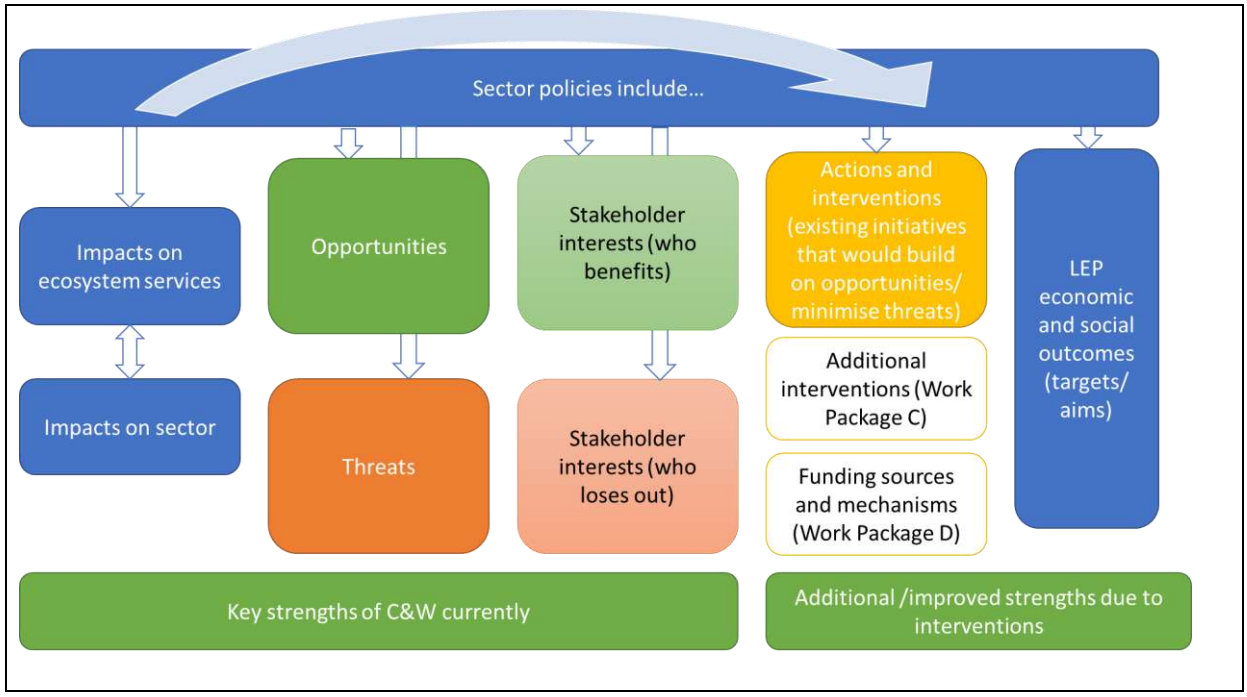

Figure Error! No text of specified style in document.**7** Natural capital enablers and barriers by sector: Identification of the drivers and pressures from policies that are likely to affect investment in priority areas.

The list below shows the overarching sectors that were identified as being key to Cheshire & Warrington during the policy review. A summary following the above structure is provided for each of these sectors:

1. Agriculture
2. Skills and education (including research, science and innovation)
3. Energy, housing and construction
4. Manufacturing, logistics and services (including digital)

5. Minerals and waste management
6. Environmental management (including waste, water management, forestry and woodlands and nature conservation)
7. Health, wellbeing and tourism
8. Transport

Quality of place is considered an important aspect for all sectors, with this being over-arching and cross-cutting, but especially linked to housing and construction due to the need to ensure there is appropriate and affordable housing to help underpin economic growth in the C&W LEP area. The importance of manufacturing, chemicals, life sciences, finance and business services, energy and environment and logistics and distribution need to be recognised, as do strengths in rural areas. Quality of place is also essential for the visitor economy, underpinning health, wellbeing and tourism and for attracting inward investment.

C&W LEP's strategic economic plan identifies an aim to grow to £50 billion in Gross Value Added in 2040, creating an additional 120,000 jobs and building 127,000 new homes. It is recognised that there needs to be investment in the environment to attract people with the right skills, while transitioning to a low carbon economy. One of the keys to balancing the growth ambitions with the desire for Cheshire & Warrington to be the best place to live in the UK is to identify opportunities to build on the existing value of natural capital, drawing together policies to provide a coordinated approach to development.

6.2 Agriculture

Agriculture policies include: Environmental Land Management Scheme, Quality of Place Strategy, Ecological Network and Rural Economy.

Key strengths of C&W LEP

Cheshire remains in many places a rural area with agriculture and land-based industries. The agri-tech and food industry is small in terms of overall GVA but is seen as having significant growth potential. There are well developed agriculture, dairy and food production sector and also important land-based colleges and centres for food innovation and agricultural engineering.

Current status of natural capital

Classification	Area (ha)	Percentage of total area (%)
Cultivated / disturbed land	39,951	17.41
Grassland, improved	108,626	47.33
Grassland, marshy	2,115	0.92
Grassland, semi-natural	4,292	1.87
Grassland, unknown	503	0.22

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
National	ELMS Tier 1	→	↗	→	↗
	ELMS Tier 2	↘	↗	↗	→
	ELMS Tier 3	↓	↗	↗	→
Regional	Quality of place strategy	→	→	→	→
Local	Ecological Network	↓	↗	↗	↑
	Rural economy	→	→	↗	→

Impacts of policies on the agricultural sector

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
National	ELMS Tier 1	→	→	→	→
	ELMS Tier 2	↘	→	→	↘
	ELMS Tier 3	↓	↘	→	↘
Regional	Quality of place strategy	↗	↗	↗	↗
Local	Ecological Network	↓	→	→	↓
	Rural economy	↗	↗	↗	↗

Opportunities to improve outcomes through enhanced natural capital in the agriculture sector

- Support for rural economy
- Development of agri-tech
- Farm diversification
- Sustainable land management
- Landscape scale and catchment scale management
- Biodiversity or environmental net gain offering a new source of income to farmers
- Growth in local markets
- R&D, precision farming
- Dairying and grassland management technologies
- Skilled labour
- Renewable energy

Threats to natural capital and the agriculture sector

- Loss of agricultural land to policies to encourage other land uses (development, forestry, etc.)
- Reduction in agricultural output
- Loss of land due to development
- Market uncertainty (Brexit)
- International competition
- Soil degradation
- Declining yields
- Further degradation
- Water pollution

Stakeholders who may benefit

- Public
- Farmers
- Land managers
- Defra
- Nature conservation sector
- Businesses in the tourism sector

Stakeholders who may lose out

- Farmers
- Suppliers and customers of farmers (supply chain)

See Annex 2 for a detailed assessment of stakeholders

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- ELMS Tiers 1 and 2
- Rural economy
- Quality of Place Strategy

LEP economic and social outcomes (targets/aims) with interventions

Improvement of air and water quality, wildlife habitats, enhancement of the rural landscape and its heritage, mitigation of flood risk, efficient resources use and increased efficiency through technologies, waste reduction and combating climate change.

6.3 Skills and education

Skills and education policies include: Quality of Place Strategy, Cheshire East's Sustainable Community Strategy 2010-2025, Science and Innovation Strategy and Delivery Plan and the Skills and Education Plan.

Key strengths of C&W LEP

There are numerous educational facilities including the University of Chester and important land-based colleges and centres for food innovation and agricultural engineering. Schools are mostly very good or outstanding.

Current status of natural capital

Built-up area classification	Area (ha)	Percentage of total area (%)
Business or industry	1,224	0.5
Sealed surface	5,372	2.3
Other structure	98	0.04

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
Regional	Quality of place strategy	→	→	→	→
Local	Cheshire East's Sustainable Community Strategy 2010 to 2025	→	↗	↑	↗
	Science and Innovation Strategy and Delivery Plan	↘	↓	↑	↘
	Skills and Education Plan	→	↘	↑	→
	Cheshire West and Chester's Schools Forum	→	↗	→	→
	Digital Strategy and Delivery Plan	→	↗	↑	→

Impacts of policies on the skills and education sector

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
Regional	Quality of place strategy	↗	↗	↗	↗
Local	Cheshire East's Sustainable Community Strategy 2010 to 2025	→	↗	↗	↗
	Science and Innovation Strategy and Delivery Plan	↗	↗	↗	↗
	Skills and Education Plan	↑	↑	↗	↗
	Cheshire West and Chester's Schools Forum	↗	→	↗	↗
	Digital Strategy and Delivery Plan	↗	↗	↗	↗

Opportunities to improve outcomes through enhanced natural capital in the education and research sector

- Quality of Place Strategy
- Cheshire West and Chester's Schools Forum
- Cheshire East's Sustainable Community Strategy 2010 to 2025
- Digital strategy and Delivery Plan

Threats to natural capital and the education and research sector

- Technocratic perspective
- Demographic challenges
- Skilled labour
- Ageing highly skilled workforce (230,000 jobs need to be replaced by 2025)
- 25% of workers earning below the living wage
- Many working on unstable low hours contracts.
- 5,000 graduates are being lost each year
- Larger commuting population impacting air pollution
- Mismatch between the skills employers need and the skills individuals choose to acquire (particularly for STEM and digital skills)
- Prioritising short-term growth over sustainability
- Increased construction creating noise pollution and potentially harming biodiversity

Stakeholders who may benefit

- Industry
- Education: schools, universities
- Young working population
- R&D sector
- BIDs
- LAs/LEP

Stakeholders who may lose out

- Residents (house prices, air pollution)

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Quality of Place Strategy
- Cheshire East's Sustainable Community Strategy 2010-2025
- Cheshire West and Chester's School Forum
- Digital Strategy and Delivery Plan

LEP economic and social outcomes (targets/aims)

Aims to put employers at the heart of inspiring and informing all residents about career and progression opportunities and making the curriculum fit for purpose setting out plans for working with businesses and skills and learning providers to ensure that businesses have the skills they need to grow and individuals have the skills they need to progress.

6.4 Energy, housing and construction

These policies include: Energy and Clean Growth Strategy, Strategic Economic Plan, Transport Strategy, Environment Strategy and other Government initiatives and policies

Key strengths of C&W LEP

Cheshire and Warrington have over 7,000 businesses in the wider Energy and Environment sector, employing over 31,000 people. This region has a nationally significant energy cluster with particular expertise in nuclear, energy systems and the impact of low carbon vehicles on local energy networks.

Current status of natural capital

Built-up area classification	Area (ha)	Percentage of total area (%)
Caravan site	4	0.002
Shed/garage/farm building	345	0.15
Glasshouse	47	0.02
Business or industry	1,224	0.53
Domestic buildings	4,153	1.81
Sealed surface	5,372	2.34
Other structure	98	0.04

Impacts of policies on ecosystem services

Level	Policy	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
National	Smart Energy GB	→	↗	→	→
	HM Government The Clean Growth Strategy	→	↗	→	→
	Qwest energy: Home Energy help for residents	→	↗	→	→
	Warm Homes Fund - Green doctor Energy Efficiency Advisory Service	→	↗	→	→
	Eco flexible eligibility	→	↗	→	→
	Home Safety Grants	→	↘	↑	→
	Home Assistance Policy	→	→	↑	→
	Guidance Helping consumers with energy 2013	→	→	→	→
	Green Deal: energy saving for your home	→	↗	↗	→
	Energy Company Obligation	→	↗	↗	→
	Domestic Renewable Heat Incentive	→	↗	↗	→
Regional	ESIF Low Carbon Action Plan	→	↗	→	→
	Energy and clean growth strategy	→	↗	→	→
	Rural Housing Strategy 2016	→	↘	↗	↘
	Empty Homes Strategy 2016-2021	↗	↗	↗	↗
	Affordable Warmth Action Plan 2016-20	→	↘	↗	→
	Housing Strategy 2014-2020	↘	↓	↑	↓

Impacts of policies on the energy, housing and construction sectors

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
National	Smart Energy GB	→	↗	↗	→
	HM Government The Clean Growth Strategy	→	↗	↗	→
	Qwest energy: Home Energy help for residents	→	↗	↗	→
	Warm Homes Fund - Green doctor Energy Efficiency Advisory Service	→	↗	↗	→
	Eco flexible eligibility	→	↗	↗	→
	Home Safety Grants	→	→	→	→
	Home Assistance Policy	→	↗	→	→
	Guidance Helping consumers with energy 2013	→	→	→	→
	Green Deal: energy saving for your home	→	↗	↗	→
	Energy Company Obligation	→	→	→	→
	Domestic Renewable Heat Incentive	→	↗	↗	→
Regional	ESIF Low Carbon Action Plan	↗	↗	↗	↗
	Energy and clean growth strategy	→	↗	→	→
	Rural Housing Strategy 2016	↗	↗	↘	↗
	Empty Homes Strategy 2016-2021	→	→	→	→
	Affordable Warmth Action Plan 2016-20	→	→	→	→
	Housing Strategy 2014-2020	↑	↑	↘	↗

Opportunities to improve outcomes through enhanced natural capital in the energy, housing and construction sector

- LEP's Low Carbon Energy Innovation Fund to stimulate development
- Cheshire Science Corridor as a premier location for energy-related investment, including hydrogen utilisation
- Focus on nuclear, hydrogen geothermal energy and electric cars
- Increase Low Carbon Energy Supply
- low carbon economy lead
- Skilled workforce
- Strengths in energy and environment
- Growing potential for digital sectors
- Liaison with universities/research
- Green mortgage products
- Refurbishment
- Construction of sustainable buildings, e.g. passive houses
- Innovative low carbon heat technologies in homes and businesses
- Improved energy efficiency
- Sustainable construction
- Biodiversity and environmental net gain attracting house buyers and supporting house prices
- Affordable housing
- Reduced emissions; climate change mitigation

Threats to natural capital and the energy, housing and construction sector

- Focus on nuclear, hydrogen geothermal, energy and electric cars
- Inefficient resource use
- Technocratic perspective
- Demographic challenges
- Skilled labour
- International competition for low-carbon investment
- Prioritising short-term growth over sustainability
- Release of green belt areas for housing
- Diminishing land availability due to development
- Brexit: loss of economy of scale, investment and EU funding
- Funding pressures due to competing demands
- Increased climate change risk and necessity to adapt
- Biodiversity or environmental net gain reducing developer activity

Stakeholders who may benefit	***Stakeholders who may lose out***
• Public/health sector • Government (on all administrative scales) • Low carbon industry (e.g. energy companies) • BEIS • Residents • LAs/LEP • Construction industry • Highways England	• Fossil fuel investors • Energy companies specialised in hydrocarbon fuel sources • Residents • Nature conservation stakeholders

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Growth Strategy (2017)
- Climate Change Act 2008
- Industrial Strategy White Paper
- Paris Agreement
- Engagement with key national energy innovation assets including the Energy Systems Catapult, Nuclear Advanced Manufacturing Research Centre, the Advanced Propulsion Centre and Government opportunities
- Smart Energy
- Clean Growth Strategy
- Qwest Energy
- Warm Homes Fund/Green Doctor
- Eco Flexible Eligibility
- Home safety grants
- Home Assistance Policy
- Rural Housing Strategy
- Empty Homes Strategy
- Affordable Warmth Action Plan
- Housing Strategy
- ECO
- RHI
- Home Energy Conservation Act 1995
- Climate Change Act 2008
- Statutory target to tackle fuel poverty

LEP economic and social outcomes (targets/aims)

By 2040, Cheshire and Warrington will have a resilient energy system, based on locally integrated low carbon power and heat systems, reducing climate gas emissions by 50%. Facilitating the delivery of well located, high quality, affordable housing as part of an attractive place offer and build up to 127,000 new homes by 2040.

6.5 Manufacturing, logistics and services

Combining industry, logistics and distribution, finance, commerce, economic strategy and science and innovation

Science and innovation policies include: Cheshire and Warrington LEP Science and Innovation Strategy and Delivery Plan, Digital Strategy and Economic Strategy

Key strengths of C&W LEP
Cheshire has world leading businesses in world leading sectors such as AstraZeneca, Bentley Motors, Unilever and Jungheinrich.

Current status of natural capital

Built-up area classification	Area (ha)	Percentage of total area (%)
Glasshouse	47	0.02
Business or industry	1,224	0.53
Sealed surface	5372	2.34
Other structure	98	0.04

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisior	Regulating	Cultural	Supporting
Regional	Science and Innovation Strategy and Delivery Plan				
	Digital Strategy and Delivery Plan				
Local	Economic Strategy for Cheshire East 2019-2024				

Impacts of policies on the manufacturing, logistics and services sector

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
Regional	Science and Innovation Strategy and Delivery Plan				
	Digital Strategy and Delivery Plan				
Local	Economic Strategy for Cheshire East 2019-2024				

Opportunities to improve outcomes through enhanced natural capital in the manufacturing, logistics and services sector

- Advanced Agricultural Engineering Academy (potential investments in food manufacturing)
- Strengths in chemicals, life sciences (including pharmaceuticals), finance and business services and logistics and distribution
- Clean growth
- Attracting new occupiers and investors into the sub-region
- Cheshire Science Corridor Enterprise Zone

Threats to natural capital and the manufacturing, logistics and services sector

- New commercial building/construction
- Biodiversity or environmental net gain reducing developer activity
- Competition
- External market drivers

Stakeholders who may benefit

- Industry
- Distribution Network Operators and OFGEM
- BIDs
- LAs
- Industry
- Education: schools, universities
- Young working population
- R&D sector

Stakeholders who may lose out

- Nature conservation stakeholders

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Digital Strategy and Delivery Plan
- Economic Strategy for Cheshire East 2019-2024

LEP economic and social outcomes (targets/aims)

Creating 120,000 jobs (net additional), growing the economy to at least £50 billion pa GVA (from £29 billion), being 20% more productive per resident than the UK average and 'creating an economy that works for all'.

6.6 Minerals and waste management

Economic policies include: Local Plans, Minerals Resource Study and Policy Review (Warrington); Sustainable Community Strategy; Greenspace Strategy

Key strengths of C&W LEP

The mineral resources include superficial deposits (glaciofluvial, river terrace and sub-alluvial sand and gravel), peat, salt and coal.

Current status of natural capital

Artificial rock/exposure/waste classification	Area (ha)	Percentage of total area (%)
Spoil	47	0.02
Refuse-tip	183	0.08
Unknown waste	276	0.12

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
Regional	Sustainable Community Strategy	→	↗	↑	↗
	Greenspace Strategy	↑	↑	↑	↑
Local	Cheshire East Local Plan Strategy 2010-2030	→	→	↑	→
	Warrington Mineral Resource Study and Policy Review	↘	↘	→	↘

Impacts of policies on the minerals and waste management sectors

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
Regional	Sustainable Community Strategy	↘	↘	→	↘
	Greenspace Strategy	↘	↘	→	↘
Local	Cheshire East Local Plan Strategy 2010-2030	↘	↘	→	↘
	Warrington Mineral Resource Study and Policy Review	↗	↗	↗	↗

Opportunities to improve outcomes through enhanced natural capital in the sector

- Land restoration
- Carbon storage
- Minerals supply and safeguarding
- Offsetting

Threats to natural capital and the minerals sector

- Threats to biodiversity
- Proposals for new development will only be permitted where any adverse impacts on a range of criteria is avoided or can be appropriately mitigated
- Soil quality
- Water pollution
- Reducing demand for sand and gravel

Stakeholders who may benefit	***Stakeholders who may lose out***
• Mining companies/industry • BEIS • Landowners	• Homeowners in areas close to mining • Landowners • Nature conservation stakeholders

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- National Planning Policy Framework, including minerals safeguarding policy
- Sustainable Community Strategy
- Greenspace Strategy
- Local Plan Strategy 2010-2030

LEP economic and social outcomes (targets/aims)

Sustainably growing the economy to at least £50 billion pa GVA.

6.7 Environmental management

Including water management, forestry and nature conservation

Sustainability and natural environment policies include: Strategic Economic Plan, Transport Strategy, Local Plans, Environment Strategy, Environmental Land Management Scheme.

Key strengths of C&W LEP

There are numerous areas of irreplaceable natural habitat such as ancient woodland, glacial meres and peatlands. Furthermore, there are important green corridors such as the Manchester Ship Canal, the River Mersey, the Bridgewater Canal and the Transpennine Way. The region is adjacent to the Peak District National Park.

Current status of natural capital

Classification	Area (ha)	Percentage of total area (%)
Hedgerows	2,753	1.20
Cultivated / disturbed land	39,951	17.41
Grassland, improved	108,626	47.33
Grassland, amenity	9,136	3.98
Grassland, marshy	2,115	0.92
Grassland, semi-natural	4,292	1.87
Grassland, unknown	503	0.22
Heathland	393	0.17
Intertidal	1,890	0.82
Bog	967	0.42
Natural rock	15	0.01
Saltmarsh	2,041	0.89
Scrub	351	0.15
Fen and swamp	265	0.12
Trees / Parkland	1,163	0.51
Unclassified	950	0.41
Water, fresh	3,962	1.73
Woodland, broadleaved	10,802	4.71
Woodland, coniferous	1,749	0.76
Woodland, mixed	3,776	1.65

The majority of landcover is cultivated/disturbed land, improved and amenity grassland (69%) and only approximately 14% of land supports biodiversity.

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
National	ELMS Tier 1	→	↑	→	↗
	ELMS Tier 2	↘	↗	↗	→
	ELMS Tier 3	↓	↑	↗	→
Regional	Quality of place strategy	→	→	→	→
	Stategic Economic Plan	↘	↓	↑	↘
	Mersey Forest Plan	↑	↑	↑	↑
	The Northern Forest	↑	↑	↑	↑
	Greenspace strategy	↑	↑	↑	↑
	Green Infrastructure Framework Action Plan	→	↗	↗	↑
	Green Infrastructure Partnership	→	↗	↗	↗
	Environment Strategy	↗	↗	↗	↗
Local	Cheshire East Local Plan Strategy 2010-2030	→	→	↑	→
	Ecological Network	↓	↗	↗	↑
	Green Infrastructure Plan for Cheshire East 2019-2030	↗	↗	↗	↗

Impacts of policies on the environmental management sector

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
National	ELMS Tier 1	→	→	→	→
	ELMS Tier 2	↗	→	→	↗
	ELMS Tier 3	↗	→	→	↗
Regional	Quality of place strategy	↗	↗	↗	↗
	Stategic Economic Plan	↗	↗	↗	↗
	Mersey Forest Plan	↗	↗	↗	↗
	The Northern Forest	↗	↗	↗	↗
	Greenspace strategy	→	↗	→	→
	Green Infrastructure Framework Action Plan	→	↗	→	→
	Green Infrastructure Partnership	→	↗	→	→
	Environment Strategy	→	↗	→	→
Local	Cheshire East Local Plan Strategy 2010-2030	→	↗	→	→
	Ecological Network	→	↗	↗	→
	Green Infrastructure Plan for Cheshire East 2019-2030	↗	↗	↗	↗

Opportunities to improve outcomes through enhanced natural capital in the environmental management sector

- Private investment through low carbon lead
- Recycling and waste management
- Restoring lost habitats
- Creating new habitats e.g. planting forest
- Energy efficiency
- Redevelopment of vacant brownfield sites
- Employment in green sector
- Restoration of land
- Reducing GHG emissions
- Improved farmland and soils
- Implementation of Sustainable Drainage Systems (SUDS)/flood risk management
- Improved air quality in hotspots through emissions reduction Skilled workforce
- Biodiversity and environmental net gain
- Blended finance in natural capital
- Employment
- Efficiency
- Reduction of minerals extracted through reuse of waste materials from construction

Threats to natural capital and the environmental management sector

- Planned construction of leisure and retail areas and consequent emissions
- Loss of green belt
- Demographic challenges
- Loss of EU funding
- Soil/water/air quality
- Flood risk

Stakeholders who may benefit

- Public
- Public health sector
- United Utilities
- Local businesses

Stakeholders who may lose out

- Construction companies due to limitations
- Mineral companies due to limitations

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Green Infrastructure Partnership
- ELMS
- Smart Energy GB
- HM Government The Clean Growth Strategy
- Mersey Forest Plan
- The Northern Forest
- Bollin Valley projects and proposals

LEP economic and social outcomes (targets/aims)

Sustainable growth and regeneration of the region, including green infrastructure and spaces to promote physical activity and visitors

6.8 Health, wellbeing and tourism

Including recreation, tourism, health and wellbeing

Sustainability and natural environment policies include: Warrington Health and Wellbeing Strategy 2019 – 2023, Environment Strategy, Ecological Network, Mersey Forest Plan, The Northern Forest, Green Infrastructure Plan for Cheshire East 2019-2030, Greenspace strategy, Green Infrastructure Framework Action Plan, Cheshire East's Sustainable Community Strategy 2010 to 2025.

Key strengths of C&W LEP

Cheshire and Warrington benefit from a strong economic position. They have a thriving third sector, well-established neighbourhood networks and a strong, multi-agency Community Safety Partnership.

Current status of natural capital

Classification	Area (ha)	Percentage of total area (%)
Garden	13,720	5.98
Grassland, improved	108,626	47.33
Grassland, amenity	9,136	3.98
Grassland, marshy	2,115	0.92
Grassland, semi-natural	4,292	1.87
Grassland, unknown	503	0.22
Cultivated/disturbed land	39,951	17.41
Heathland	393	0.17
Intertidal	1,890	0.82
Natural rock	15	0.01
Path	500	0.22
Saltmarsh	2,041	0.89
Scrub	351	0.15
Trees / Parkland	1,163	0.51
Unclassified	950	0.41
Water, fresh	3,962	1.73
Woodland, broadleaved	10,802	4.71
Woodland, coniferous	1,749	0.76
Woodland, mixed	3,776	1.65

A large proportion of land is improved grassland or amenity grassland (50%) which provides recreation ecosystem services. Warrington was named as the second worst city in the North West for breaching safety levels of air pollution by the WHO in 2016.

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
	Environment Strategy	↗	↗	↗	↗
	Ecological Network	↑	↑	↑	↑
	Greenspace strategy	↑	↑	↑	↑
Regional	Green Infrastructure Framework Action Plan	→	↗	↗	↑
	Cheshire East's Sustainable Community Strategy 2010 to 2025	→	↗	↑	↗
	Green Infrastructure Plan for Cheshire East 2019-2030	↗	↗	↗	↗
	Mersey Forest Plan	↑	↑	↑	↑
	The Northern Forest	↑	↑	↑	↑
Local	Well Warrington Health and Wellbeing Strategy 2019 - 2023	→	↘	↑	↘

Impacts of policies on the health, wellbeing and tourism sectors

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
	Environment Strategy	↗	→	↗	↗
	Ecological Network	↗	→	↗	↗
	Greenspace strategy	↗	→	↗	↗
Regional	Green Infrastructure Framework Action Plan	→	→	↗	↗
	Cheshire East's Sustainable Community Strategy 2010 to 2025	→	↗	↗	↗
	Green Infrastructure Plan for Cheshire East 2019-2030	↗	↗	↗	↗
	Mersey Forest Plan	↗	↗	↗	↗
	The Northern Forest	↗	↗	↗	↗
	Well Warrington Health and Wellbeing Strategy 2019 - 2023	↗	↗	↗	↗
Local	Local Plan Strategy 2010-2030	↗	↗	↗	↗

Opportunities to improve outcomes through enhanced natural capital in the health, well-being and tourism sector

- Private investment through low carbon lead
- Sustainable/eco-tourism; natural visitor attractions
- Recycling and waste management
- Green infrastructure to promote biodiversity and greening of public spaces for recreation (walking, cycling)
- Employment in green sector
- Reducing GHG emissions
- Improved farmland and soils
- Improved air quality in hotspots through emissions reduction
- Skilled workforce
- Blended finance in natural capital
- Sustainable tourism, including stimulation through biodiversity net gain
- Green infrastructure as a visitor attraction
- Greening of space as a pull factor for students and skilled labour
- Environmental net gain linked to improvements in mental and physical health

Threats to natural capital and the health, well-being and tourism sector

- Planned construction of leisure and retail areas and consequent emissions
- Loss of green belt
- Demographic challenges
- Loss of EU funding
- Socioeconomic deprivation
- Public health issues (e.g. obesity, alcoholism)
- Communal issues (e.g. crime rate)
- Population increase
- Housing construction
- Business growth
- Demand on services

Stakeholders who may benefit	***Stakeholders who may lose out***
• Public/communities • Public health sector • United utilities	• Construction companies due to limitations • Mineral companies due to limitations

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Green Infrastructure Partnership
- ELMS
- Smart Energy GB
- HM Government The Clean Growth Strategy
- Mersey Forest Plan
- The Northern Forest
- Bollin Valley projects and proposals

LEP economic and social outcomes (targets/aims)

Sustainable growth and regeneration of the region, including green infrastructure and spaces to promote physical activity and increase the number of visitors.

6.9 Transport

Transport policies include: Transport Strategy, Local Plans, Environment Strategy and the Economic Strategy

Key strengths of C&W LEP

There are several key growth opportunity areas of which transport and connectivity will be vital. These include: Cheshire Science Corridor and Enterprise Zone, Mersey Dee Economic Axis, Constellation Partnership Development Zone and Warrington New City.

Current status of natural capital

Classification	Area (ha)	Percentage of total area (%)
Roads	462	0.20
Railway	1,253	0.55
Pavement	500	0.22
Path	13,720	5.98

Air pollution is a significant concern with Warrington found to be the most polluted city in the North West in 2016 by the WHO. Roads make up a significant proportion of land area, with this more than ten times the area of land used for railway.

Impacts of policies on ecosystem services

Level	Policies	Ecosystem services			
		Provisioning	Regulating	Cultural	Supporting
Regional	Stategic Economic Plan	→	↓	↑	→
	Environment Strategy	↗	↗	↗	↗
	ESIF Low Carbon Action Plan	→	↗	→	→
	Digital Strategy and Delivery Plan	→	↗	↑	→
	Quality of place strategy	→	→	↑	→
Local	Economic Strategy for Cheshire East 2019-2024	→	→	↑	→
	Warrington Local Plan	→	↗	↑	→
	Cheshire East Local Plan Strategy 2010-2030	→	↗	↑	→
	Cheshire East Rights of Way Impovement Plan	→	↗	↗	→

Impacts of policies on the transport sector

Level	Policies	Sector			
		Output	Employment	Sustainable businesses	Supply chains
Regional	Stategic Economic Plan	↗	↗	→	→
	Environment Strategy	↗	↗	→	↗
	ESIF Low Carbon Action Plan	↗	↗	→	→
	Digital Strategy and Delivery Plan	↗	↗	→	→
	Quality of place strategy	↗	↗	→	→
Local	Economic Strategy for Cheshire East 2019-2024	→	→	↑	→
	Warrington Local Plan	→	↗	↑	→
	Cheshire East Local Plan Strategy 2010-2030	→	↗	↑	→
	Cheshire East Rights of Way Impovement Plan	→	→	→	→

Opportunities to improve outcomes through enhanced natural capital in the transport sector

- Sustainable/public transport
- Emissions reduction
- HS2 at Crewe Hub and development of the Northern Powerhouse Rail Network

Threats to natural capital and the transport sector

- Construction
- Loss of biodiversity
- Lack of transport links for rural communities
- Highway development

Stakeholders who may benefit

- Councils
- Homeowners
- Homes and Communities Agency
- Network rail
- Public transport stakeholders/operators

Stakeholders who may lose out

- Rural communities
- Landowners
- City dwellers

See for a detailed assessment of stakeholders involved in Annex 2

Actions and interventions (existing initiatives that would build on opportunities/minimise threats)

- Environment Strategy
- ESIF Low Carbon Action Plan
- Digital Strategy and Delivery Plan
- Cycle to Work Scheme
- Cheshire East Rights of Way Improvement Plan
- Quality of Place Strategy
- Economic Strategy for Cheshire East 2019-2024
- Warrington Local Plan
- Cheshire East Local Plan Strategy 2010-2030

LEP economic and social outcomes (targets/aims)

Improve the main areas of congestion across the local and strategic road network, and improving the public transport offer in the region.

7. Key findings from the policy analysis

Work Package B involves an analysis of existing initiatives, plans, policies and strategies at local, regional and national levels. This includes an assessment of the drivers and pressures that could affect (positively and negatively) the natural capital and ecosystem services. Analysis of the potential impacts of these initiatives, plans, policies and strategies is undertaken at the sectoral level, with this intended to assist with identifying specific opportunities and priorities for intervention in Work Package C (see Technical Report 2 for details).

The analysis has been undertaken for eight sectors: agriculture; skills and education; energy, clean growth, housing and construction; manufacturing, logistics and services; minerals and waste management; environmental management; health, wellbeing and tourism; and transport. Quality of place is identified as an important aspect that cuts across all sectors, being one of the key factors to attracting and retaining talent in the C&W LEP area.

The analysis shows that there are many existing initiatives, policies, plans and strategies that could help deliver an improvement to natural capital and so help deliver quality of place. There are opportunities across all sectors that could enhance natural capital and help deliver the LEP's economic and social targets. Key opportunities include the development of forests and urban green spaces, the transition to clean growth and supporting local communities to develop digital skills. However, there are also some policies and plans that could lead to negative effects on natural capital and threats facing each sector that could reduce the condition or extent of habitats. Leading threats include: the significant housing developments some of which are located on the green belt, the stimulation of the economy attracting more workers to the area which puts pressure on services and the emphasis on the development of roads. By identifying both these opportunities and threats, the policy analysis provides an evidence-based approach to assessing where future interventions need to be targeted to ensure opportunities can be maximised while threats are minimised.

Table 7 below shows how and where the sectors could interact with each other: where there may be synergies between sectors and where there may be antagonisms. In some cases, there could be both synergies and antagonisms, depending on how policies develop moving forwards. These will be key areas for focus in terms of potential interventions to ensure that opportunities are not missed and that threats are avoided.

Table 7 Potential synergies and antagonisms between sectors.

Sector	Agriculture	Skills and education	Energy, housing and construction	Manufacturing, logistics and services	Minerals and waste management	Environmental management	Health, wellbeing and tourism	Transport
Agriculture		+	-/+	-/+	-/+	-/+	-/+	0
Skills and education	++		+	++	-/+	+	+	+
Energy, housing and construction	- -	+		+	++	- -	-/+	-/+
Manufacturing, logistics and services	-	+	+		-/+	-/+	-/+	+
Minerals and waste management	- -	-/+	-/+	-/+		-/+	-/+	-/+
Environmental management	+	++	-/+	-/+	-/+		++	+
Health, wellbeing and tourism	+	+	-/+	-/+	-/+	++		-/+
Transport	- -	+	-/+	-/+	+	-/+	-/+	

The interactions with each sector are shown from left to right, so the impacts of agriculture on education and research is shown as + (potential for stronger relationships between farmers and universities/research originations) while the impacts of education and research on agriculture is shown as ++ (educational and research opportunities for agriculture already in place).

Note that the interaction of energy, housing and construction with environmental management can be offset through biodiversity net gain, thereby reducing negative impact.

Key:
++ strong synergies with established initiatives, policies, plans and strategies in place
+ potential for synergies but limited exiting initiatives, or initiatives not yet fully in place
0 no identified synergies or antagonisms
- potential antagonisms could arise in the future without interventions that could affect natural capital
- - existing antagonisms already identified that are affecting natural capital

Annex 1: Baseline ecosystem service valuation

A1.1 Air quality regulation

The ability of the woodland and grassland vegetation in the Cheshire and Warrington local authorities to absorb particulate matter ≤2.5µm in diameter ($PM_{2.5}$) was measured. Quantifying the physical flow of the air quality regulation service provided by the woodland and grassland was based on the absorption calculation in Powe & Willis (2004[10]) and the method in ONS (2016[11]). The deposition rates for $PM_{2.5}$ in coniferous woodland, deciduous woodland, and grassland were taken from Powe & Willis (2004). Average background pollution concentrations for $PM_{2.5}$ were calculated using Defra data (Modelling of Ambient Air Quality 2018 and 2001). The surface area index of coniferous and deciduous woodlands in on-leaf and off-leaf periods was taken from Powe & Willis (2004). The proportion of dry days in 2020 (rainfall <1mm) for north-west England was estimated using MET office regional value data (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using the Woodland Trust data averages tool.

The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2019[12]). These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of absorbed pollutant by the woodland and grassland habitats was equal to the average damage cost of that pollutant. The $PM_{2.5}$ damage cost estimates depend on the location (urban size or rural) and source of pollution. The local authority areas were considered to fall into two, urban medium, and urban small according to the Defra ONS (2016)[13] categorisation at ward level, and the damage cost levels associated with these categories were used. We intend to review this valuation with a more spatial calculation of $PM_{2.5}$ pollution, also including a rural component in Cheshire East and West in the future, as the urban categorisations used may slightly over estimate the value of this service. When calculating the present value over 50 years, the absorption rate was assumed to be constant. The Defra damage cost of $PM_{2.5}$ is in 2017 prices, and so was adjusted to reflect inflation up to 2020. The value was also subject to an uplift of 2% per annum to reflect the assumption that willingness to pay for health will rise in line with economic growth, as recommended by Defra (2019). The central damage cost figures are presented in the monetary flow estimates, low and high damage costs from Defra (2019) were used in the sensitivity analysis.

A1.2. Carbon sequestration

The annual physical flow of the carbon sequestration service was calculated as in Section 3.2 above. Monetary flows were calculated using the Government's non-traded central carbon price for 2020 (DBEIS 2019[14]). We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of carbon sequestration. The present

[10] Powe, N., A., & Willis, K.G. (2004) Mortality and morbidity benefits of air pollution (SO2 and PM10) absorption attributable to woodland in Britain. *Journal of Environmental Management,* 70, 119-128.
[11] ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts.
[12] Defra (2019) Air quality damage costs guidance. Crown Copyright.
[13] Defra an ONS (2016) Urban and rural classification of English local authority districts and similar geographical units in England: Methodology.
[14] DBEIS (2019) Carbon priced and sensitivities 2010-2100 for appraisal in HM Treasury (2018) The Green Book. Central Government guidance on appraisal and evaluation, version 3. London.

value (PV) of the ability of the woodland to sequester carbon into the future was calculated by summing the values for each year over a 50-year period, after discounting using the discount rate suggested in HM Treasury (2019[15]) of 3.5%. The HM Treasury also provides low and high estimates of current and future non-traded carbon prices. These were used to provide a sensitivity analysis to the economic valuation of this ecosystem service.

A1.3 Greenhouse gas emissions from agriculture

Agricultural activities release CO_2 and other greenhouse gasses such as methane and NO_2 into the atmosphere, with emissions highly variable depending on the type of farming practices employed. These emissions can therefore negate the benefits obtained through carbon sequestration of habitats within a site.

The greenhouse gas emissions of the site were calculated by multiplying the area of each crop type and the numbers of livestock by emissions figures for each crop type and livestock type in Bateman et al. (2013[16]). These emission figures are based on three types of agricultural emissions:

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N_2O from fertilizers
3. Emissions of N_2O and methane from livestock, caused by enteric fermentation and the production of manure

The total physical flow of greenhouse gas emissions was calculated by adding crop type and livestock emissions (in tCO2e). These were monetised using the DBEIS (2019) non-traded central carbon price, as described for carbon sequestration above, and discounted at the standard rate. The low and high non-traded carbon prices were used for the sensitivity analysis.

A1.4 Agricultural production

The physical annual flow of agricultural production for each local authority within the Cheshire and Warrington region was simply measured as the area of land under agriculture derived from the asset register (Table 1). These were classified to an appropriate Defra farming system, that is the proportion of different livestock and crops, using data on the structure of the farming system in England at the county scale.

The monetary value of agricultural production was calculated as the economic value of land, net of all non-land costs. Net Farm Income (NFI), the return to farm operators once all expenses have been deducted, were obtained from Defra's Farm Accounts in England (Farm Business Survey) for the three local authority areas. This takes into account yields and farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, husbandry, feed and forage costs) and fixed costs (labour, machinery, fuel, buildings). Annual NFI estimates were obtained over 5 years for the period 2015/16 to 2019/2020. These were then adjusted to remove the effects of Basic Farm Payments (income support), to remove any charges for imputed (unpaid) rent, and to include charges for the imputed value of unpaid family labour. This gives a return (an economic rent) to the land resource itself after deducting all costs associated with production except for land ownership and rental costs, and excluding income support subsidies. The annual estimates of adjusted NFI were inflation adjusted to 2020 prices, and a mean estimate per hectare was derived for the period for each of the farming systems. Low and high estimate

[15] HM Treasury (2019) The Green Book. Crown Copyright.

[16] Bateman, I. J. et al. (2013) Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. Science 341 45-50.

were also calculated. The per hectare estimates were multiplied by the area of land under each of the farming systems in the local authorities, to derive the total annual value of agricultural production. Present Value was calculated over 50 years using the standard discount rate and assumes that the mix of crops and livestock numbers stays approximately the same. The low and high production values were used for the sensitivity analysis.

A1.5 Recreation

The annual physical and monetary flows of recreation was estimated for each of the local authorities within Cheshire and Warrington using the University of Exeter's Outdoor Recreation Valuation Tool (ORVal) version 2.0 (https://www.leep.exeter.ac.uk/orval/). This tool uses a statistical model called a Recreational Demand Model to predict the number of visits that are made to currently accessible greenspaces by adult residents of England. The number of visits are modelled using data from the Monitor of Engagement with the Natural Environment (MENE) survey, and adjusted based on factors such as socioeconomic characteristics of people, the day of the week, attributes of the greenspace, the availability and quality of any alternative greenspaces. The model, through a welfare function, also describes the welfare an individual derives from making different recreational choices, and the welfare values are, therefore, provided by the tool. The welfare gained from a particular greenspace will depend on a number of factors (e.g. socio-economic status, month of the year) and the benefits experience at a site is traded-off against the costs of travelling to the site. The overall annual physical flow and monetary value for recreation in each of the Cheshire and Warrington local authorities was the sum of the visit estimates and the welfare values for each accessible greenspace in those areas. For further details of the ORVal model see the advanced technical report for details: https://www.leep.exeter.ac.uk/orval/pdf-reports/ORValII_Modelling_Report.pdf. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

A1.6 Physical health

There is now a growing body of evidence to show the positive effect that the natural environment can have on human health and well-being. Physical health is more commonly valued, although methods are still being refined. The physical flow of health benefits delivered by Cheshire were valued using an approach developed by White et al. (2016[17]), who analysed the implications of recreational physical activity in the natural environment on health in England. The method relies on estimates of visitors to natural environments who meet recommended activity guidelines (based on both duration and intensity of physical activities).

The first step in the calculations was to estimate the number of visitors to the publicly accessible green areas in and around Cheshire. These were taken from the University of Exeter's Outdoor Recreation Valuation Tool (ORVal) version 2.0. Using this estimate we converted the visits (which includes repeat visits by the same individuals) to the number of visitors (individuals), using a visit rate calculated from the latest 5 years of national MENE survey data from Natural England. These can be translated into Quality Adjusted Life Years (QALYs) scores, with 30 minutes of moderate to intense physical activity (if taken 52 weeks a year) being equal to 0.0107 of a QALY. QALY scores have an associated monetary value through estimated savings in health care costs. This physical health benefit can, therefore, be estimated by calculating the total number of QALYs by active visitors to sites that meet guidelines, and multiplying this by the QALY value. The social value of one QALY remains under review. It has been estimated to be worth £20,000 (White et al. 2016), and £60,000 (HM Treasury 2019). However, the recent Defra ENCA project suggests a more conservative value of £15,000 should be used, and this is what is used here. We use the

[17] White, M.P. et al. (2016) Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. Preventative Medicine 91 383-388.

£60,000 estimate for the upper estimate of value in the sensitivity analyses, highlighting that the value of physical health could be considered to be much higher. The lower estimate was 50% of the central value.

The present value (PV) of the area to deliver physical health benefits into the future was the sum of annual values over the 50-year period, using the discount rates suggested in HM Treasury (2019). Discount rates for QALY effects are recommended at 1.5%, (differing from the 3.5% rate recommended for other service indicators). Also see amenity value below for discussion of double counting issue.

A number of assumptions are used in these calculations and the results should therefore be interpreted with caution; it is one of two ecosystem services with the greatest degree of uncertainty out of all those assessed.

A1.7 Timber/woodfuel production

For existing woodland, annual physical flows of timber/woodfuel production were calculated in terms of average annual yield, by multiplying the yield class of the different species by the area of each woodland type see Section 3.11.

The annual monetary flows for the woodland areas were calculated by multiplying the yield by the standing price of timber or woodfuel. The average price for softwood in 2020 was taken from the Forestry Commissions Coniferous Standing Sales Price Index (Forestry Commission 2020[18]). The price for broadleaved timber in 2015 ranged from £15 to high quality timber reaching £250 per m^3 standing (ABC 2015[19]). We assume the lowest value here for woodfuel, and convert this to 2020 priced using Government deflators. To convert to a present value the annual value was multiplied by the standard government discount rate (3.5%) for each respective year up to 50 years. It was assumed that the area of woodland remains static and the unit price was also assumed to be constant. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

A1.8 Mineral extraction

The physical flow of mineral extraction for each Local Authority area are the annualised average allocations for each aggregate type (sand and gravel and crushed rock). These were derived from the Warrington Borough Council minerals resource study and policy review (2017), the Cheshire West and Chester Council local aggregates assessment 2019, and the Cheshire East local plan strategy 2010-2030. The annual monetary value could not be broken down by local authority, so is presented for Cheshire only. The value was taken from the regional gross value added (balanced) by industry figures from the ONS (2019). The most recent value was for 2018, and this was uprated using the Consumer Price Index to 2020 prices. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

A1.9 Recreational angling

Data on type of fishing, average number of trips, and average spend per trip in Cheshire was disaggregated from RPA (2017): A survey of freshwater angling in England and associated economic activity and value, Phase 1 final report, Angling activity and expenditure, report to the Environment Agency, March 2017. Data on rod licences by postcode were from the EA for 2015. Expenditure per trip was estimated at £63.10 (2015), which includes food and drink, transport costs (public and car including parking and fuel), hire of tackle and boats, fishing guides, bait and day ticket, match fee. This value was

[18] Forestry Commission (2020) Timber price indices. Data to March 2020.
[19] ABC (2015) The agricultural budgeting and costing book. 81st edition, Argo Business Consultants.

uplifted to 2020 prices using the Government Deflator Index March 2020. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

A1.10 Amenity value

The proximity of greenspace can have a positive effect on residential property values. House prices show significant positive price variations with greater proximity to greenspace and water considered separately and together (ONS 2019[20], Moranto et al. 2010[21]). Conversely, increasing distance to natural amenities is 'unambiguously associated with a fall in prices' (Moranto et al. 2010). A recent study by the Office for National Statistics has looked at this relationship in some depth, and has provided an average uplift in house value across Great Britain of 1.2% for residences within 500 metres of publicly accessible green spaces. They looked in detail at the effect of 100, 200 and 500 metre distances, at different residential property types and sizes, and the proximity to greenspaces of varying size. The analyses also included the average uplift in house value from proximity to greenspace in travel to work areas in England and Wales, because this varies considerably across these areas. We have been able to extract the value of 1.72% for Warrington, and 1.95% for Chester.

We used GIS software to locate the number of residential buildings within 500 metres of greenspaces over 2.5 ha in area. We extracted average house prices for each of the local authorities from 'House price statistics for small areas' from ONS, and applied the % uplift associated with Warrington and Chester to the relevant local authorities. The house prices were adjusted to 2020 prices, and the total annual value was discounted using the standard government discount rate (3.5%) for each respective year up to 50 years.

We are aware of the potential for double counting here: it is incorrect for example to value increases in property value if the benefit streams responsible for this increase have already been accounted for. This is potentially the case with amenity value and the physical health service. Physical health depends on access to greenspace for exercise, and people may purchase houses due to close proximity to greenspace specifically so they can exercise in them. However, the amenity value estimate also captures other important reasons why people buy near greenspace, such as tranquillity, green views, air quality etc, that will also be factored into the property price uplift. We have, therefore, decided to keep these values in the study, but they should be interpreted with caution. It is not possible to establish the magnitude of this double counting issue without significant further study.

[20] ONS (2019) Valuing green spaces in urban areas: a hedonic price approach using machine learning techniques. ONS.
[21] Mourato, S. et al. (2010) Economic analysis of cultural services. UK NEA Economic Analysis Report.

Annex 2: Stakeholder analysis

Table A2 Stakeholders involved in each sector

Stakeholders	*Agriculture*	*Energy and clean growth*	*Flood risk and water management*	*Health and wellbeing*	*Housing and construction*	*Science and innovation*	*Skills, employment and education*	*Sustainability and natural environment*	*Transport*
BEIS		✓				✓			✓
Businesses	✓	✓	✓	✓					
Central Area Neighbourhood Board				✓	✓		✓		✓
Cheshire & Warrington Local Enterprise Partnership		✓			✓	✓	✓		✓
Cheshire Archaeology Planning Advisory Services					✓				✓
Cultural Commission							✓		
Distribution Network Operators and OFGEM									✓
Education: schools, universities						✓	✓		
Energy hub: industry		✓							
Energy Systems Catapult		✓							
Environment Agency									
ESIF Low Carbon Economy Group		✓							
Farmers, land managers	✓								
Health: Cheshire Clinical Commissioning Group (CCG), Public Health England, Cheshire and Merseyside Health and Care Partnership, Innovation Agency, Halton and Warrington NHS Hospital Trust, Warrington Clinical Commissioning Group				✓					
Highways England									✓
Historic England							✓		

Table A2 Stakeholders involved in each sector

Stakeholders	*Agriculture*	*Energy and clean growth*	*Flood risk and water management*	*Health and wellbeing*	*Housing and construction*	*Science and innovation*	*Skills, employment and education*	*Sustainability and natural environment*	*Transport*
Homes England					✓				
Households					✓				
HSE									
Industry						✓	✓		
Land owners and large estates	✓							✓	
LAs: Cheshire East, Cheshire West and Chester, Warrington	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lead Local Flood Authorities (LLFA)									
National and regional governments	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nature conservation sector: local area Wildlife Trusts, National Trust, RSPB, Natural England and LGA conservation offices								✓	
Natural environment sector: Groundwork, the Land Trust, Floodhub Cheshire and Weaver Gowy Catchment Partnership			✓					✓	
Neighbourhood Plan Groups				✓	✓				
Neighbouring Authorities: Halton and Wirral Councils, The Greater Manchester Combined Authority, Salford City Council, Trafford Borough Council and Wigan Borough Council		✓		✓					
Neighbouring LEPs: Liverpool City Region and Greater Manchester									
Network Rail									✓
Partnerships for Action in Cheshire East (PACE)						✓	✓		
Performance and Investment Committee		✓			✓	✓			✓
Police				✓			✓		✓

Table A2 Stakeholders involved in each sector

Stakeholders	*Agriculture*	*Energy and clean growth*	*Flood risk and water management*	*Health and wellbeing*	*Housing and construction*	*Science and innovation*	*Skills, employment and education*	*Sustainability and natural environment*	*Transport*
Private Sector Developers					✓	✓			✓
Public Sector Stakeholders								✓	✓
Public Transport operators									✓
Registered Providers					✓				
Residents, working population, tourism industry, rural communities	✓	✓	✓	✓	✓	✓	✓	✓	✓
Skills and Growth Company							✓		
SMEs						✓	✓		
St Helens Borough Council	✓	✓	✓	✓	✓		✓	✓	✓
Sustainability Commission				✓				✓	
The Mersey Forest team, Woodland Trust and the other Community Forests in The North of England, the Northern Forest				✓				✓	
Transport for the North									✓
United Utilities			✓						
Utility Providers		✓	✓						
Warrington & Co						✓	✓		
Warrington Cultural Commission							✓		
Warrington Together				✓					
Warrington Town Centre Business Improvement District						✓	✓		
Young working population, first time buyers, lower socioeconomic groups, students					✓		✓		