West Lothian natural capital assessment

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Executive Summary

West Lothian Council (WLC) are working to update the previous Local Biodiversity Action Plan (2004-2009) to bring it up to date (2023-2033) using WLC Climate Change Emergency funding. The council proposed to use an ecosystem approach to assess and plan the conservation and enhancement of biodiversity throughout West Lothian. WLC therefore commissioned Natural Capital Solution to undertake a combination of UK Habitat Classification habitat and condition surveys (in conjunction with WSP) throughout the whole of West Lothian, supported by a Natural Capital Assessment of West Lothian Council landholdings.

A detailed basemap of the current habitats present across West Lothian has been produced. This used a variety of data sources available, supported by UK Habitat Classification survey undertaken on site by WSP in 2022. This map was used to assign habitats classes, which were used as the basis of the subsequent assessments of carbon, biodiversity and ecosystem service provision.

The most common habitat across West Lothian is improved grassland, primarily associated with agriculture, which comprises 25% of the region, with arable agricultural land identified to comprise a further 12%. Semi-natural grassland is frequent, comprising over 15% of the area, and woodlands take up almost 16% of the area. Built-up areas and infrastructure take up 8.6% of the area, with associated areas of amenity grassland comprising 5.2%, and private gardens 4.3%.

In comparison the most common habitat type across West Lothian Council (WLC) landholdings are woodland and tree habitats, as a whole comprising 34%, including 16% of broadleaved woodland. Amenity grassland is the next most common habitat taking up 21%. Semi-natural grassland occupies 6.3% of the areas and improved grassland comprises 8%, although there is very little arable land. Built up areas and infrastructure together make up 19%, with council residential gardens comprising 5.4%.

The habitats in each polygon of the West Lothian basemap were assigned a distinctiveness, condition and strategic significance score so that a biodiversity score could be assigned based on the Biodiversity Metric 3.1. The condition of WLC landholdings were assessed in line with Defra methodologies by WSP during their survey of the region, with a range of assumptions applied to assign condition to the wider region. The overall biodiversity score was 186,191 biodiversity units (BU) for the West Lothian region. WLC landholdings were estimated to contribute 16,558 of these units.

In total, eleven ecosystem services were modelled and mapped: carbon storage and sequestration, air purification, noise regulation, local climate (urban heat) regulation, pollination capacity, water flow regulation, water quality (sediment yield and nutrient deposition) regulation, food production, timber production and accessible nature.

The maps demonstrate that the presence of large areas of deep peat soils mean there is a significant carbon stock within the soil of West Lothian, with an average of 153 tC/ha across the region. WLC landholdings have a lower average (130 tC/ha) when compared to the region as a whole, primarily due to the dominance of mineral soils over peat. Blanket bog habitats were identified as important for carbon storage, with woodland assets shown as important for the provision of many of the ecosystem services (carbon sequestration, air quality, local climate and noise regulation, pollination, water flow and quality). Both of these habitats were identified to lie primarily to the south and west of the region. Within WLC landholdings both Beecraigs Country Park and Almondell and Calderwood Country Park were identified as important assets for the provision of many ecosystem services.

The West Lothian region is identified, on average, to be a source of yearly carbon emissions at a rate of -0.33 tCO_2e/ha/yr, primarily due to emissions associated with agriculture and degraded bog habitats which are not currently offset by the presence of good condition semi-natural habitats. WLC

landholdings, in comparison, sequester carbon at an average across the whole landholding of 2.4 tCO_2e/ha/yr, as woodland is common and emissions from farming and degraded peat habitats are much less common on these sites.

Maps showing the local demand for air purification, noise and local climate regulation were also produced. Demand for these services is greatest in urban areas close to major roads (such as Livingston and Whitburn), as these contain large populations, with potentially poor health, that would benefit from pollution amelioration and noise abatement from the main roads. The supply and demand maps show some spatial disparity between capacity and need for regulation as there is limited capacity in urban areas, as most of the woodland is found in rural areas (although street trees have not been mapped as part of this project).

On average, WLC landholdings provide higher (better) levels of ecosystem service provision when compared to the West Lothian average for 6 ecosystem services (carbon sequestration capacity, air purification capacity, noise regulation capacity, pollination capacity, timber production capacity and accessible nature capacity), worse for 4 (carbon storage capacity, local climate regulation capacity, water flow capacity and food production capacity) and there is a mixed picture for one (water quality). Typically, WLC landholdings contain more woodland, less agriculture, less peat soils and less upland areas than the county average. However, the WLC landholdings also have a higher than average demand for these services given their location in urbanised areas of the region.

This report provides an assessment of the existing baseline provision of biodiversity and other ecosystem services across West Lothian and WLC land holdings and provides the first step necessary to inform ecosystem service led policy documents such as the new LBAP.

This work could be further enhanced through the undertaking of a habitat connectivity analysis or biodiversity opportunity mapping, as well as habitat opportunity mapping for a range of ecosystem services, to show areas where new habitats could deliver multiple benefits and thus a more resilient multifunctional ecological network across the area. Another consideration would be to undertake a natural capital valuation (or natural capital accounting) of the WLC landholdings. This would demonstrate the value of the parks, particularly the public benefits that are not always recognised. This assessment can therefore be used as a basis to start to develop a strategy and a vision for the enhancement of the natural capital across West Lothian.

Contents

1. Introduction

The concept of natural capital is now embedded in policies and strategies in Scotland. Scotland's Environmental Strategy[1], the recent Economic Strategy[2] and the implementation plan for economic recovery post Covid-19[3] are built on the recognition that Scotland's natural environment, and the natural capital it supports, underpins our economy and is fundamental to our health and well-being.

The Climate Change (Scotland) Act[4] outlines a key role for nature-based solutions to climate change and emissions reduction. The Agriculture (Scotland) Bill[5] recognises that post Brexit, agriculture in Scotland will likely have to be supported by funding which promotes improved environmental outcomes – payments for the delivery of public goods. Particularly important in this context is Scotland's draft National Planning Framework 4[6] that states that natural capital will play a vital role in locking in carbon and building resilience by providing valuable ecosystem services, and there is a specific action to sustain and enhance natural capital. It also includes the need for planning and development to contribute to biodiversity in a positive way.

The Four Capitals Approach has also emerged from a report focused on delivering a robust and well-being centred economy for Scotland[7]. This is complementary to the natural capital approach and outlines four pillars of capital that need to be recognised for a sustainable economy that works for all: environment, people, community and business.

West Lothian Council (WLC) aim to update the previous Local Biodiversity Action Plan (2004-2009) to bring it up to date (2023-2033) using WLC Climate Change Emergency funding. The council propose to use an ecosystem approach to assess and plan the conservation and enhancement of biodiversity throughout West Lothian. WLC therefore commissioned Natural Capital Solution to undertake a combination of UK Habitat Classification habitat and condition surveys (in conjunction with WSP) throughout the whole of West Lothian, supported by a Natural Capital Assessment of West Lothian Council landholdings.

This assessment is useful in the context of climate change and carbon (net zero emissions targets), enhancing biodiversity, biodiversity off-setting (habitat banking), changes to the agricultural policy towards farming for public benefits, the Government's tree planting targets, and local air pollution reduction.

1.1 The natural capital and ecosystem services framework

The natural environment underpins our wellbeing and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. Natural Capital is defined as "*..elements of nature that directly or indirectly produce value or benefits to people, including*

[1] Available at: https://www.gov.scot/publications/environment-strategy-scotland-vision-outcomes/.
[2] Available at: https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/documents/
[3] Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2020/08/economic-recovery-implementation-plan-scottish-government-response-to-the-advisory-group-on-economic-recovery/documents/economic-recovery-implementation-plan-scottish-governments-response-advisory-group-economic-recovery/economic-recovery-implementation-plan-scottish-governments-response-advisory-group-economic-recovery/govscot%3Adocument/economic-recovery-implementation-plan-scottish-governments-response-advisory-group-economic-recovery.pdf
[4] https://www.legislation.gov.uk/asp/2019/15/enacted
[5] https://www.legislation.gov.uk/asp/2020/17/enacted
[6] Available at: https://www.gov.scot/publications/scotland-2045-fourth-national-planning-framework-draft/
[7] Scottish Government (2020) Towards a robust, resilient well-being economy for Scotland. Report on written submissions to the Advisory Group on Economic Recovery. Crown Copyright. Available at: https://www.gov.scot/publications/towards-robust-resilient-wellbeing-economy-scotland-report-written-submissions-advisory-group-economic-recovery/documents/

ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions" (Natural Capital Committee 2014[8]). 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 (Figure 1).

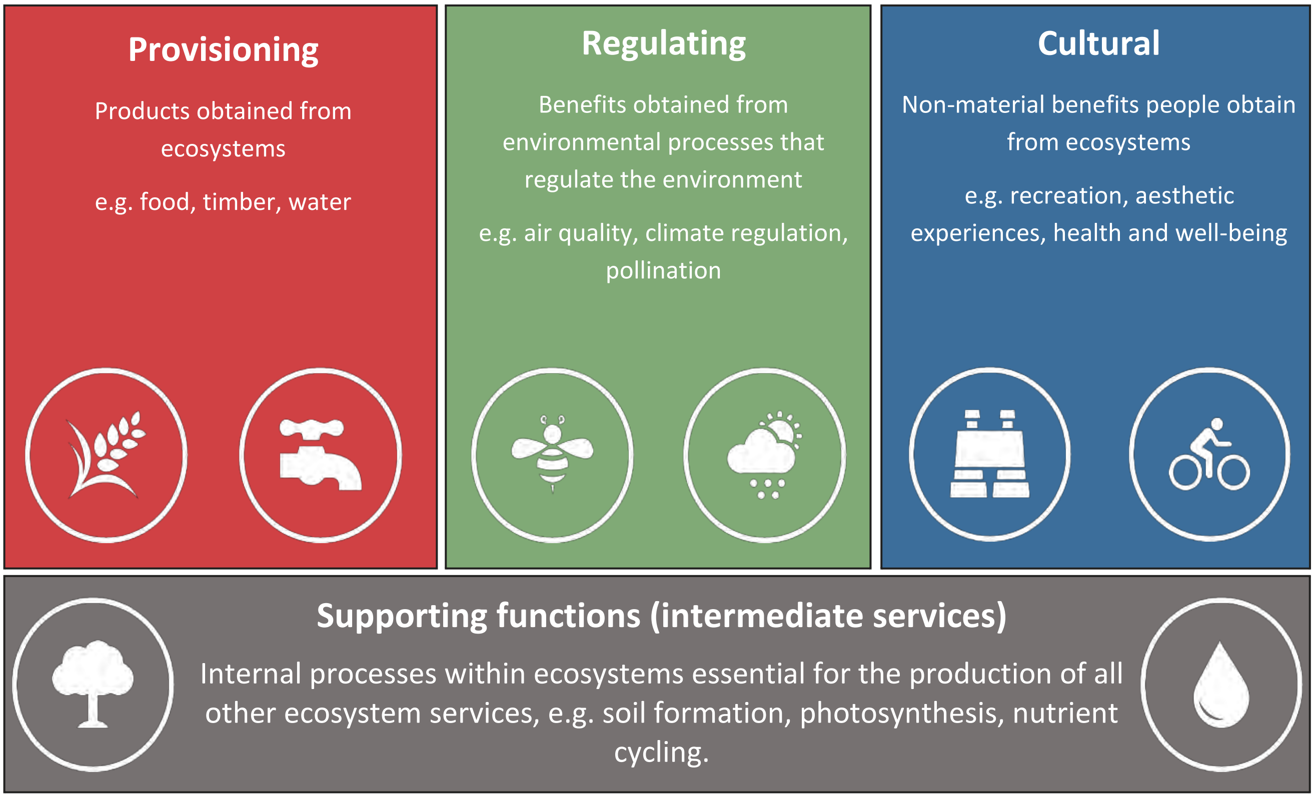


Figure 1 Key types of ecosystem services (based on MA 2005[9]). Note that supporting or intermediate services are now categorised as ecological functions (CICES[10]). They are the underpinning structures and processes that give rise to ecosystem services.

The natural environment is being increasingly regarded as 'multi-functional', delivering a range of environmental, social and economic benefits to society. Green spaces can sequester carbon, reduce downstream flood risk and water quality problems, as well as providing quality space for recreation and biodiversity gain, demonstrating how multi-functional benefits can be delivered. Changing habitats within existing greenspaces can further enhance the benefits delivered and reduce environmental inequalities.

Work is progressing on how to deliver the natural capital and ecosystem services approach on the ground, and how to use it to inform and influence management and decision-making. One of the most important steps is to recognise and quantify ecosystem service delivery (the physical flow of services derived from natural capital). It is also possible to examine how this will change following

[8] Natural Capital Committee (2014) The state of natural capital: Restoring our natural assets. Second report to the Economic Affairs Committee. Natural Capital Committee, March 2014.

[9] Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Synthesis. Island Press, Washington D.C. https://www.millenniumassessment.org/en/index.html

[10] Haines-Young, R. & Potschin, M. (2018) Common International Classification of Ecosystem Services (CICES) V5.1. Guidance on the application of the revised structure. Fabis Consulting.

development, and hence determine its potential impact and likelihood of net gains being achieved. Additional insight can be gained by taking a spatial perspective on the variation in ecosystem service supply across a study area using a Geographic Information System (GIS). Maps are able to highlight hotspots and coldspots of ecosystem service delivery, highlight important spatial patterns that provide much additional detail, and are inherently more user friendly than non-spatial approaches.

1.2 Report structure and scope

A key first step in any natural capital project is to understand the natural capital assets present across the study area. The baseline natural capital assets of West Lothian, and the assets that are associated with WLC landholdings, are presented in Section 2. Section 3 considers the baseline biodiversity value of West Lothian and WLC landholdings. These sections have been supported by on site survey by WSP who recorded UK Hab classification and habitat condition of approximately 10% of WLC landholdings and priority habitats (Scottish Biodiversity List[11]) outside of WLC ownership. More detail of the on site methodologies and results can be found in the WSP Biodiversity Baseline Report (2023)[12].

The presentation of natural capital assets is followed by the assessment of ten different ecosystem services and one stock for the whole of West Lothian and for WLC landholdings (Section 4). Brief conclusions and recommendations are described in Section 5. A HTML version of this report has also been produced.

[11] Nature Scot 2020 Scottish Biodiversity List https://www.nature.scot/doc/scottish-biodiversity-list
[12] WSP 2023 West Lothian Council Biodiversity Baseline Report

2. West Lothian baseline natural capital assets

2.1 Approach to mapping habitats

The first step of the project was to produce a detailed map of the current habitats present across the area. This is an important component of any assessment of natural capital assets and is required before an assessment of the current benefits being delivered by the natural capital can be determined. To do this we used Ordnance Survey MasterMap polygons as the underlying mapping unit and a series of different data sets to classify each polygon to a detailed habitat type. We also added a range of additional data to the polygons across the area. The data used is outlined in Box 1.

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

- Ordnance Survey MasterMap (OSMM)
- National Woodland Survey
- National Forestry Inventory (which includes the National Woodland Survey of Scotland dataset)
- Habitat Map of Scotland
- Scotland Land Cover Map
- OS Open Greenspaces
- CORINE Land Cover
- Digital terrain model

Polygons were classified into Phase 1 habitat types and were also classified into broader habitat groups and UK Habitat classification following the methodologies outlined in WSP (2023). The final basemap covered the whole of West Lothian, and covers an area of 43,170 ha or 431.7 km^2. It contained 425,000 polygons, each of which was classified to an appropriate habitat type.

WLC then provided detail of their landholdings which allowed the habitats contained within these sites to be considered for ground truthing by WSP. WLC landholdings cover an area of 4,125ha or 41.25km^2 and contains 139,000 polygons. WSP ground truthed approximately 10% of habitats within WLC ownership and additional areas of identified priority habitats across the West Lothian region, including all fen and swamp, dwarf shrub and heath and some areas of acid grassland outside of WLC ownership. The basemap was then updated following survey results from WSP.

Note that the basemap provides the best approximation of habitat types that can be achieved based on available data, but has not been fully ground-truthed and will inevitably contain errors. However, there are high levels of confidence in the classification of some habitat types including all urban and agriculture across the region, as well as areas identified as woodland. Specific woodland and grassland types are harder to identify, although confidence can be provided in the broad habitat classifications and we have cross-referenced against multiple data sources to increase confidence in the classification. Issues can arise where there is disagreement between different data sources, but this is a relatively small amount of the study area and we checked these areas through field work where possible.

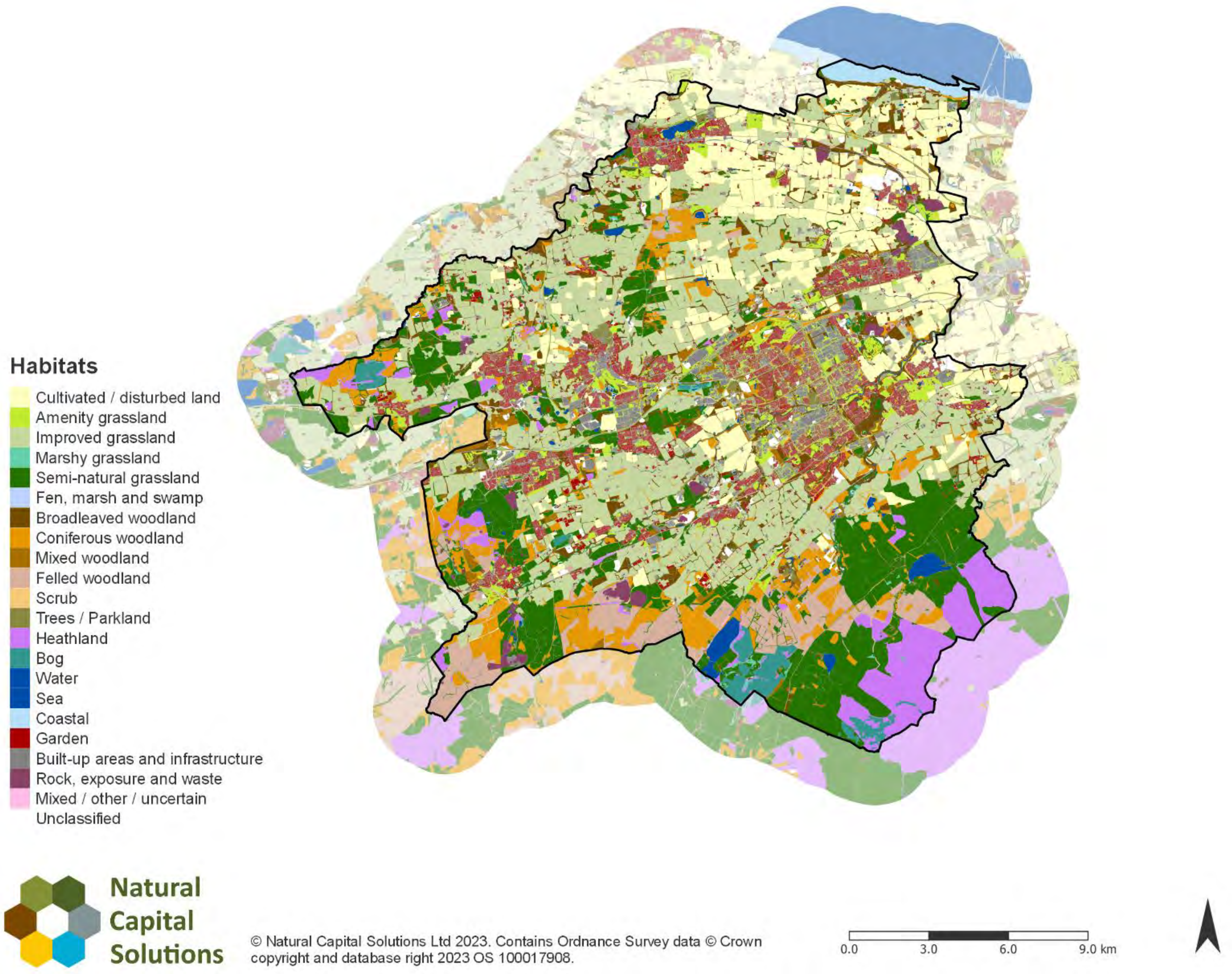
2.2 Asset register for West Lothian

Map 1a shows the distribution of broad habitat types across West Lothian and Map 1b shows the distribution across WLC landholdings, with the area and percentage cover shown in Table 1. The most common habitat across West Lothian is improved grassland, primarily associated with agriculture, which comprises 25% (10,650 ha) of the region, with arable agricultural land identified to comprise a further 12% (5,000ha). Semi-natural grassland is also frequent, comprising over 15% (6,600 ha) of the area. Built-up areas and infrastructure take up 8.6% of the area (3,700 ha), with associated areas of amenity grassland comprising 5.2% (2,200 ha), and private gardens 4.3% (1,900 ha). Both coniferous and broadleaved woodland comprise approximately 7% each (just under 3,000 ha each). The remaining 17% of the region comprises a range of semi-natural habitats, including 4.3% felled woodland (1,900 ha) and 1.3% bog (540 ha).

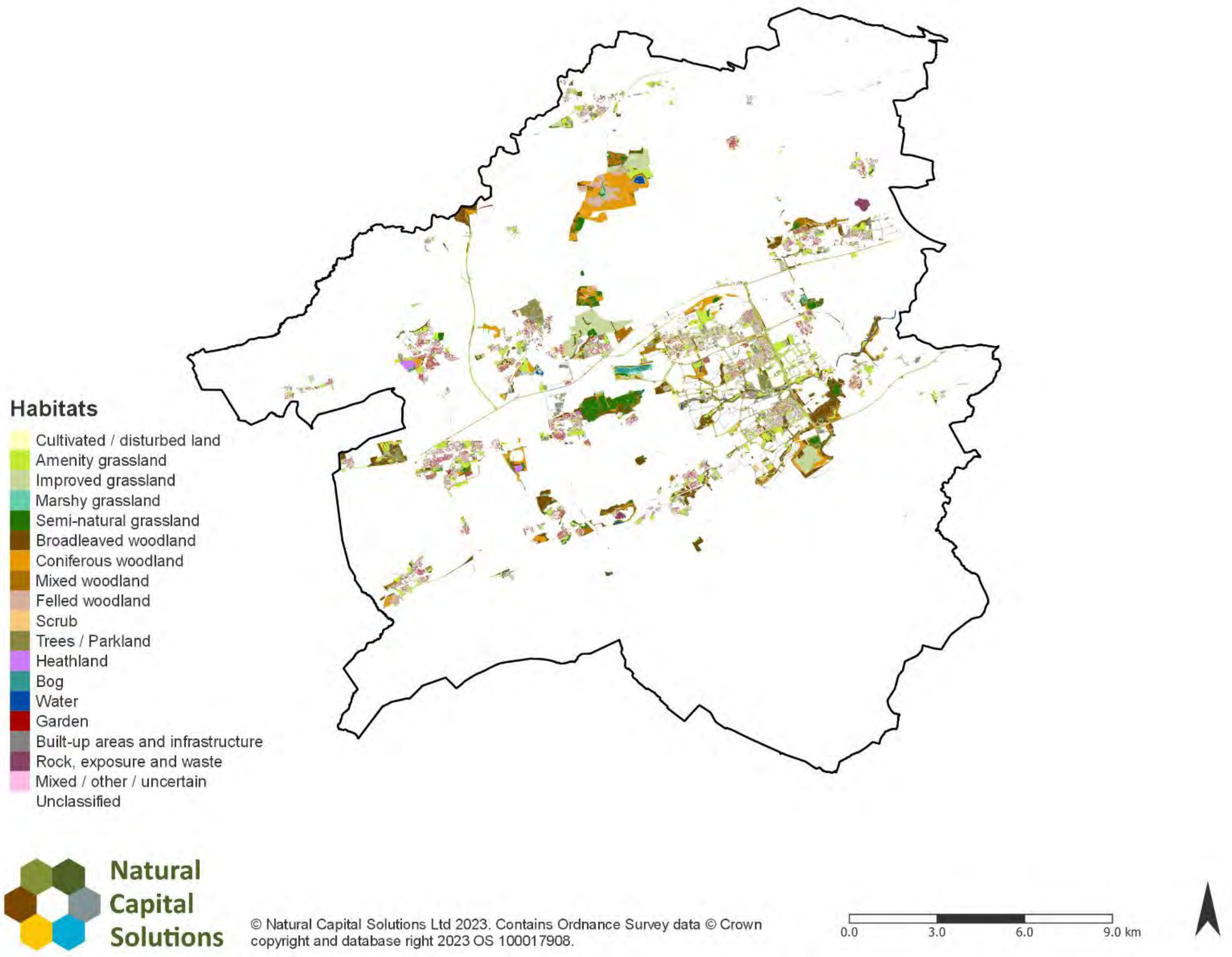
Woodland and tree habitats are the most common across WLC landholdings (Map 2), comprising 33% in total, including 16% (660 ha) of broadleaved woodland and 8.7% (360 ha) of coniferous woodland. Mixed woodland also makes up a significant portion of the landholdings at 6.1% (approximately 260 ha), followed by parkland/scattered trees and recently felled woodland both at around 2% (90 ha and 70 ha respectively). Amenity grassland is also a common habitat type across WLC landholdings, comprising 21% (870 ha). Built up areas and infrastructure together make up 19% (800 ha), with council residential gardens comprising 5.4% (220 ha). The remaining areas comprise semi-natural habitats such as water, scrub and grassland . Bog habitats have been identified to comprise 0.5% (19 ha). Whilst there are a number of additional sites described as 'bog' in records, their deterioration through drainage, burning, grazing, scrub encroachment and other modification means that the current habitat is more accurately reflected through classification as heathland or grassland habitats on peat soils.

Table 1. Baseline habitats at West Lothian.

	West Lothian Region		WLC Landholdings	
Habitat	**Area ha**	**Area %**	**Area ha**	**Area %**
Woodland, broadleaved	2,849.6	6.6	663.6	16.1
Woodland, coniferous	2,969.7	6.9	358.0	8.7
Woodland, Mixed	897.2	2.1	252.6	6.1
Scrub	163.1	0.4	32.8	0.8
Parkland/scattered trees	317.1	0.7	90.1	2.2
Recently felled woodland	1,856.9	4.3	72.1	1.7
Grassland, acid	1.6	0.0	0.3	0.0
Grassland, neutral	13.2	0.0	1.3	0.0
Grassland, improved	10,647.2	24.7	330.4	8.0
Grassland, marshy	111.2	0.3	22.3	0.5
Grassland, semi-natural	6,634.7	15.4	260.0	6.3
Heath	175.6	0.4	15.9	0.4
Mosaic; acid grassland, heath	1,760.7	4.1	5.5	0.1
Bog	542.6	1.3	18.8	0.5
Fen	2.6	0.0	0.0	0.0
Swamp	3.3	0.0	2.3	0.1
Water	602.5	1.4	50.3	1.2
Intertidal	280.5	0.6	0.0	0.0
Natural rock	3.0	0.0	0.1	0.0
Artificial rock, exposure and waste	368.5	0.9	21.1	0.5
Arable	4,985.8	11.5	19.2	0.5
Amenity grassland	2,225.5	5.2	870.3	21.1
Built up area	1,951.6	4.5	282.8	6.9
Infrastructure	1,770.8	4.1	515.5	12.5
Gardens	1,865.4	4.3	223.8	5.4
Other	5.8	0.0	0.9	0.0
Unclassified (under development)	164.3	0.4	15.4	0.4
Total	**43,170.0**	**100.0**	**4,125.4**	**100.0**



Map 1a: Baseline habitats at West Lothian Region.



Map 1b: Baseline habitats at West Lothian Council (WLC) landholdings.

3. Biodiversity baseline

Here we are setting a biodiversity baseline for West Lothian. The Biodiversity Metric 3.1, a relatively simple metric developed by Natural England (2022)[13], has been used to calculate 'biodiversity units' for West Lothian by WSP. Whilst the Scottish government are in the process of developing their own metric, the Natural England version has been used in lieu of its availability.

The biodiversity units score is based on the area of the habitat, its distinctiveness, condition and strategic significance. Habitats that have a high distinctiveness, are in good condition and cover a greater area will achieve a higher biodiversity unit score, than smaller areas, with less strategic significance, lower distinctiveness and condition scores. This metric is already starting to be used in the development sector in England to test whether Biodiversity Net Gain (BNG) will be achieved post-development. This is in line with requirements of the Environment Act[14] (England only) which mandates the requirement for a minimum of 10% BNG to be delivered by development. Using the metric at a landscape scale is useful (i) to predict how changes in habitats or in habitat management will impact biodiversity, and (ii) to work out which parcels of land could be managed as biodiversity off-sets by the council, if this was desirable.

The first step was to assign the distinctiveness scores to each mapped polygon within the study area. These are set scores in the Biodiversity Metric 3.1 that are assigned based on the habitat type. The second was to assign a habitat condition to each of the habitat polygons according to the Biodiversity Metric 3.1. This assigns categories from 'good' to 'poor' and also includes two N/A categories for agriculture and other (non-natural) habitats (Table 2). When used in the metric, these categories are also given a score from 0-3 (Table 2). Based on descriptions in the Biodiversity Metric 3.1, it is possible to assign condition categories to a number of low quality land covers without the need for any further information. This includes all built habitats such as buildings and infrastructure (N/A – other) and arable (N/A – Agriculture). This could only be applied to a small portion of the region associated with arable fields (<12%). Designated sites, such as SSSI's (Site of Special Scientific Important) and SAC (Special Areas of Conservation) are subject to regular condition assessments which are made publicly available. These were integrated into the study area where available.

Table 2 Biodiversity Metric 3.1 condition categories and associated scores.

Category	Multiplier
Good	3
Fairly Good	2.5
Moderate	2
Fairly Poor	1.5
Poor	1
N/A – Agriculture	1
N/A - Other	0

WSP undertook habitat condition assessments on site, using the metric guidance, for 10% of areas within WLC landholdings. There was not sufficient evidence provided by surveys to draw assumptions on habitat condition across the whole of West Lothian, as only a small subsample of the wider area

[13] Natural England. (2021) The Biodiversity Metric 3.0 auditing and accounting for biodiversity. Calculation Tool
[14] Environment Act (2021) Available at https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted

was visited and assessed. Therefore, the following approach to condition was taken for those polygons not subject to survey:

- For low distinctiveness habitats, e.g. modified grassland, these have been assigned poor condition due to the lack of species diversity and likelihood of improvement activities being present (e.g. fertiliser application).
- For areas of woodland the Native Woodland Survey of Scotland (NWSS)[15] is a recent survey which undertook condition assessment of woodland across Scotland and has been applied to woodland polygons where no survey was undertaken.
- For the remaining habitats, moderate condition has been assigned, accepting that in some locations habitats will be in high condition and in some areas low condition, assigning moderate provides an average.

Map 2 shows the majority of the study area scores poor for condition, primarily due to the dominance of arable land which is automatically classified by the metric as 'N/A – Agriculture' (Table 2) and modified grassland which is assigned poor condition (1) based on the assumptions above. This study has not however, been able to identify features such as arable field margins, considered a high value habitat, due to the level of detail possible in mapping the region.

The final multiplier of the metric is strategic significance. This is a measure of how important the location is in relation to locations which have been identified as important for biodiversity within local biodiversity policy or strategy. The following criteria was applied:

- High strategic significance (1.15): all habitats within statutory designated sites, Local Biodiversity Sites, Scottish Wildlife Trust reserves, B-Lines.
- Medium strategic significance (1.1): all habitats within 500m of the sites above.
- Low strategic significance (1): all other habitats excluded from the above.

Map 3 shows the network that forms through applying the medium and high strategic significance categories.

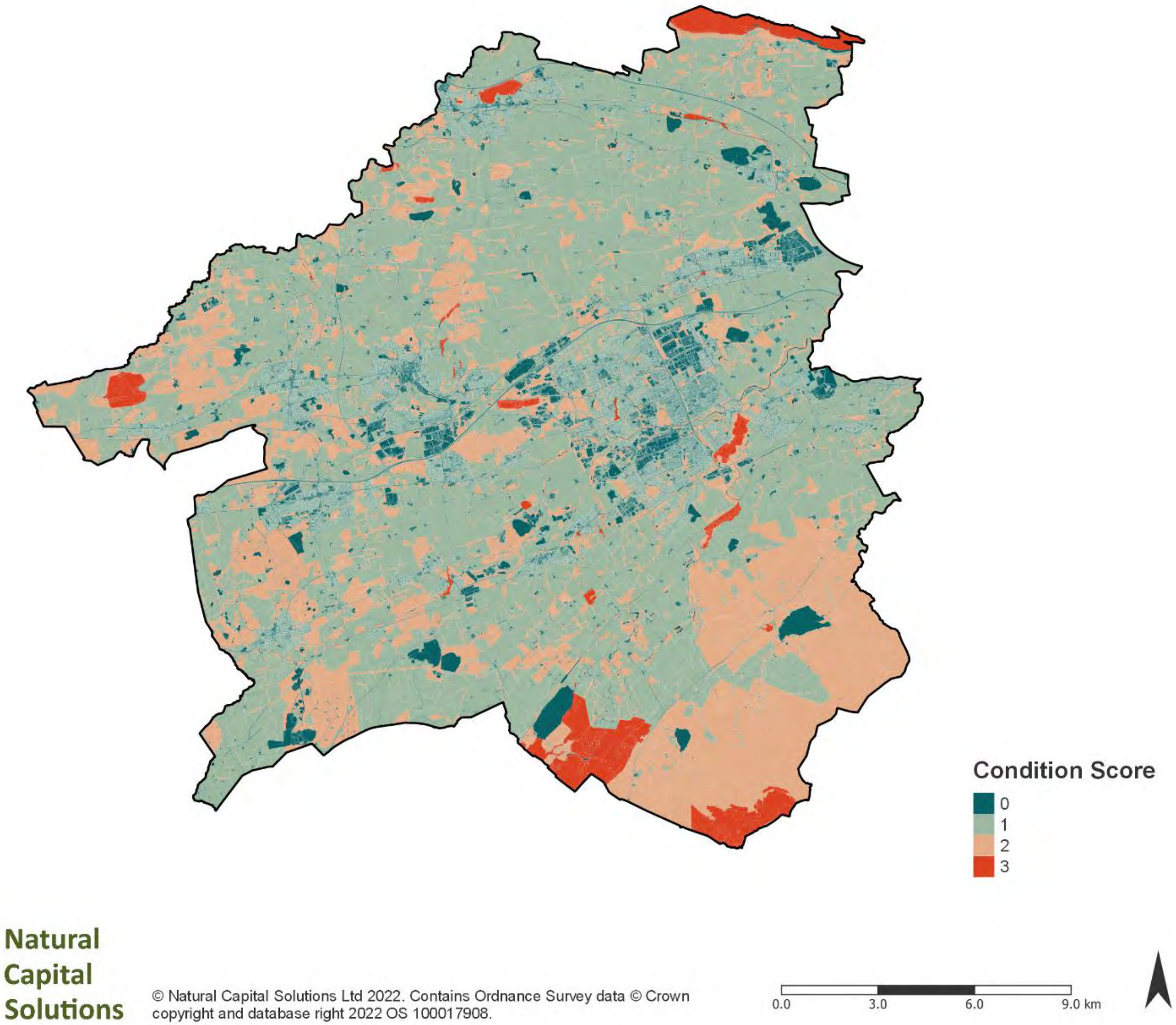
Further detail on how condition and strategic significance was applied can be found within the WSP Biodiversity Baseline report (2023).

These multipliers are used in the metric to produce the pattern of biodiversity unit scores that are shown in Map 4 below. Scores are generally low across the region, with the highest scoring polygons shown in red.

This biodiversity baseline assessment using the metric gives an overall value for habitats assessed as 178,464 BU for the West Lothian region (note that some habitats shown on Map 2 and 3 below, comprising 2.42% of the West Lothian region, are excluded from metric calculations, see WSP report[16] for more detail). WLC landholdings were estimated to contribute 16,558 of these units.

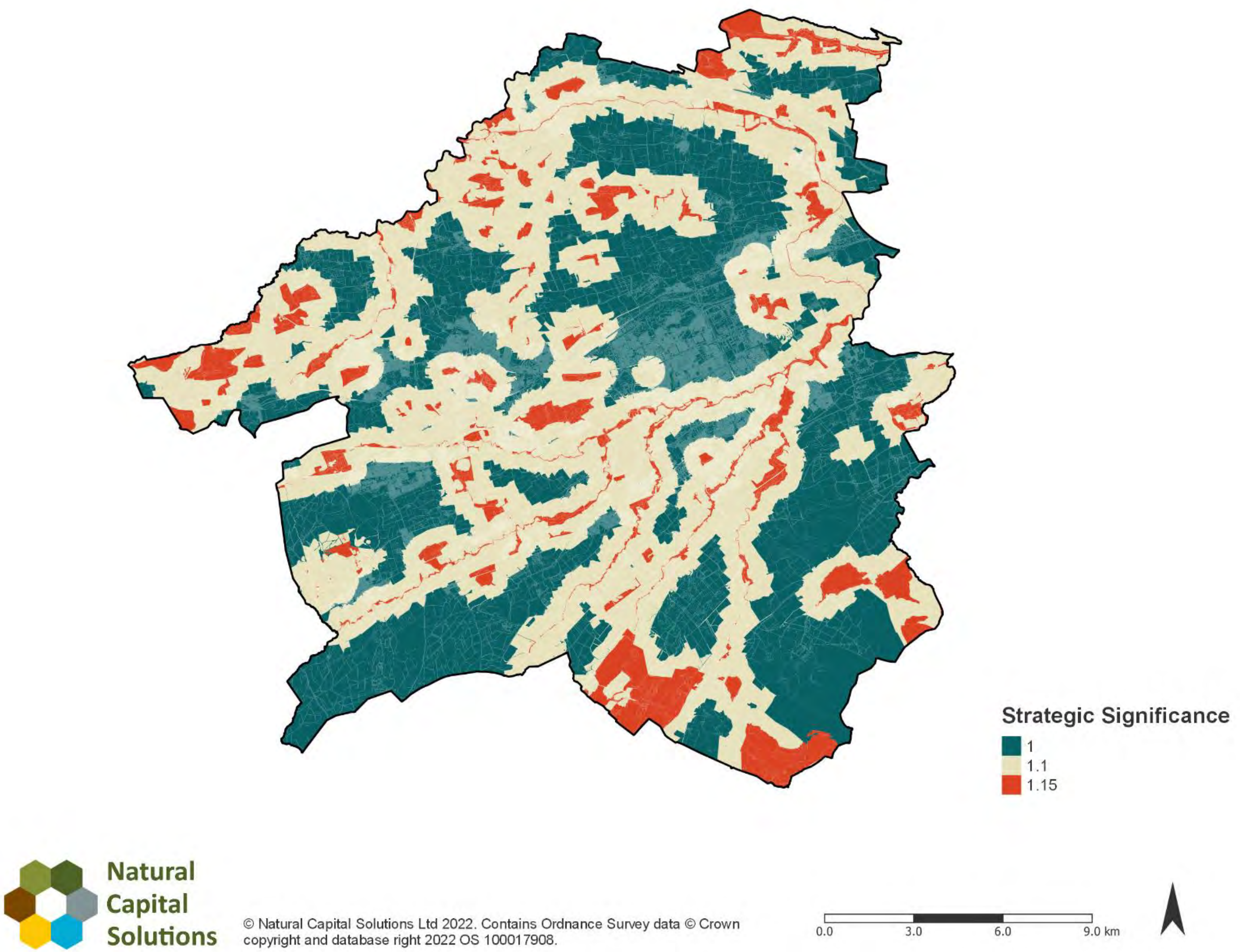
The biodiversity baseline score in and of itself is not particularly informative. The power of this score lies in its comparison with past or future scenarios. This baseline, therefore, can be utilised to test scenarios once viable habitat changes and interventions across West Lothian have been discussed. Biodiversity units may also be re-calculated in the future to track changes in habitat and landscape level biodiversity; or after a development project in the region, it will indicate whether management changes have increased (a net gain) or decreased biodiversity. A way of increasing the biodiversity score is to focus on increasing the condition of the habitats that are in poor or moderate condition.

[15] Native Woodland Survey of Scotland (2022) Scottish Forestry Open Data available at: https://experience.arcgis.com/experience/aa6b4ff901294dea84dcff3205d48fab
[16] WSP 2023 West Lothian Council Biodiversity Baseline Report

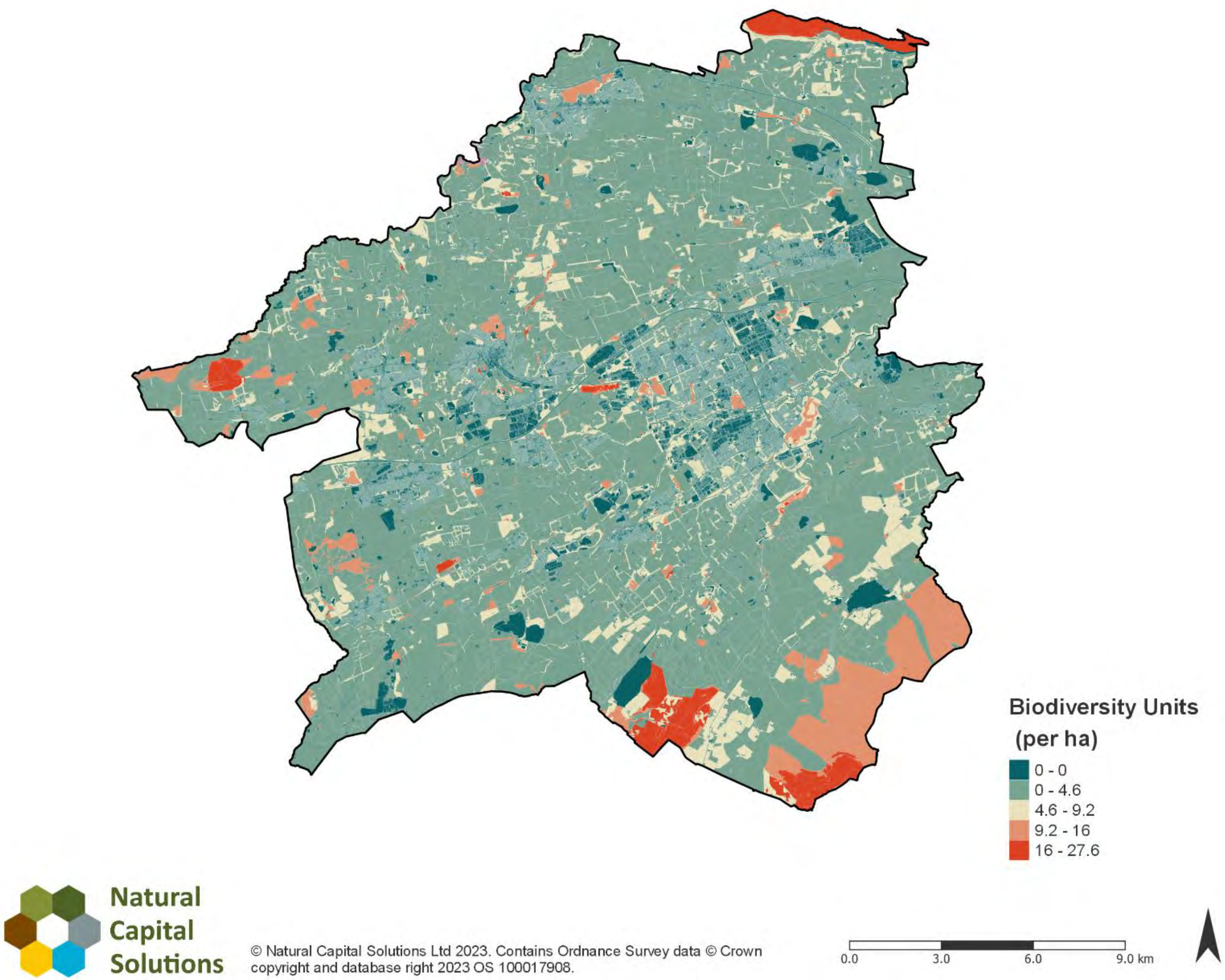


Natural Capital Solutions

Map 2. Habitat condition across West Lothian.



Map 3. Strategic significance across West Lothian.



Map 4. Biodiversity units across West Lothian.

4. Ecosystem service provision

Once a detailed habitat basemap had been created for West Lothian, it was then possible to quantify and map the benefits that these habitats (natural capital assets) 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
- Pollination capacity
- Water flow regulation
- Water quality regulation
- Food production
- Timber production
- Accessible nature

The list of services assessed was considered to capture the most important benefits provided by the natural capital assets of West Lothian in its baseline condition.

A variety of methods were used, and these are described for each individual ecosystem service in the sections below. The models are based on the detailed habitat information determined in the natural capital basemap, together with a variety of other external data sets (e.g. digital terrain model, and many other data sets and models mentioned in the methods for each ecosystem service). The models were applied at a 5m resolution to provide fine-scale mapping across the area. Note, however, that several of the models are indicative (showing that certain areas have higher capacity than other areas) and are mapped relative to the values present within the wider West Lothian study area. Most ecosystem services were scaled to be out of a maximum possible of 100, except for water flow which was calculated in m^3/ha, water quality which was calculated in t/ha (sediment yield) and kg/ha (Nitrogen and Phosphorus sediment), carbon storage which was measured in tC/ha, and carbon sequestration which shows tCO_2e/ha/yr.

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, local climate regulation and accessible nature 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 provides useful additional insight. Mapping demand is not possible for some services as either there is no obvious method to apply (water flow and quality regulation), or local demand is not relevant (food and timber production). Food and timber, for example, is not more valuable when grown close to people's houses, whereas trees that ameliorate air pollution or block noise are.

4.1 Carbon storage capacity

What is it and why is it important?

Carbon storage and sequestration are seen as increasingly important as we move towards a low-carbon future. Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation and is the stock of carbon in the natural environment, whereas carbon sequestration (Section 4.2) indicates the annual physical flow of carbon captured by growing plants or emitted by agricultural activities, and measures its annual flow. 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 significant changes in carbon storage, as can the restoration of degraded habitats.

How is it measured?

This model estimates the amount of carbon stored in each habitat type. It applies average values (tC/ha) for each habitat type taken from Natural England (2019) [17]. A multiplier [18] is then applied to habitat carbon storage values depending on which soil type the habitat occurs on. 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 every 5m by 5m cell across the study area. Scores are measured in tonnes of carbon per ha.

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

Results for West Lothian

Map 5 (right panel) shows the baseline carbon storage values across West Lothian. The highest values (>800 tC/ha, red on Map 5) are found in areas of blanket bog to the south of the region, associated with Craigengar SSSI and SAC, and Cobbinshaw Moss SSSI; and to the north west, associated with Blawhorn Moss SSSI and SAC. Areas of raised bog also score highly, such as Tailend Moss SSSI close to Livingston. There is an additional area of raised bog identified to the south of Longridge which also shows high values of carbon storage.

Areas of coniferous woodland and semi-natural habitats including heathland and grasslands on deep peat soils also show high capacity for carbon storage (in pink 400-520tC/ha) and are found in large areas to the south west and west of the region. Coniferous woodland on shallow peat shows the next highest capacity at 390tC/ha, followed by recently felled woodland on deep peat soils and semi-natural habitats (including woodland, grassland and heathland) on shallow peat (275-375tC/ha), again found largely to the south of the region. Woodland on mineral soil has the next highest capacity (in cream, 200-260 tC/ha) with Beecraigs County Park and areas of Almondell Country Park scoring the highest of all WLC landholdings (Map 5b). Improved grassland on shallow peat soils and habitats including scrub and felled woodland on mineral soils have capacity of 150-200tC/ha. The majority of the region has relatively low values of between 100-120tC/ha, including most habitats such as residential gardens where they lie on mineral soils. Arable land has low capacity at under 100tC/ha but carbon storage is lowest in built surfaces (buildings, roads), which have no capacity, as well as bodies of water (dark blue).

West Lothian mean = 152.8 tC/ha **WLC mean = 130.0 tC/ha**

[17] Sunderland T, Waters RD, Marsh DVK, Hudson C, Lusardi J. (2019) Accounting for National Nature Reserves: A natural capital account of the National Nature Reserves managed by Natural England. Natural England Research Report, No. 078.
[18] Lagas and Sweep (2020) Ecosystem service – carbon storage and sequestration.

4.2 Carbon sequestration capacity

What is it and why is it important?

As described above, carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation, whereas carbon sequestration capacity indicates the annual physical flow of carbon captured by growing plants or emitted by agricultural activities (e.g. machinery use, fertiliser application, enteric fermentation from livestock), based on national estimates. Sequestration rates also depend on the soil type on which the habitat lies. Many habitats on peat soils emit greenhouse gases for numerous different reasons. There is very little consistent information about sequestration across all habitats (apart from woodlands on mineral soils), but what we do have shows that sequestration rates can be relatively low.

How is it measured?

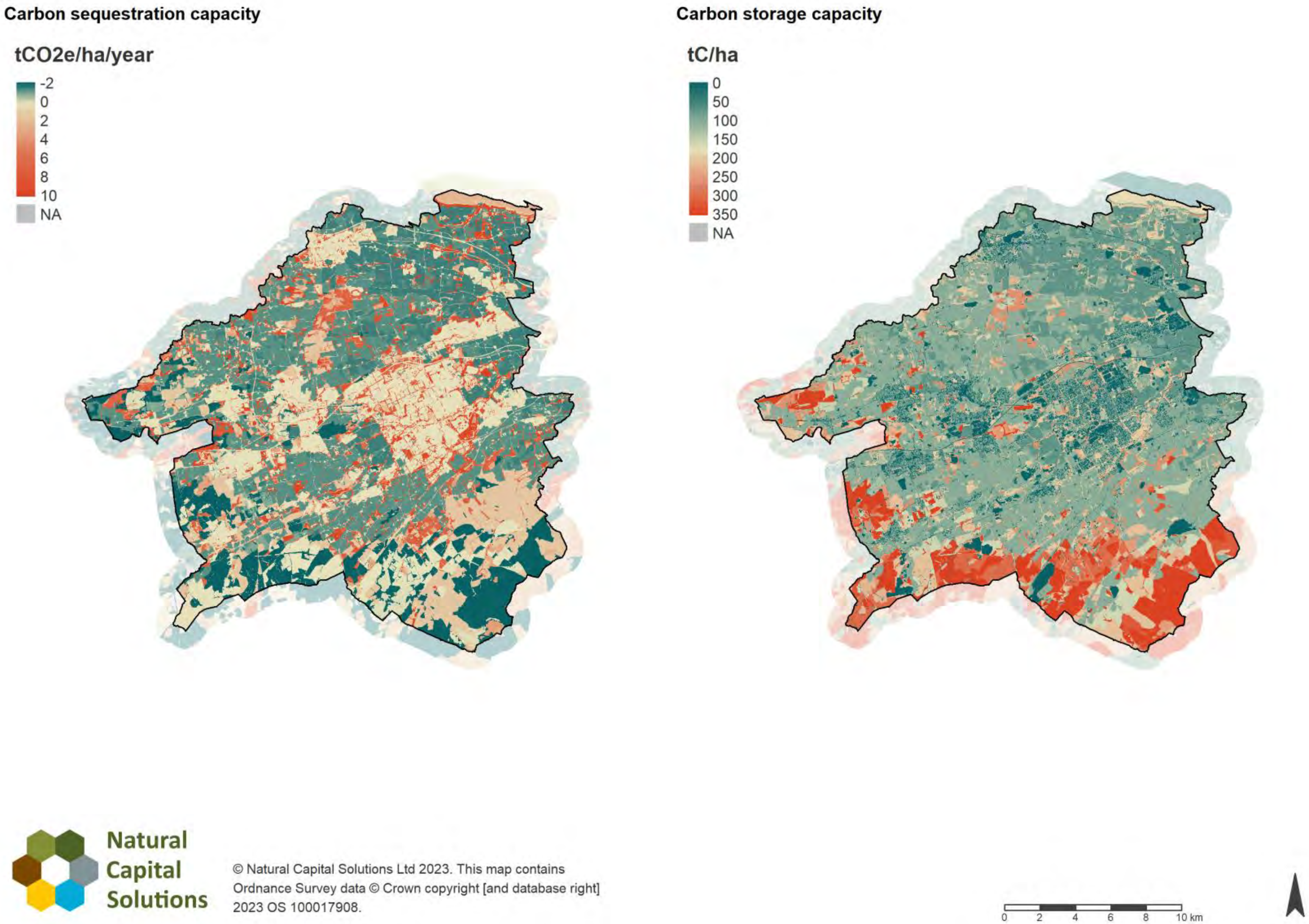
This model estimates the amount of carbon sequestered by each habitat type. It applies average values (tCO_2e/ha/year) for each habitat type taken from Natural England (2019) [19] and the RSPB's Accounting for Nature report [20] with more detailed data on GHG flux from land covers on deep and shallow peat soils and from degraded peat bogs from Evans et al. (2017)[21]. It is calculated for every 5m by 5m cell across the study area and takes soil type into account. Unlike most of the other services which are on a 0-100 scale, amounts are in tonnes CO_2e/ha/yr.

Results for West Lothian

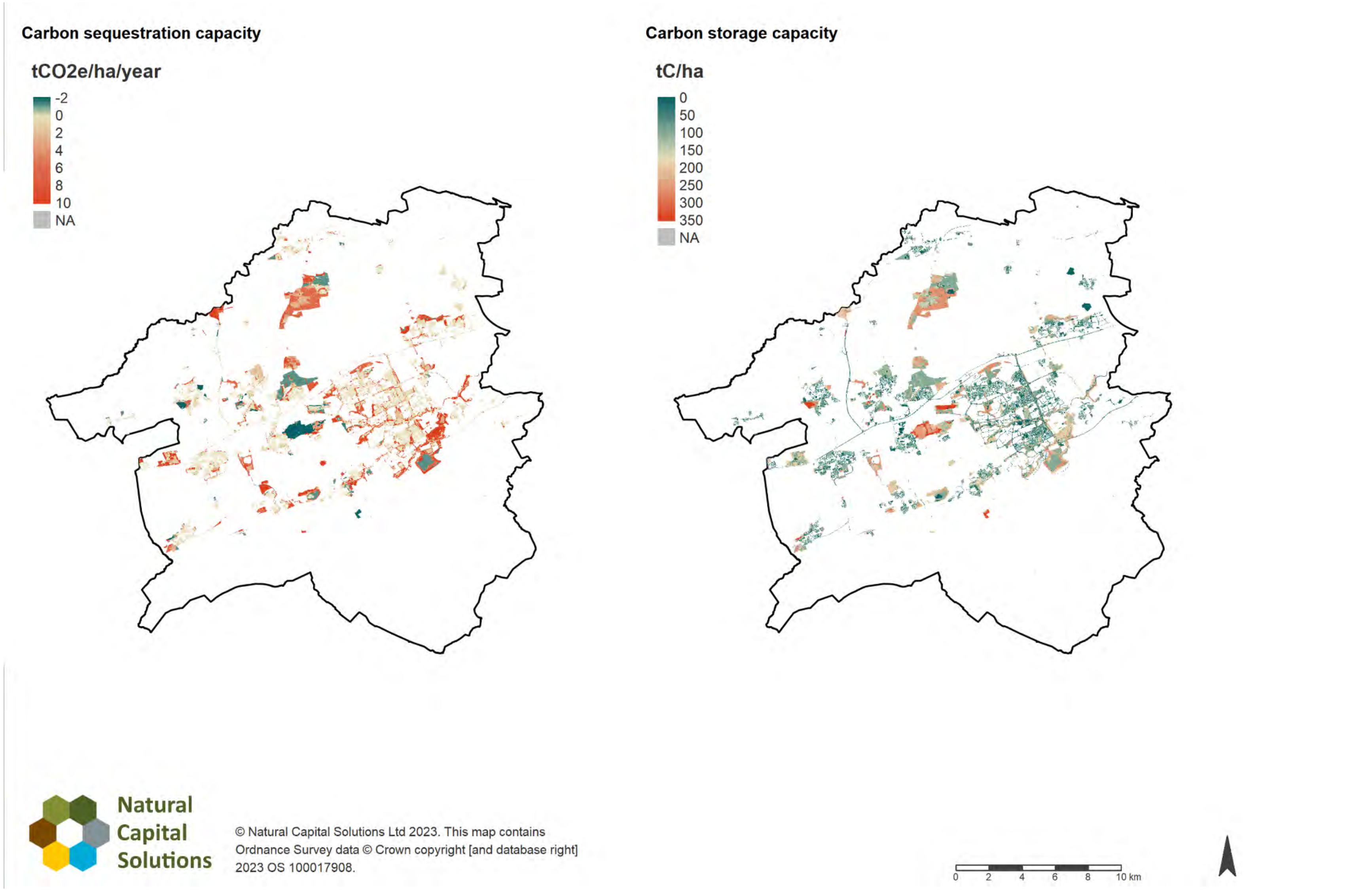
The baseline carbon sequestration map (Map 5, left panel) shows that the greatest areas of carbon sequestration (in dark red, typically 9 tCO_2e/ha/year) are broadleaved woodland habitats on mineral soil found spread across the county, with areas in WLC landholdings such as Beecraigs Country Park and Almondell and Calderwood Country Park demonstrating high capacity (Map 5b). Other woodland, including coniferous woodland and scrub, has a slightly lower capacity (typically 5-6 tCO_2e/ha/yr). Grassland and other semi-natural habitats on mineral soil have relatively low carbon sequestration capacity (shown in light red to cream, 1.8-4 tCO_2e/ha/year) with residential gardens on mineral soils lower still at around 1.6 tCO_2e/ha/yr. Bogs on deep peat soils (associated with designated sites such as Cobbinshaw Moss SSSI, Craigengar SSSI, SAC and Lawhorn Moss SSSI, SAC) are almost carbon neutral (emitting at -0.01 tCO_2e/ha/yr); whereas agricultural land (including improved grassland) on both shallow peat and mineral soil emitting larger volumes of carbon due to emissions associated with agricultural practices, this covers the bulk of the map (in orange, -1.5 tCO_2e/ha/year). Coniferous woodland on shallow peat soils and semi-natural habitats on deep peat soils, demonstrate larger emissions of carbon between -2-2.5 tCO_2e/ha/yr, with coniferous woodland on deep peat emitting larger volumes at -9.9 tCO_2e/ha/yr. However, agricultural land (improved grassland and arable land) on deep peat are by far the largest emitters at between -18 and -39 tCO_2e/ha/yr. These figures indicate that West Lothian as a whole is emitting slightly more carbon than is sequesters, whereas WLC landholdings are sequestering more than it is emitting. A full breakdown of the carbon sequestration values for each habitat type across West Lothian and WLC landholdings can be found in Appendix 1.

West Lothian mean = -0.33 tCO_2e/ha/yr **WLC mean = 2.37 tCO_2e/ha/yr**

[19] Sunderland T, Waters RD, Marsh DVK, Hudson C, Lusardi J. (2019) Accounting for National Nature Reserves: A natural capital account of the National Nature Reserves managed by Natural England. Natural England Research Report, No. 078.
[20] The RSPB. (2017) Accounting for Nature: A Natural Capital Account of the RSPB's area in England. Annex 7.
[21] Evans, C., Artz, R., Moxley, J., Smyth, M-A., Taylor, E., Archer, N., Burden, A., Williamson, J., Donnelly, D., Thomson, A., Buys, G., Malcolm, H., Wilson, D., Renou-Wilson, F. (2017). Implementation of an emission inventory for UK peatlands. Report to the Department for Business, Energy and Industrial Strategy, Centre for Ecology and Hydrology, Bangor.88pp.



Map 5a: Carbon sequestration capacity for West Lothian (left) shown in tCO_2e/ha/yr and carbon storage for West Lothian (right) shown in tC/ha.



Map 5b. Carbon sequestration capacity for WLC landholdings (left) shown in tCO_2e/ha/yr and carbon storage for WLC landholdings (right) shown in tC/ha.

4.3 Air purification capacity

What is it and why is it important?

According to the Public Health England, air pollution is the biggest environmental threat to health in the UK, with between 28,000 and 36,000 deaths a year attributed to long-term exposure, with the greatest threats from particulate matter ($PM_{2.5}$) and nitrous oxides (NO_x). Even small changes in $PM_{2.5}$ concentrations can have a significant impact on disease outcomes, with modelling showing that just a $1\mu g/m^3$ reduction in $PM_{2.5}$ concentrations could prevent 50,000 new cases of coronary heart disease and 9,000 new cases of asthma by 2035[22]. Air pollution also contributes to climate change, reduces crop yields, and damages habitats and 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[23], although this varies depending on the species of plant[24]. 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?

Air purification capacity was mapped using an EcoServ R model. 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 every 5m-by-5m 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.

The final capacity score was calculated for every 5m-by-5m 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 West Lothian

Woodland is by far the best habitat at intercepting and adsorbing air pollution, with the very highest scores from the coniferous woodland within West Lothian (red areas; Map 6, left panel). Broadleaved, coniferous and mixed woodland provide a high level of this service in blocks throughout the county, with Beecraigs Country Park providing some of the highest levels of WLC landholdings (Map 6b), although the best performing areas are somewhat concentrated along the south western boundary of West Lothian. Scrub and trees/parkland provide a medium level of air purification capacity (shown in cream). Semi-natural grassland and bog habitats have a low capacity (shown in light blue). Much of the map is covered by agricultural land which has very little capacity. The lowest scores are from man-made sealed surfaces and areas of water, which have no ability to ameliorate air pollution (dark blue).

West Lothian score = 22.1 **WLC score = 30.8**

[22] Public Health England (2018) Estimation of costs to the NHS and social care due to the health impacts of air pollution. Crown Copyright.

[23] Powe, N., A., & Willis, K.G. (2004) Mortality and morbidity benefits of air pollution (SO_2 and PM_{10}) absorption attributable to woodland in Britain. *Journal of Environmental Management,* 70, 119-128

[24] O'Sullivan, O.S., Holt, A.R., Warren, P.H. & Evans, K.L. (2017) Optimising UK urban road verge contributions to biodiversity and ecosystem services with cost-effective management. *Journal of Environmental Management*, 191, 162-171.

4.4 Air purification demand

What is it and why is it important?

Air purification demand estimates the 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 model from EcoServ R. The model combines two indicators of air pollution sources (log distance to roads and % cover of sealed surfaces) and two indicators of the 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.

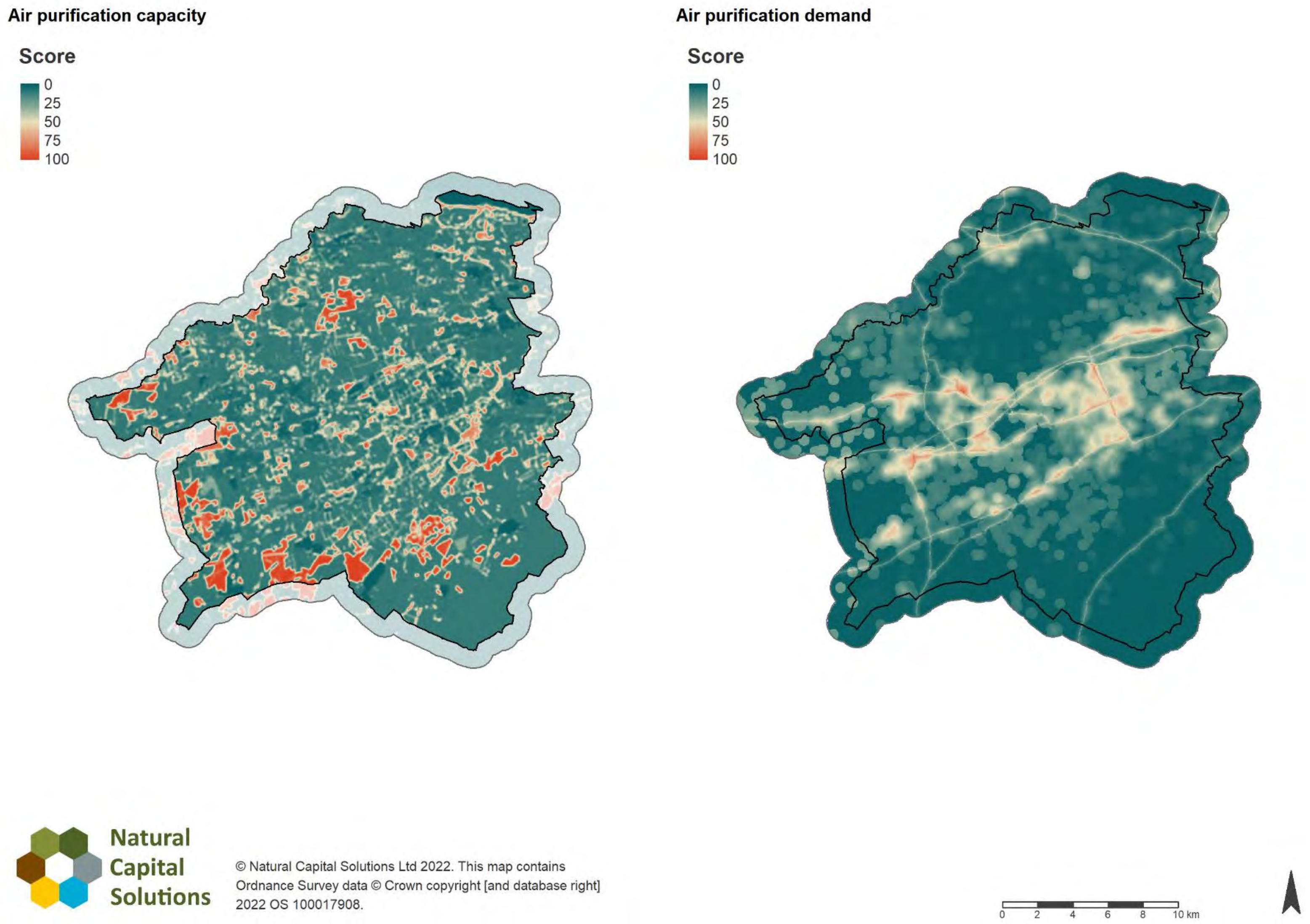
Results for West Lothian

Air purification demand is highest in urban centres (Map 6, right panel) which in West Lothian shows as towns such as Livingston, Whitburn and Bathgate, as these have both higher air pollution levels and higher populations that would benefit from better air quality. The main road networks are a major pollution source and where these main roads pass through built-up areas, there is increased demand for air purification. There is high demand on the M8, the A89 and the A71 as intersections and as they pass through the centres of villages including, Polbeth and Armadale. Moderate demand is also shown along the M9, the A70 and in smaller settlements such as Fauldhouse.

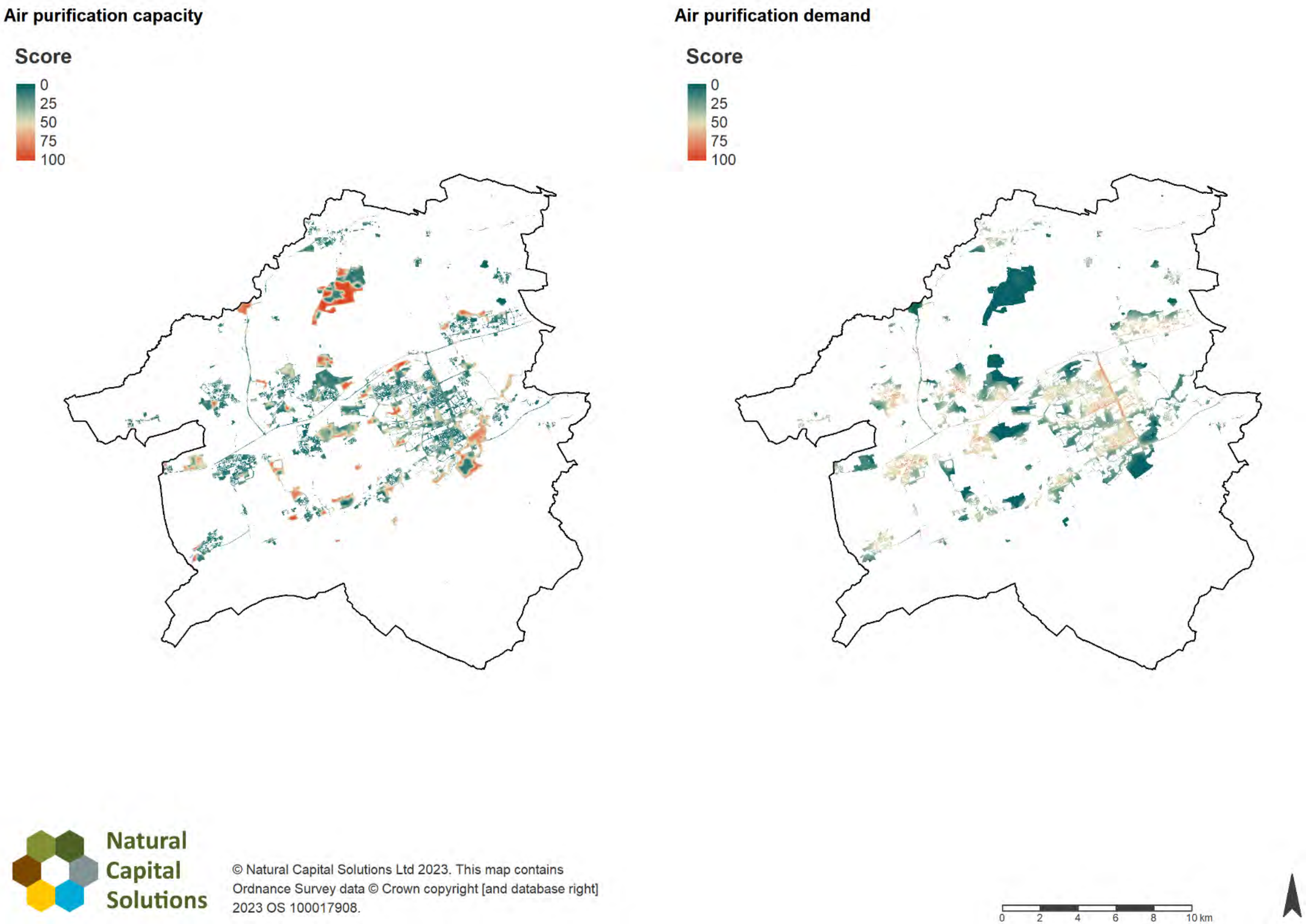
West Lothian score = 12.6 **WLC score = 27.5**

Balancing supply and demand

Comparing the supply and demand maps, there is often spatial disparity between the provision of and need for air pollution amelioration, as areas of woodland are largely concentrated outside of urban areas. There will be street trees in the urban centres, and we were not able to incorporate data on these into the basemap, and consequently the model. These will be important providers of this service where they are located in areas with high pollution levels, for example, by busy roads. However, we do not know to what extent this is the case in the towns and villages of West Lothian. Comparing the supply and demand of this service is a useful reminder that trees do play an important role providing this service, and that it is very much required in the urban areas within West Lothian. Local authorities need to consider whether their urban tree stock, as well as their hedgerows, are positioned to provide this service effectively, and consider expanding these habitats close to main roads where people live. Air pollution can be very localised; hence, it is important to consider the specific location of trees to gain the maximum benefit of this service. Trees are effective at mitigating the effects of air pollution although careful placing must be considered, as there are certain situations where this is not the case. 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. There is potential opportunity for urban parks and greenspaces to play a greater role in delivering this service through tree planting, particularly when close to roads.



Map 6a Air purification capacity (left) and demand (right) for West Lothian.



Map 6b. Air purification capacity (left) and demand (right) for WLC landholdings.

4.5 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 health, wellbeing, productivity and the natural environment. Consequently, the World Health Organisation (WHO) has 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 [25]). Major roads, railways, airports and industrial areas can be sources of considerable noise, but the 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. However, any vegetation cover is more effective than artificial sealed surfaces, and the effectiveness of vegetation increases with width.

How is it measured?

A modified EcoServ R noise regulation model was used. First, the capacity of the natural environment was 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 every 5m by 5m 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 West Lothian

Woodland habitats are by far the most effective habitat at absorbing noise (Map 7, left panel). The larger and wider blocks of woodland have the highest provision of this service, for instance within areas of plantation woodland to the south and west of the region and within WLC landholdings, Beecraigs Country Park. However, the effects are modest, with reductions of 2-4 dB typically recorded across dense tree belts.

West Lothian score = 21.5 **WLC score = 26.6**

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

4.6 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 is mapped using a modified version on an EcoServ R model. The model combines one indicator that maps noise sources (inverse log distance to different road classes,railways and airports, custom built for the study area based on Defra noise modelling and airport noise contour mapping) 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 West Lothian

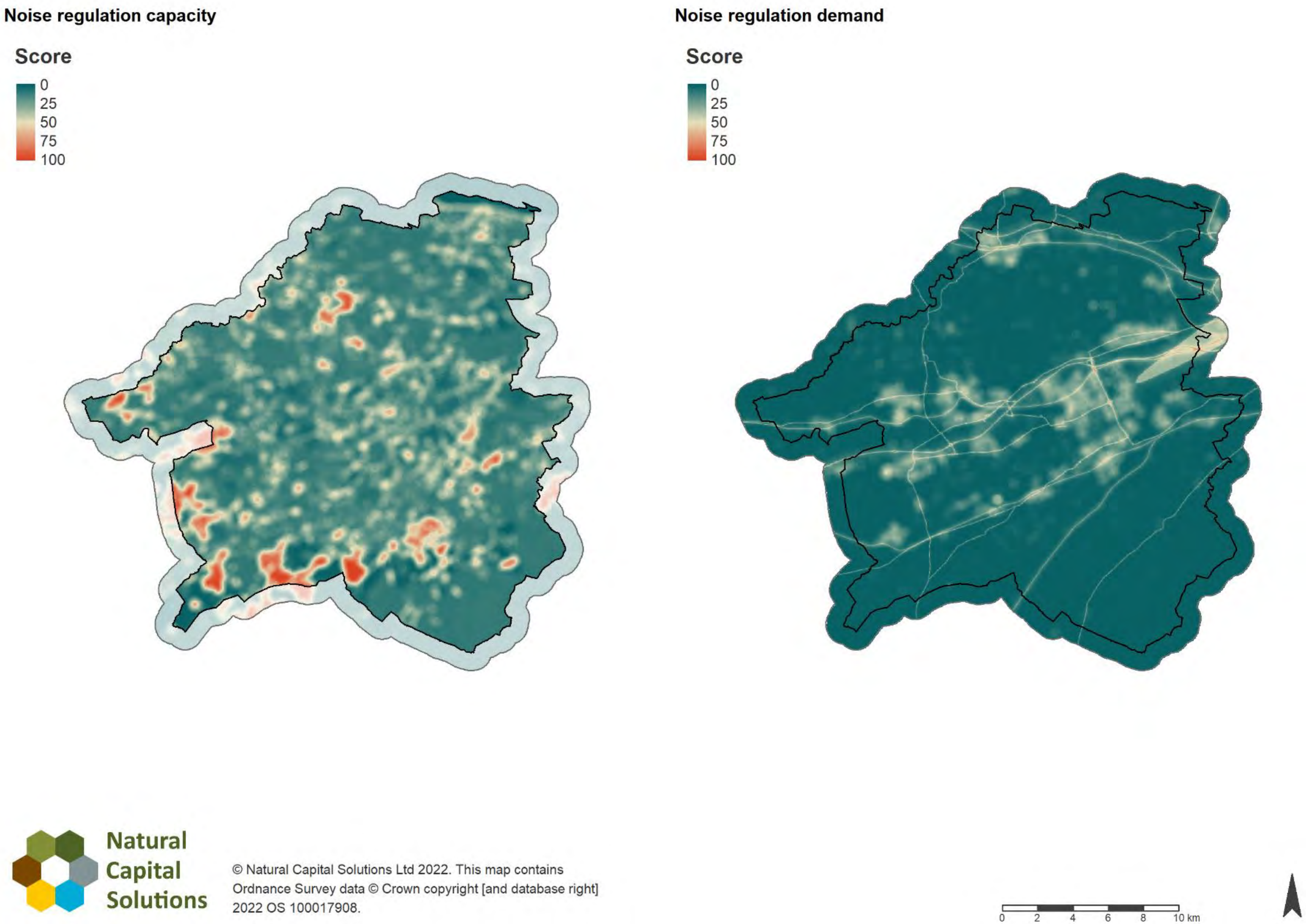
Demand for noise regulation (Map 7, right panel) is greatest in urban areas close to major roads, as these contain large populations, with potentially poor health, that would benefit from noise abatement from the main roads. There is moderate demand for noise regulation across the towns and villages of West Lothian. The highest demand is found to the east of the region associated with Edinburgh Airport.

West Lothian score = 5.9 **WLC score = 13.6**

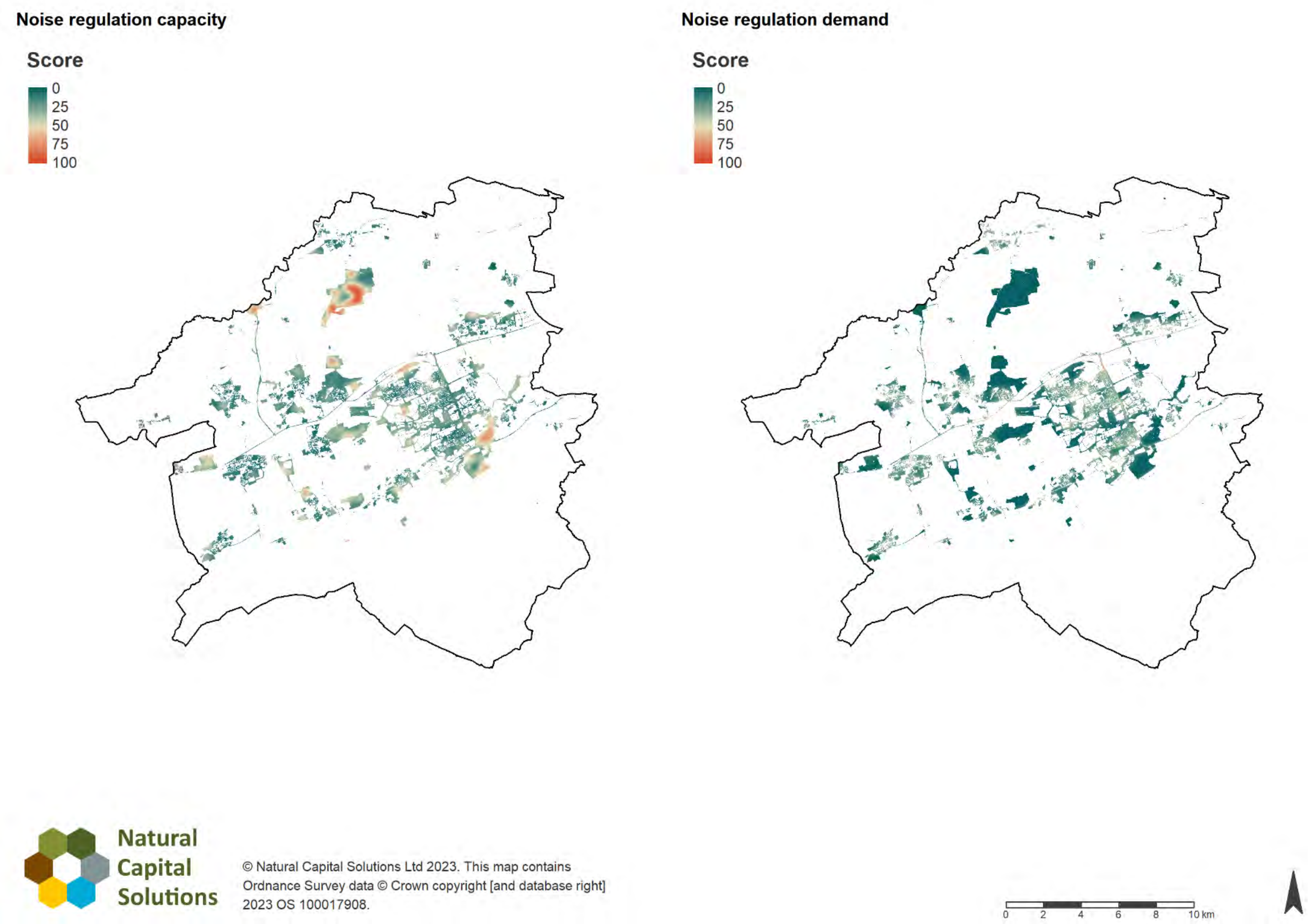
Balancing supply and demand

Similar to air purification, the supply and demand maps show a spatial disparity between capacity and need for noise regulation. There is very little capacity in urban areas, as most of the woodland is found in rural areas. Planting of new woodland or tree belts in urban areas next to roads would be the most effective way to meet demand.

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.



Map 7a: Noise regulation capacity (left) and demand (right) for West Lothian.



Map 7b. Noise regulation capacity (left) and demand (right) for WLC landholdings.

4.7 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 the 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/waterbodies, can have a moderating effect on the 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 is mapped using an InVest model. Vegetation can help reduce the urban heat island by providing shade, modifying thermal properties of the urban fabric, and increasing cooling through evapotranspiration.

The model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks) for each pixel.

The raster generated by this process shows the capacity of each landuse to cool the air and is calculated relative to the average temperature across the summer months.

The temperatures recorded in each location will differ from the index shown here since landuse would generate a given temperature which in reality is blended with the temperatures generated by the landcover of the surroundings.

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 capacity for local climate regulation as a service.

Results for West Lothian

Woodland and water bodies deliver the highest provision of the local climate regulation service with larger patches shown as red areas (Map 8, left panel). The largest patches are to the south and west of the county, associated with large areas of plantation woodland. There are small patches spread across West Lothian, with both Beecraigs Country Park and Almondell and Calderwood Country Park (WLC landholdings, Map 8b) providing moderate provision; however as the area is dominated by agricultural land it is predominantly of low provision for this service. Buildings and built surfaces provide zero capacity (blue areas).

West Lothian score = 68.9 **WLC score = 63.5**

4.8 Local climate regulation demand

What is it and why is it important?

Local climate regulation demand estimates the 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 an adapted version of an EcoServ R model. The model combines two indicators showing the societal need for local climate abatement (population density and proportion of the population in the highest risk age categories – defined as under ten and over 65) with one indicator showing the location of areas suffering from the urban heat island effect. The latter, is created using the InVest "Urban Cooling" tool and represents the average summer predicted temperatures over the study area.

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 West Lothian

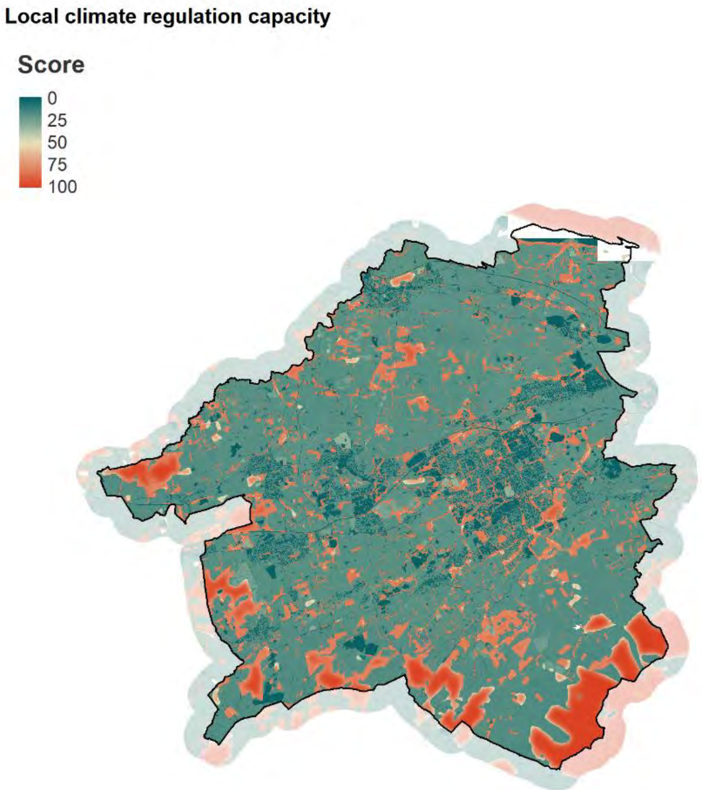
Demand for local climate regulation is greatest in the following urban centres in West Lothian: Armadale, Livingston, Broxburn, Bathgate, Whitburn, East Calder, Linlithgow and Blackburn (Map 8, right panel). The highest level of demand is found in the south of Armadale, whereas Livingston has the most extensive demand. Lower demand is also present across a number of the smaller urban areas across the county. Demand is centred in urban areas due to the urban heat island effect.

West Lothian score = 8.6 **WLC score = 28.7**

Balancing supply and demand

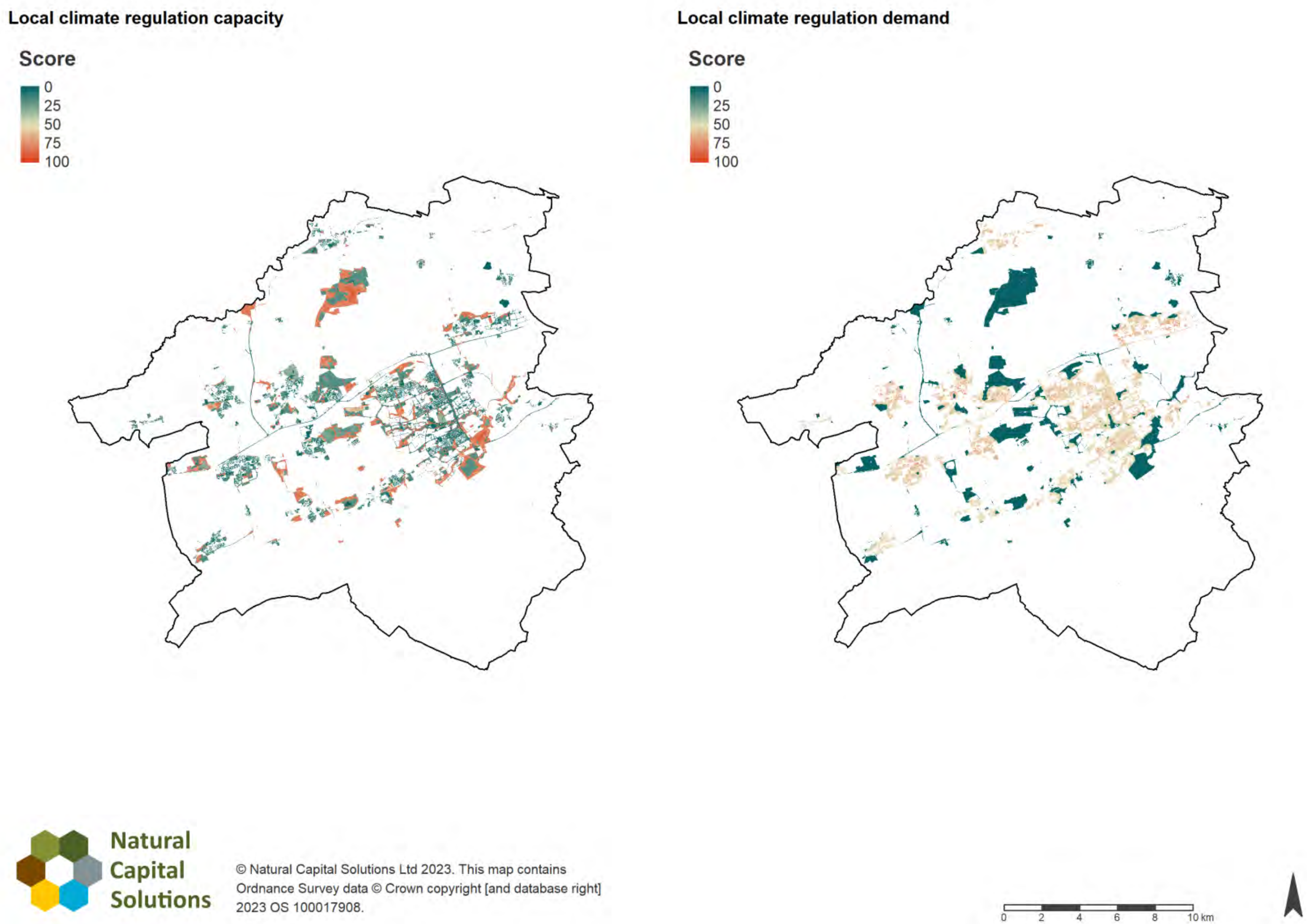
Large water bodies, and large areas of woodland in or adjacent to towns are particularly beneficial to local climate regulating services as they can bring moderating conditions into the heart of these urban areas. A prime example of this is Livingston, where the River Almond and associated woodlands within the river corridor extend right into the heart of the town.

In other parts of West Lothian there is a small amount of overlap where there are woodland areas or waterbodies in urban fringes, but for the most part, woodland and water habitats are found outside of urban centres where demand is highest. There will be street trees in the urban centres that we were not able to incorporate into the natural capital asset basemap, and consequently the model, that may play a role in local climate regulation. Planting urban trees, incorporating more green spaces and providing water features within or adjacent to the urban centres would help to decrease urban temperatures. Urban parks and greenspaces are important at delivering urban cooling in areas of high need and can be ideal locations to further enhance delivery though planting additional woodland or creating water features (or by creating new parks). Although regulating local climate and moderating the impacts of the urban heat island effect may not be considered to be the highest priority at present, its importance will increase over time due to climate change and an increasing (and ageing) population.



Natural Capital Solutions

Map 8a. Local climate regulation capacity (left) and demand (right) for West Lothian.



Map 8b. Local climate regulation capacity (left) and demand (right) for WLC landholdings.

4.9 Pollination capacity

What is it and why is it important?

Insect pollinators are essential for human survival and for the natural environment. They pollinate 75% of the native plant species in Britain (Ollerton et al. 2011)[26] and directly contribute an estimated £603 million per annum to the British economy through the pollination of agricultural crops (Vanbergen et al. 2014[27]). They also pollinate orchard, allotment and garden fruit and vegetables and are essential to the continuing existence of most wild plant species. They have high cultural value, both in their own right and through the maintenance of our countryside and gardens.

Pollination capacity measures the capacity of the land to provide pollination services by estimating the visitation rate of each particular pixel of land (relative to the landscape analysed) for wild insect pollinators (assuming a steady state pollinator population).

How is it measured?

Adapted from the model created in Häussler et al. (2017) and Gardner, E. et al (2020); this model simulates population processes of colony building bumblebees (ground and tree nesting bumble bees) as well as short-lived ground nesting solitary bees. For each guild, the model generates a nesting resource as well as a floral resource map for each season, based on the nesting and floral attractiveness of each habitat. First, nests are randomly allocated across the landscape. The model then uses the foraging distance of the guild to calculate the floral resources gathered from the nest surroundings which in turn determines how many workers (if social) and new reproductive females the nest produces.

New reproductive females disperse according to the dispersal distance of each guild. The number of reproductive females cannot exceed that of the expected number of nests according to the nesting resource map (carrying capacity). For each guild, a visitation rate per pixel per season is generated and these three rasters are then summed to create a total visitation rate raster for each season.

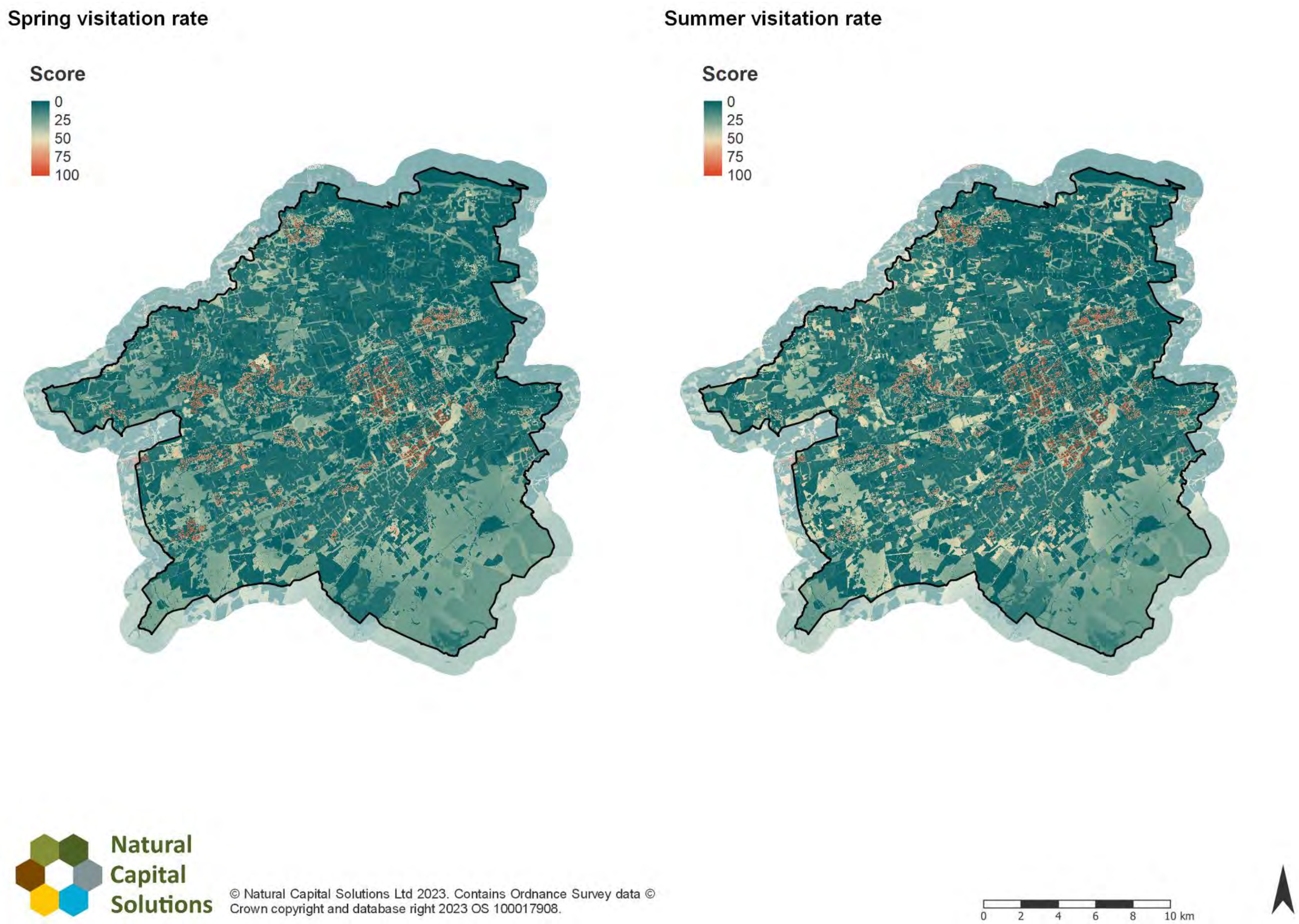
The final capacity score was calculated for each 10x10m cell across the study area, and was scaled from 0 to 100, relative to values present within the mapped area. High values (red) indicate areas where the visitation rate (which will result in pollination) is highest.

Results for West Lothian

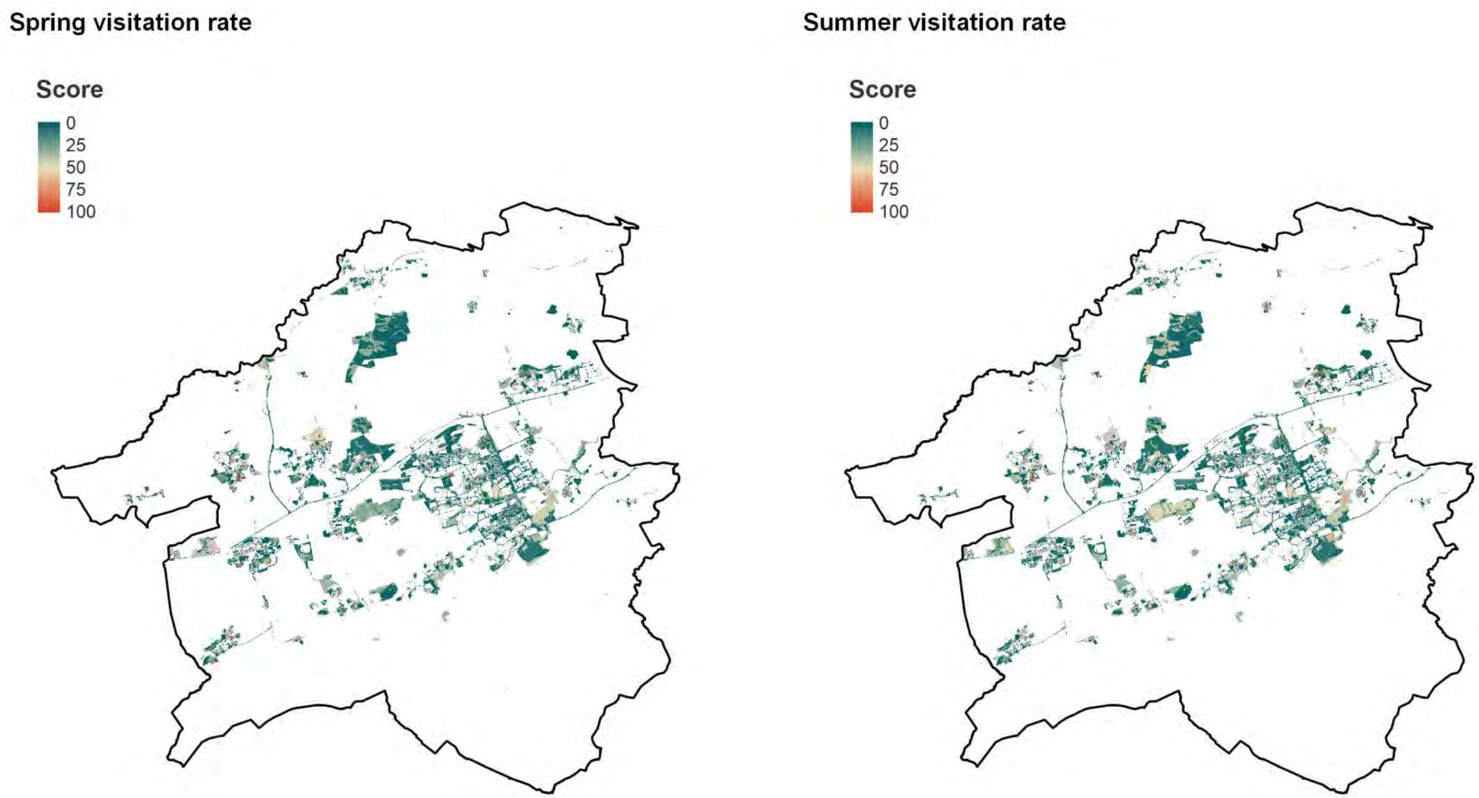
Pollination capacity is generally low across the county (Map 9), in both spring and summer, due to the dominance of agricultural land (including modified grassland), with areas of woodland and heathland habitats to the south of the region providing slightly higher capacity. Areas of highest capacity are associated with semi-natural grassland (cream areas) and residential gardens (red areas). Areas of high spring capacity can be seen associated with the nature reserve to the south west of the area. Across WLC landholdings (Map 9b), capacity is also relatively low, with the Almondell and Calderwood country park identified as one of the highest areas of capacity.

West Lothian score = 14.9 (spring), 16.8 (summer)   WLC score = 17.9 (spring), 18.9 (summer)

[26] Ollerton, J., Winfree, R. & Tarrant, S. (2011) How many flowering plants are pollinated by animals? Oikos, 120, 321-326.
[27] Vanbergen, A.J., Heard, M.S., Breeze, T., Potts, S.G. & Hanley, N. (2014) Status and Value of Pollinators and Pollination Services. Report to the Department for Environment, Food and Rural Affairs (Defra).



Map 9a: Pollination capacity for spring (left) and summer (right) for West Lothian.



Natural Capital Solutions

0 2 4 6 8 10 km

Map 9b: Pollination capacity for spring (left) and summer (right) for WLC landholdings.

4.10 Water flow regulation 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?

The SWAT+ (Soil & Water Assessment Tool) model, which can assess the impacts of land use management on hydrology and water quality, was used. The SWAT+ model operates over a defined simulation period (in this case, 2009-2021) and outputs a range of results (measured in annual average) including precipitation, water yield, percolation, and surface run-off.

The habitat basemap was refactored to compatible SWAT+ land use types and was combined with slope categories (3°, 7°, 11°, 15°, 25° – defined by the British Land Capability classification) and soils data (European Soils Database) to create hydrological response units (HRUs), which represent the output scale. Climate data from the Met Office was obtained for the simulation period and adjusted to the required SWAT+ format.

The final output was created by subtracting the water yield values from the precipitation values. The results are shown in m^3/ha. High values indicate HRUs that retain large volumes of water (good areas) whereas low values indicate HRUs that lose larger volumes of water (primarily due to higher rates of run-off).

Results for West Lothian

The best locations for slowing water runoff tend to be areas of woodland on flat land. The worst areas tend to be impermeable surfaces and slopes. Map 10 (left panel) shows capacity within the baseline is relatively uniform across the region, driven by changes in micro-topography and habitat type, with highest capacity shown in red. Across West Lothian higher scores for water yield are associated with the flood plain as it extends across the region, with lower scores associated with steeper sloping land.

West Lothian mean = 6.92 m^3/ha **WLC mean = 3.53 m^3/ha**

4.11 Water quality (sediment and nutrient) regulation capacity

What is it and why is it important?

Water quality capacity maps the risk of surface runoff becoming contaminated with high pollutant and sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. Sedimentation causes direct impacts on river substrates, fish and aquatic invertebrates, and on flood risk, but also causes indirect impacts though pollutants that are adsorbed onto sediment, and then washed into watercourses.

How is it measured?

The SWAT+ (Soil & Water Assessment Tool) model, which can assess the impacts of land use management on hydrology and water quality, was used. The SWAT+ model operates over a defined simulation period (in this case, 2009-2021) and outputs a range of sediment and nutrient loss results (measured in annual average) including sediment yield and organic sediment levels (Nitrogen and Phosphorus).

The habitat basemap was refactored to compatible SWAT+ land use types and was combined with slope categories (3°, 7°, 11°, 15°, 25° – defined by the British Land Capability classification) and soils data (European Soils Database) to create hydrological response units (HRUs), which represent the output scale. Climate data from the Met Office was obtained for the simulation period and adjusted to the required SWAT+ format.

Three SWAT+ outputs were used to assess water quality regulation:

- **Sediment yield (tonnes/ha):** sediment yield leaving the landscape caused by water erosion
- **Organic N & P sediment (kg/ha):** organic nitrogen and phosphorus transported in surface runoff

High values indicate HRUs that are losing high quantities of sediment and organic N and P sediment (bad areas). To maintain compatibility with the other maps, bad areas (in this case high values) are shown in blue and good areas (low values) are shown in red.

Results for West Lothian

Sediment yield

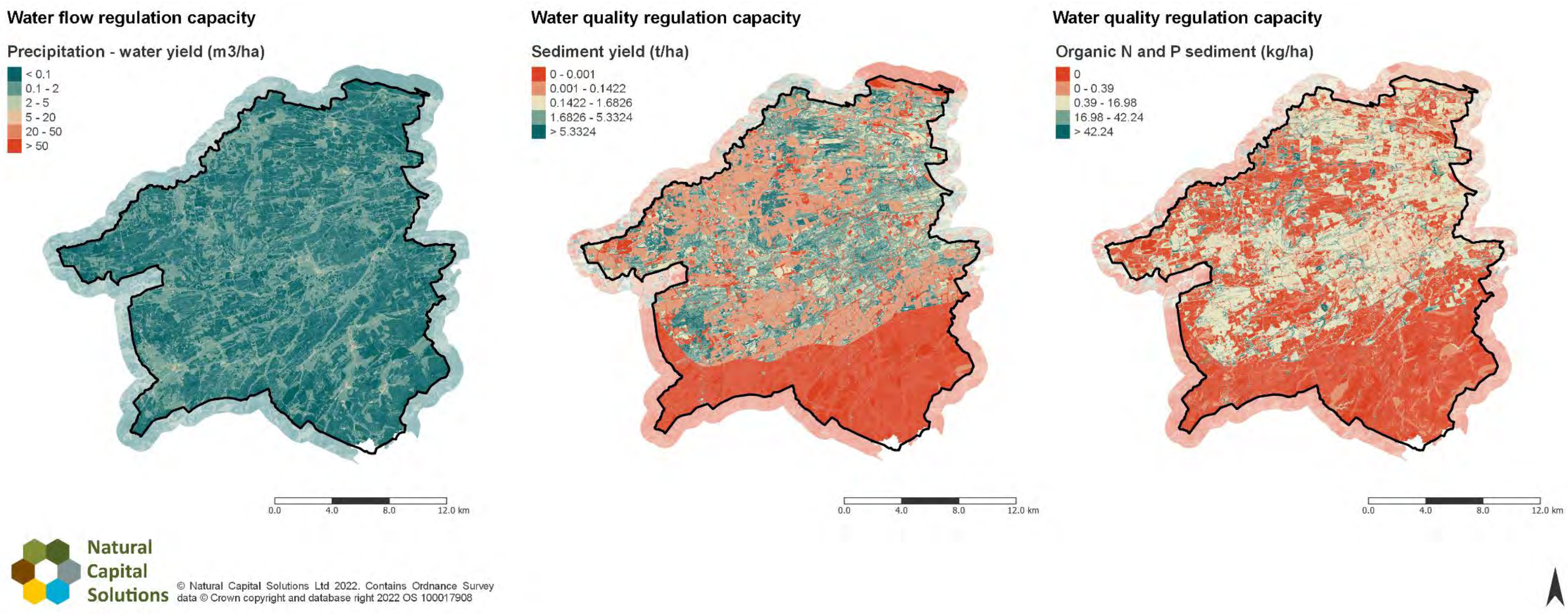
Map 10 (centre) show the sediment yield for West Lothian, with high scores demonstrating higher sediment run off. The worst locations (blue) for sediment yield are associated with flatter agricultural and urban land on mineral soils spread across the centre of the region of West Lothian. The best locations (red) are associated with semi-natural habitats to the south of the region with areas of slightly higher yields extending across from the north west. Coastal habitats to the north also have low scores of sediment yield.

West Lothian mean = 5.25 t/ha **WLC mean = 6.46 t/ha**

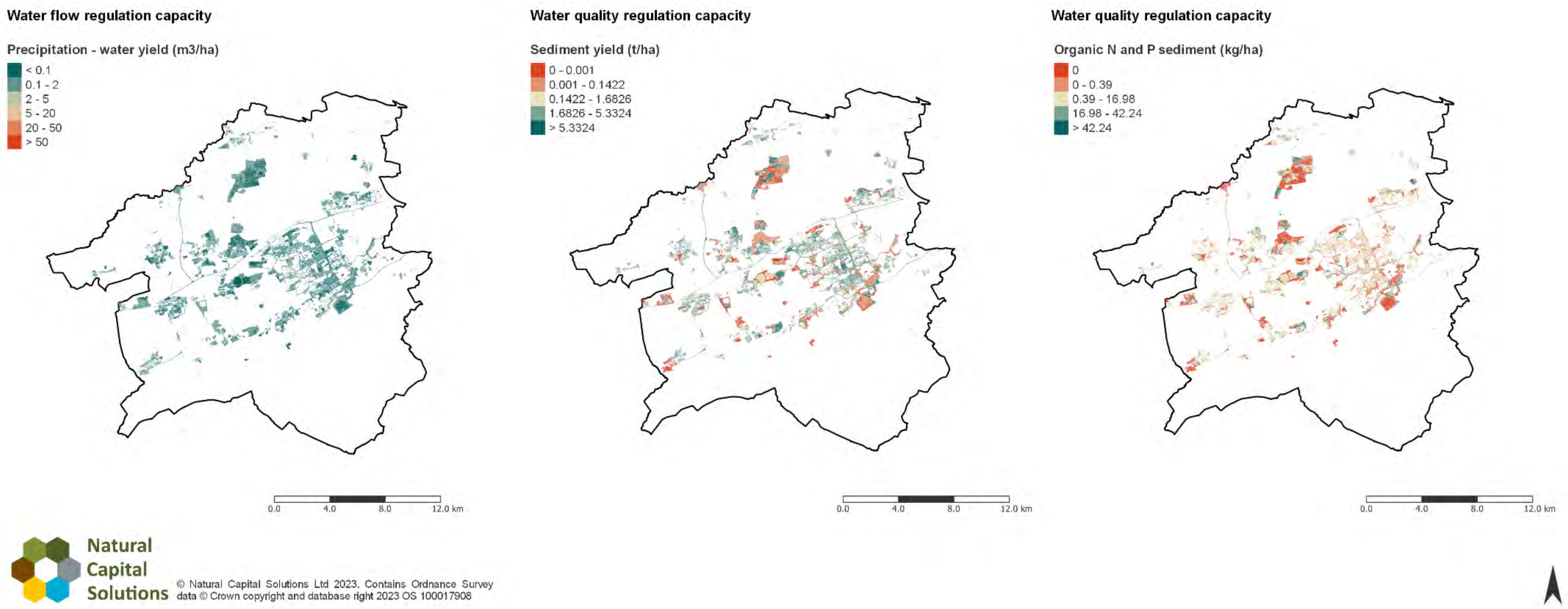
Organic N and P sediment

Comparable to sediment yield, the best locations for low organic N & P sediment are found in the semi-natural habitats and soils to the south of the site, with areas of high provision also extending across the north of the region (Map 10, right panel). The worst areas tend to be slopes close to water courses with woodlands and low vegetated cover. Impermeable surfaces score moderate values.

West Lothian mean = 20.6 kg/ha **WLC mean = 19.6 kg/ha**



Map 10a: Water flow regulation capacity for West Lothian in m^3/ha (left) and water quality regulation capacity: sediment yield (t/ha) (centre) and organic N and P sediment (kg/ha) (right) for West Lothian. For the water quality maps, high values indicate bad areas (greater sedimentation).



Map 10b: Water flow regulation capacity for WLC landholdings in m^3/ha (left) and water quality regulation capacity: sediment yield (t/ha) (centre) and organic N and P sediment (kg/ha) (right) for WLC landholdings. For the water quality maps, high values indicate bad areas (greater sedimentation).

4.12 Food production capacity

What is it and why is it important?

Food production models the capacity of the land to produce food under current farming practices. Farming is the dominant land-use across West Lothian, with improved grassland associated with grazing livestock covering a greater area than arable land. 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?

A model was developed using a methodology outlined in Smith (2020)[28] that was developed for the Eco-metric tool. Broad habitats in West Lothian were assigned a score based on their relative ability to provide food:

- Arable, improved grassland - 10
- Orchards, allotments - 7
- Semi-natural and rough grasslands - 6
- Marshy grassland - 4
- Wood pasture and parkland - 3
- Bog/heath, domestic gardens, broadleaved and mixed woodlands - 1

This was mapped in GIS and then agricultural land uses were weighted by the Agricultural Land Class in which it occurred. The weighting was based on typical dry yield and an additional multiplier for versatility, following Smith (2020):

Grade 1 - 3.03

Grade 2 - 2.40

Grade 3 - 1.33

Grade 4 - 0.67

Grade 5 - 0.50

To maintain compatibility with the other ecosystem service maps, the weighted scores were scaled on a 0 to 100 scale relative to values present within the mapped area.

Results for West Lothian

Food production capacity is low to moderate across most of West Lothian. The highest capacity is found in the east of the county, where there is a small area of arable land managed on Grade 1 mineral soil (shown in red, Map 11, left panel). Agricultural land on Grade 2 shallow peat and mineral soils also has high food production capacity (shown in orange). Grade 3 land on mineral soil is found towards the north of the county along with some areas spread across the region (shown in cream). This has a moderate food production capacity. The majority of agricultural areas are found on Grade 4 and 5 land, primarily to the south and west of the region, and consequently score low for food provision (light blue). Areas of semi-natural grassland and allotments also have fairly low capacity (also shown in light blue), and urban areas (apart from allotments), along with woodland habitats have very low food production capacity (shown in dark blue). Consequently, WLC land holdings (Map 11b) have low food production capacity.

West Lothian score = 18.0 **WLC score = 4.8**

[28] Smith, A. (2020) Natural Capital in Oxfordshire: Short report. Environmental Change Institute, University of Oxford.

4.13 Timber / wood fuel production 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. Woods and trees that aren't actively managed for timber are still included in this model, as it indicates potential capacity, and also these areas may still provide wood fuel.

How is it measured?

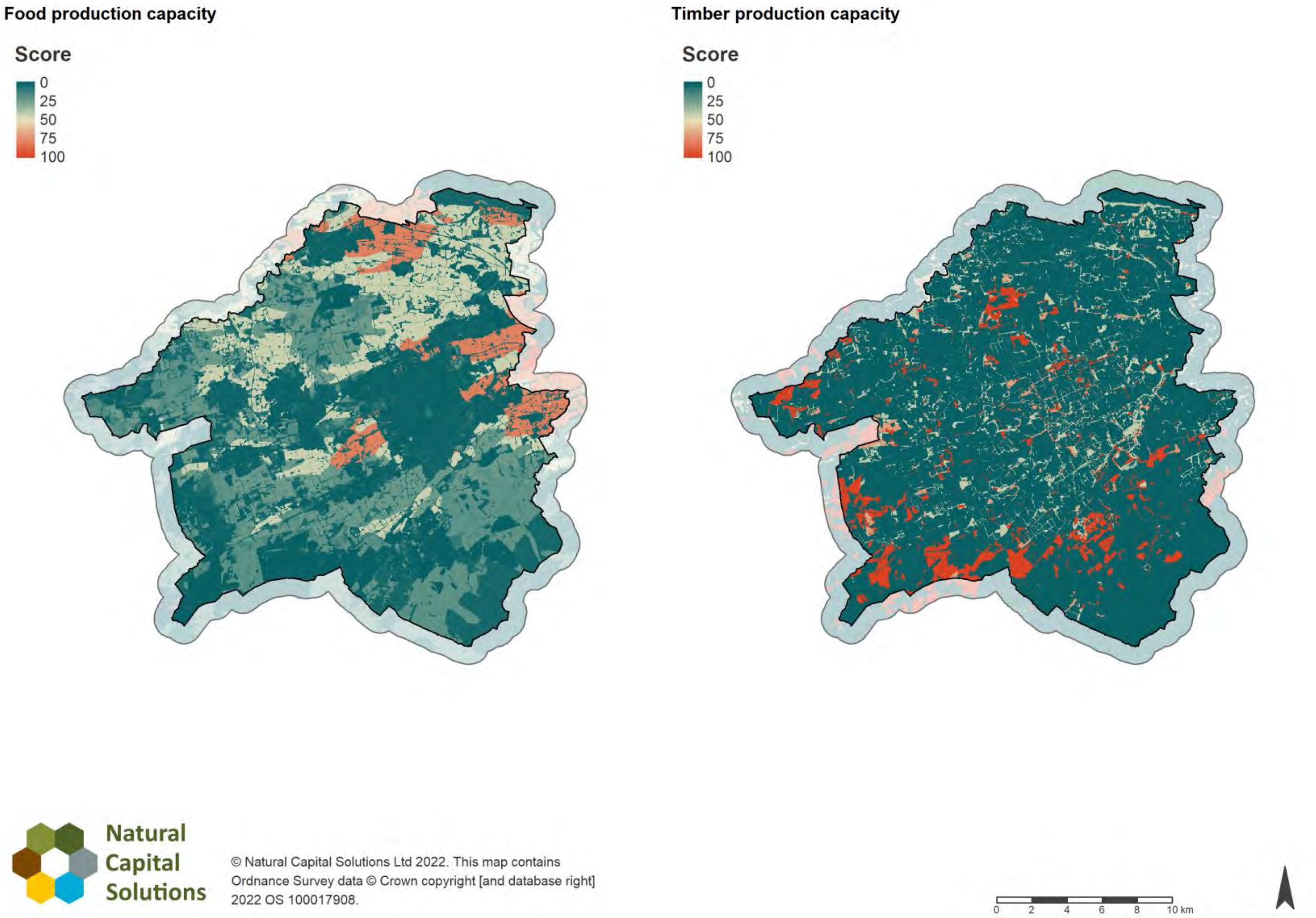
The model uses information on the species mix and yield class obtained from the Forestry Commission's National Inventory of Woodland and Trees County Report for Lothian (2002), and Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). This was used to determine the average yield of timber (m^3) per hectare per year.

To maintain compatibility with the other ecosystem service maps, the scores were scaled on a 0 to 100 scale relative to values present within the mapped area.

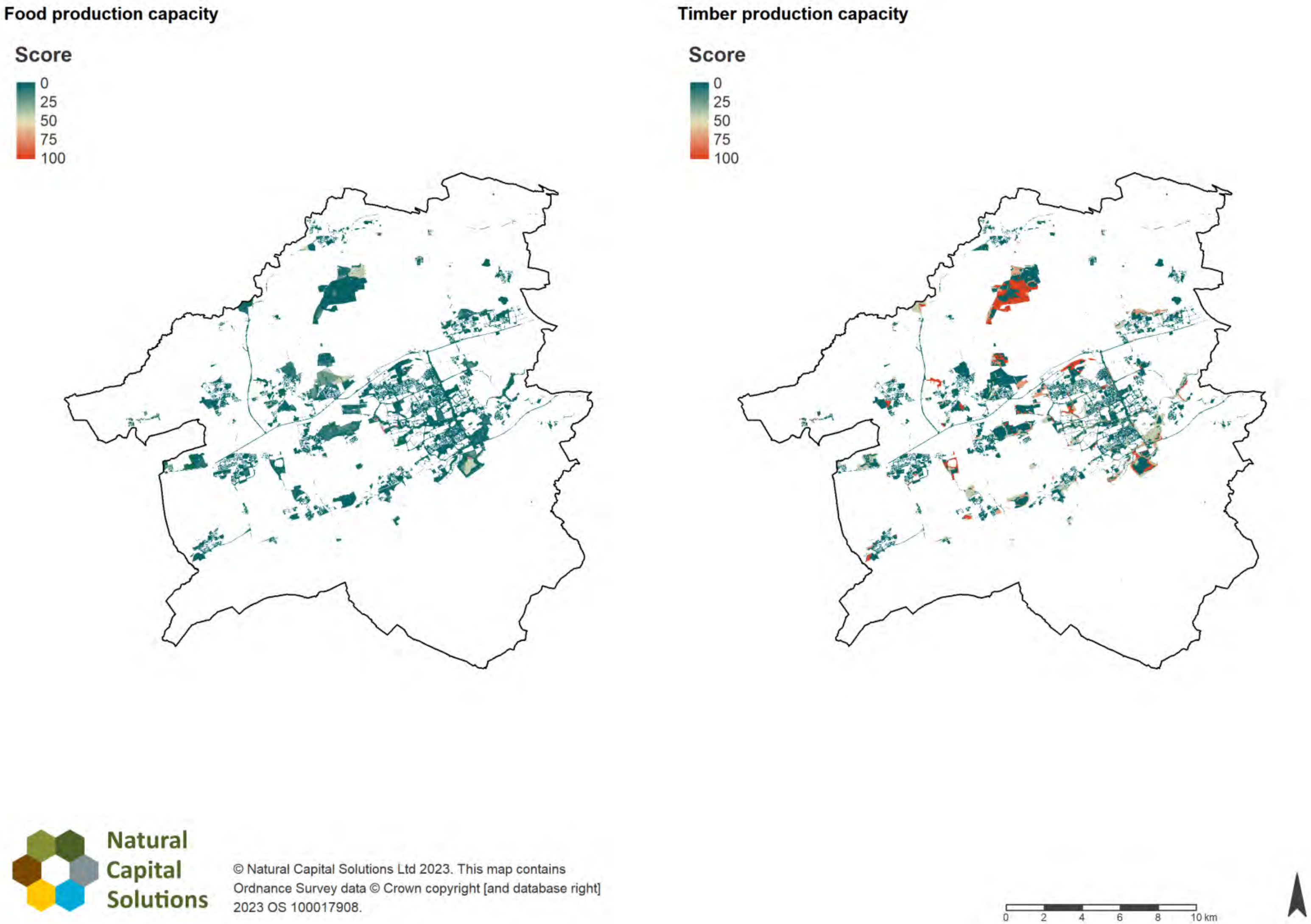
Results for West Lothian

Timber/woodfuel capacity is low across most of the county, although there are some large areas of coniferous woodland to the south and west which have high capacity (shown in red; Map 11, right panel), such as Beecraigs Country Park (WLC landholdings). Moderate capacity is found in patches of broadleaved woodland, such as Almondell and Calderwood Country Park (WLC landholding). The rest of the area has no capacity (in dark blue).

West Lothian score = 11.1 **WLC score = 19.8**



Map 11a: Food (left) and timber (right) production capacity for West Lothian.



Map 11b: Food (left) and timber (right) production capacity for WLC landholdings.

4.14 Accessible nature capacity

What is it and why is it important?

The importance of access to greenspace is increasingly recognised due to 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. NatureScot, the Scottish Government 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 public availability of natural areas and scores them by their perceived level of "naturalness".

How is it measured?

Accessible nature capacity was mapped using an EcoServ R model. 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, Countryside and Rights of Way Act (CRoW) access land, local nature reserves and accessible woodlands.
- Areas of green and blue infrastructure marked as accessible, including streams, reservoirs, canals, 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 West Lothian

Map 12 (left panel) shows accessible nature capacity across West Lothian. Red areas indicate highest provision and are shown to include WLC landholdings, with Almondell and Calderwood County Park in Livingston demonstrating the highest provision in the region. Other WLC land including Beecraigs Country Park to the north of the region and smaller areas such as Foulshiels Bing to the north of Stoneyburn also have relatively high provision. Other sites with high levels of provision in West Lothian include Polkemmet Country Park to the west and Forestry Commission sites including Woodmuir to the south and West Benhar to the west. There are also a number of smaller sites spread across the region with lower levels of provision, associated with areas of open greenspace and an extensive network of public rights of way.

West Lothian score = 6.1 **WLC score = 17.9**

4.15 Accessible nature demand

What is it and why is it important?

This indicates where there is 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), and Scotland's People and Nature Survey (SPANS), have shown that there is greatest demand for accessible greenspace close to people's homes, especially for sites within walking distance. SPANS surveys in West Lothian have also shown that most people engage with nature in parks and greenspaces.

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 West Lothian

Demand for accessible nature (Map 12, right panel) is concentrated in the centre of towns including Livingston, Whitburn and Armadale (shown in red). There are lower areas of demand in smaller settlements and surrounding villages.

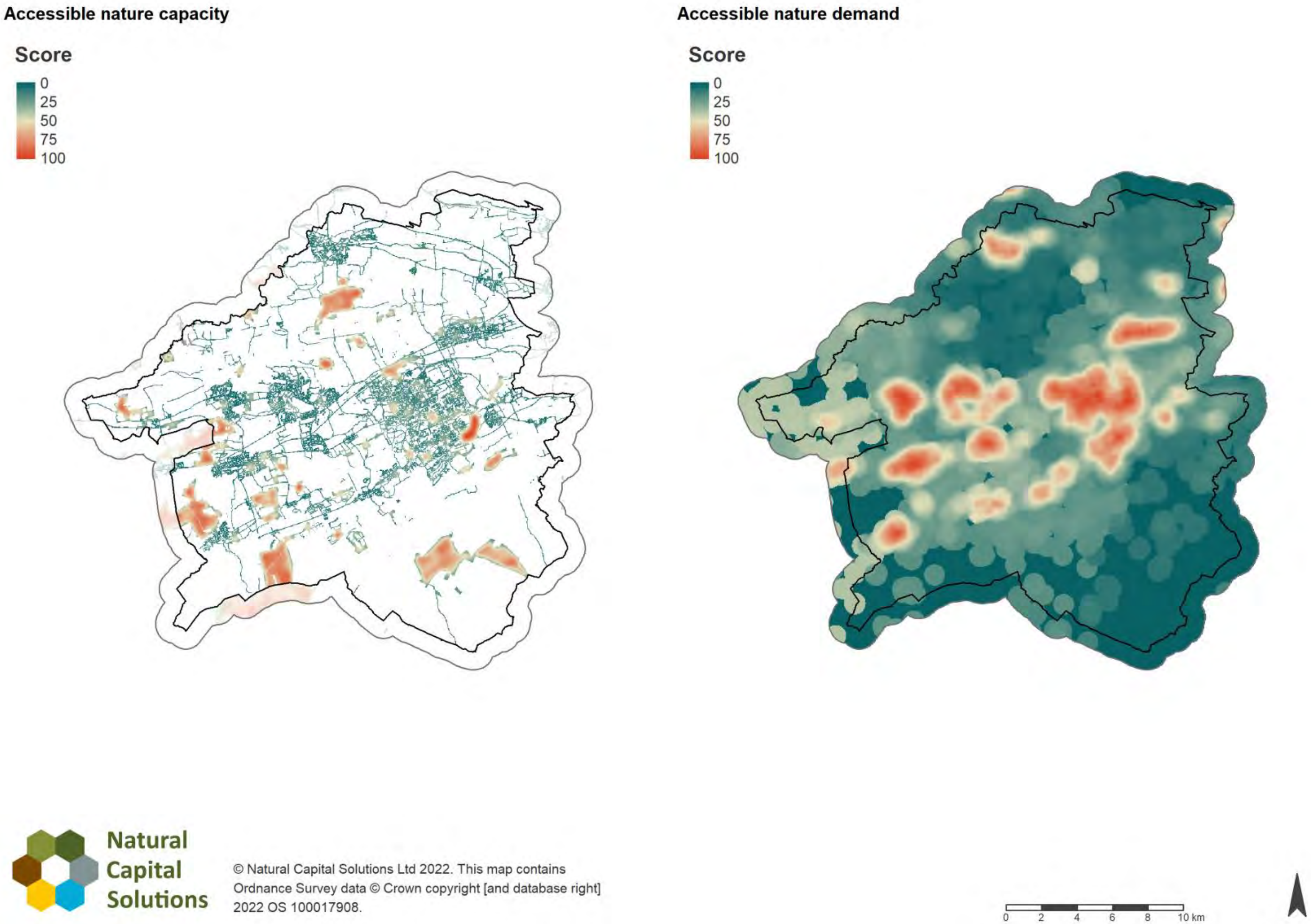
West Lothian score = 24.3 **WLC score = 47.3**

Balancing supply and demand

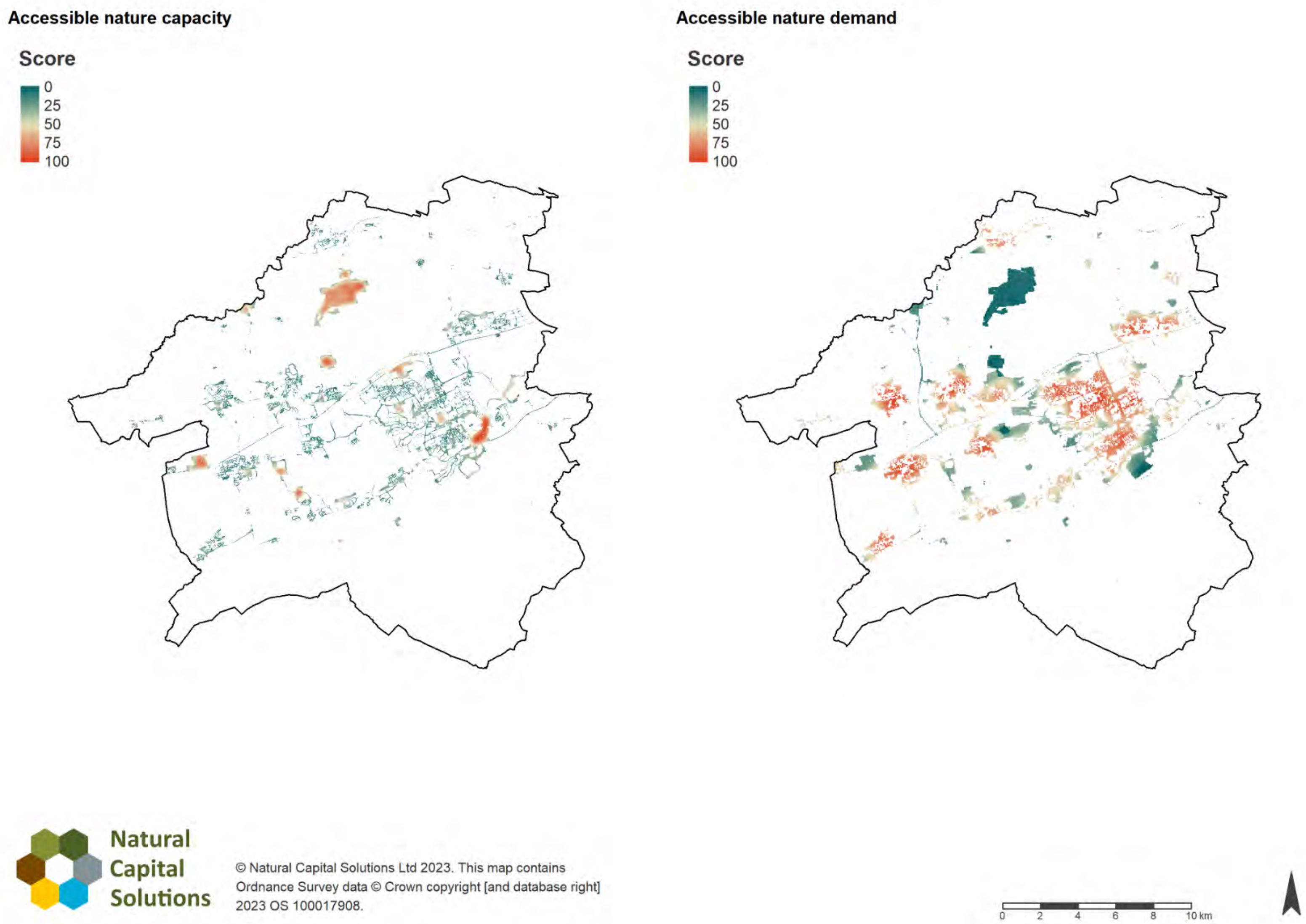
Numerous research has shown that people travel most frequently to greenspaces very close to their homes and the West Lothian Open Space Plan recommends that everyone should have access to a local park and an accessible woodland within 500m and larger sites within 1-4 km[29]. Furthermore, surveys have 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, and especially close to more deprived and densely populated neighbourhoods. New housing areas will also create increased demand for accessible greenspace, so it is important that this demand is 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 a high quality and as natural as possible.

[29] West Lothian Open Space Plan 2020-24. West Lothian Council.



Map 12a: Accessible nature capacity (left) and demand (right) for West Lothian.



Map 12b. Accessible nature capacity (left) and demand (right) for WLC landholdings.

5. Conclusions and recommendations

West Lothian contains significant areas of semi-natural and woodland habitats, together comprising 40.6% of the total area, found spread across the region but in large areas to the south and west of the county. Broadleaved, coniferous and mixed woodland take up a combined 15.6% of the area (excluding felled woodland), with semi-natural grassland occupying 15.4% and heathland and grass heath mosaics taking up a further 4.5%. Agricultural improved grassland comprises 25% with arable land comprising a further 12%. Built up areas, infrastructure and gardens take up about 13% of the region, with associated amenity grassland comprising a further 5%.

The biodiversity baseline assessment demonstrates that a large portion of the habitats found in West Lothian are in poor condition (57%), with only a small percentage found to be in good condition (3%). However, survey by WSP found that Scottish Biodiversity List woodland and grassland habitats within WLC landholdings were in good condition, with bog habitats, although showing signs of degradation, also meeting the criteria for good condition. Heathland and shrub, were primarily found to be in moderate condition. Further information on the spread of habitat condition and prevalence of SBL features can be found in WSP (2023).

The biodiversity baseline assessment also considered the spread of strategically significant habitats, i.e. those associated with and adjacent to designated sites, and thus can form the basis for the development of habitat networks for the region should the council wish to employ this.

This biodiversity baseline assessment using the metric gives an overall value for habitats assessed as 178,464 BU for the West Lothian region. WLC landholdings were estimated to contribute 16,558 of these units.

The ecosystem service maps demonstrate the spatial pattern of provision for eleven different ecosystem services and the demand for four. The maps demonstrate that the presence of large areas of deep peat soils, found to the south of the region, mean there is a significant carbon stock within the soil of West Lothian, with an average of 153 tC/ha across the region. WLC landholdings have a lower average (130 tC/ha) when compared to the region as a whole, primarily due to the dominance of mineral soils over peat.

Due to the prevalence of agriculture, primarily improved grassland areas, in the region, West Lothian is, on average, an emitter of carbon at a rate of -0.33 tCO_2e/ha/yr. In addition to emissions from livestock and farming activities, this figure is influenced by the presence of deep peat soils, where exposed peat and degraded bog have the highest emissions. Other habitats on peat also emit carbon, albeit at a slower rate than exposed peat/degraded bog, with good condition bog habitats showing the lowest emissions (only few nationally sequester carbon) and areas of bog which have been modified, for instance through scrub encroachment, grazing, drainage or other modifications, (i.e. drying out of the peat and now more appropriately classified as grassland and heathland habitats), also emitting carbon. WLC landholdings in comparison, sequester carbon at an average across the whole landholding of 2.4 tCO_2e/ha/yr, as woodland is common and emissions from farming and degraded peat habitats is much less common on these sites. A full breakdown of the carbon sequestration values for each habitat type across West Lothian and WLC landholdings can be found in Appendix 1.

There is also some capacity for air quality, noise and local climate regulation; with areas of high provision primarily found in large areas of woodland lying to the south and west of the region, although some smaller pockets are found spread across the county. The maps show that the demand for these services, which is focussed along the motorways and A-roads and around towns and villages (such as Livingston and Whitburn) is often not met by the current capacity which lies on the fringes of West

Lothian. Demand for accessible nature is also focused around these urban centres. WLC landholdings provide higher capacity for air quality and noise regulation than the regional average, although demand is also significantly higher than the region's average due to the landholdings locations in more urbanised settings. However, this does suggest that the WLC landholdings in themselves go some way to balance the supply and demand for both air quality and noise regulation. Local climate regulation provision however is marginally lower for WLC landholdings compared to the West Lothian average, although demand is again significantly higher. As mentioned in Section 4 above, the installation of urban trees may go some way to offset this supply and demand mismatch.

Pollination capacity is relatively low across the entire West Lothian region, due to the prevalence of agricultural habitats, however, features such as arable margins and hedgerows are not mapped at this level and will provide some service. Currently the highest levels of pollination capacity are associated with residential gardens in urban areas and areas of semi-natural grassland, primarily in country parks and other areas of greenspace.

Water flow appears to be fairly uniform across the region, with higher scores (better retention of water) associated with areas of floodplain. The WLC landholdings have a lower score for water flow compared to the average across West Lothian. Water quality maps demonstrate that there are areas of higher sediment runoff associated with the agricultural and urbanised landscape in the centre of West Lothian, with areas of semi-natural habitat found to the south, west and extending from the north-west having lower scores for runoff. The WLC landholdings perform slightly better on average than the rest of the West Lothian region for nutrient runoff, but slightly worse for sedimentation.

The maps also show that high provision for food production is limited to a small area of Grade 1 land to the east, and some Grade 2 land spreading to the west; although the dominance of Grade 4 and 5 land means that the majority of the region provides low value for this service. WLC landholdings provide low provision of food production due to the lack of agricultural land found within their boundaries.

Timber production is also limited across West Lothian, although areas of high provision are associated with large coniferous woodland areas to the south and west of the region. WLC landholdings provide a significantly higher average than the regional average, due to the dominance of woodland within these sites.

There is an extensive network of public rights of way across West Lothian, with a number of country parks and open access Forestry Commission sites that deliver high capacity for this service. The WLC landholdings provide a higher than average provision for accessible nature, although demand is also significantly higher than the West Lothian average, attributable to the urban setting of these sites.

On average, WLC landholdings provide higher (better) levels of ecosystem service provision when compared to the West Lothian average for 6 ecosystem services (carbon sequestration capacity, air purification capacity, noise regulation capacity, pollination capacity, timber production and accessible nature capacity), worse for 4 (carbon storage capacity, local climate regulation capacity, water flow capacity and food production capacity) and there is a mixed picture for one (water quality). Typically, WLC landholdings contain more woodland, less agriculture, less peat soils and less upland areas than the county average. Two country parks owned by WLC are responsible for the highest level of delivery of most services within WLC land, Beecraigs Country Park to the north and Almondell and Calderwood Country Park to the south east of Livingston, due to their dominance by woodland and large size. However, the WLC landholdings also have a higher than average demand for these services given their location in urbanised areas of the region, which highlights a slight disparity in the locations of current demand and delivery of some ecosystem services.

Table 3. Ecosystem service scores across West Lothian and WLC Landholdings, values shown are indicative scores out of 100 unless indicated otherwise.

Ecosystem service	West Lothian score	WLC landholdings score
Carbon storage capacity (tC/ha)	152.8	130.0
*Carbon sequestration capacity (tCO_2e/ha/yr)	-0.3	2.4
Air purification capacity	22.1	30.8
Air purification demand	12.6	27.5
Noise regulation capacity	21.5	26.6
Noise regulation demand	5.9	13.6
Local climate regulation capacity	68.9	63.5
Local climate regulation demand	8.6	28.7
Pollination capacity - spring - summer	14.9 16.8	17.9 18.9
Water flow (m^3/ha)	6.9	3.5
**Water quality – sediment yield (t/ha)	5.3	6.5
**Water quality – organic N and P sediment (kg/ha)	20.6	19.6
Food production capacity	18.0	4.8
Timber production capacity	11.1	19.8
Accessible nature capacity	6.1	17.9
Accessible nature demand	24.3	47.3

* Negative numbers indicate net emissions, positive numbers indicate net sequestration.
** Higher sediment yields indicate that more sediment is being produced (worse).

5.1 Recommendations and next steps

The Scottish Governments draft biodiversity strategy sets out long term ambition to deliver landscape-scale, transformative change – backed by evidence to accelerate nature’s restoration, expanding and improving protected areas and supporting nature-friendly farming; with funds such as the Nature Restoration Fund having already invested in the expansion of nature networks.

There are therefore opportunities to utilise this report as an evidence base to further define local nature networks and key areas to be targeted for nature’s restoration and expansion. This report provides an assessment of the existing baseline provision of biodiversity and other ecosystem services across West Lothian and WLC land holdings and provides the first step necessary to inform ecosystem service led policy documents such as the LBAP.

The strategic significance map shown in Map 3 demonstrates areas of habitat which may be considered of importance for nature’s recovery and thus contribute to Nature Networks as part of Scotland’s nature restoration. The habitat condition map further highlights the areas in which condition of valuable areas of habitat should be targeted for restoration and enhancement.

This work area could be further enhanced through the undertaking of a habitat connectivity analysis using a tool such as Omniscape, which models the intensity of animal movement or ecological flow in all directions from all points across a landscape. The model is based on the circuit-theoretic approach to connectivity, where the landscape is viewed as an electrical circuit, and the movement of species as the electrical current that flows through it. It identifies movement via low-resistance routes, those that present little difficulty for the dispersal of individuals and low risk of mortality. At the same time it identifies barriers and pinch points in the landscape which impede flow. These areas are those that should be considered for protection and/or expansion to increase connectivity and the ability of species to move through the landscape.

Habitat (biodiversity) opportunity mapping could then be undertaken by using ecological networks to identify potential areas for new habitats. Identified areas will be ecologically connected to existing habitats, thereby expanding the size of the existing network, increasing connectivity and resilience, and potentially increasing the ecological quality of the new site.

Furthermore, Scotland's draft National Planning Framework 4 states that natural capital will play a vital role in locking in carbon and building resilience by providing valuable ecosystem services, and there is a specific action to sustain and enhance natural capital. Therefore, to further the resilience of the recommended set of interventions provided, we would advise that, in addition to mapping biodiversity opportunities for broad habitat groups, it is also possible to identify possible locations where new habitat can be created that will be able to deliver particular ecosystem service benefits. For all of the above, constraints would be mapped, and these areas would be removed from the final maps, to leave opportunity areas that were not subject to these constraints. In addition, these maps could be overlayed with each other and the biodiversity opportunity maps (as above), to show areas where new habitats could deliver multiple benefits and thus a more resilient multifunctional ecological network to be developed across the area. This mapping would also contribute towards strategies such as net zero and natural flood management.

Another consideration would be to undertake a natural capital valuation (or natural capital accounting) of the WLC landholdings. This would demonstrate the value of the parks, particularly the public benefits that are not always recognised, and could help move towards these areas being recognised as valuable assets for the council. If this was linked with the opportunity mapping outlined above, it would be possible to demonstrate the economic benefits of restoring or creating new habitats. As well as helping to present the business case for investment, this would lay the foundations for tapping into the new markets that are rapidly emerging around natural capital. Natural capital financing can be used as both a source of income and as a way of paying for habitat enhancement works. There are a number of emerging financing options, key amongst which are carbon markets, biodiversity offsetting, and agri-environment scheme reform.

Appendix. 1. Carbon sequestration breakdown by habitat

Habitat	WLC landholdings $tCO_2e/ha/yr$ (mean)	WLC Landholding tCO_2e/yr Total	West Lothian $tCO_2e/ha/yr$ (mean)	West Lothian tCO_2e/yr Total
Woodland, broadleaved	8.22	5,456.14	8.5	24,219.82
Woodland, coniferous	6.72	2,406.99	-0.13	-375.9
Woodland, Mixed	7.89	1,993.1	6.5	5,829.07
Scrub	2.97	97.25	2.43	396.84
Parkland/scattered trees	1.42	127.79	1.13	358.77
Recently felled woodland	3.17	228.2	0.5	929.85
Grassland, acid	0.78	0.23	0.6	0.96
Grassland, neutral	-2.5	-3.25	-4.82	-63.61
Grassland, improved	-1.42	-467.73	-1.52	-16,201.78
Grassland, marshy	1.5	33.44	0.52	58.32
Grassland, semi-natural	-2.08	-540.8	-2.08	-13,800.18
Heath	-1.16	-18.42	2.7	474.72
Mosaic; acid grassland, heath	-0.5	-2.74	-1.12	-1,968.83
Bog	-0.01	-0.19	-0.01	-5.43
Fen	0	0	1.49	3.87
Swamp	1.87	4.3	1.88	6.19
Water	-0.1	-4.8	-0.09	-55.48
Intertidal	0	0	2.21	619.37
Natural rock	0	0	0	0
Artificial rock	0	0	0	0
Arable	-1.96	-37.69	-1.8	-8,977.53
Amenity grassland	0.01	10.06	0.02	47.16
Built up area	0	0	0	0
Other	-0.65	-0.59	0.44	2.57
Infrastructure	0	0	0	0
Gardens	0.14	30.69	-0.03	-63.12
Unclassified	0	0	0	0
Total	**N/A**	**9,311.98**	**N/A**	**-8,564.35**