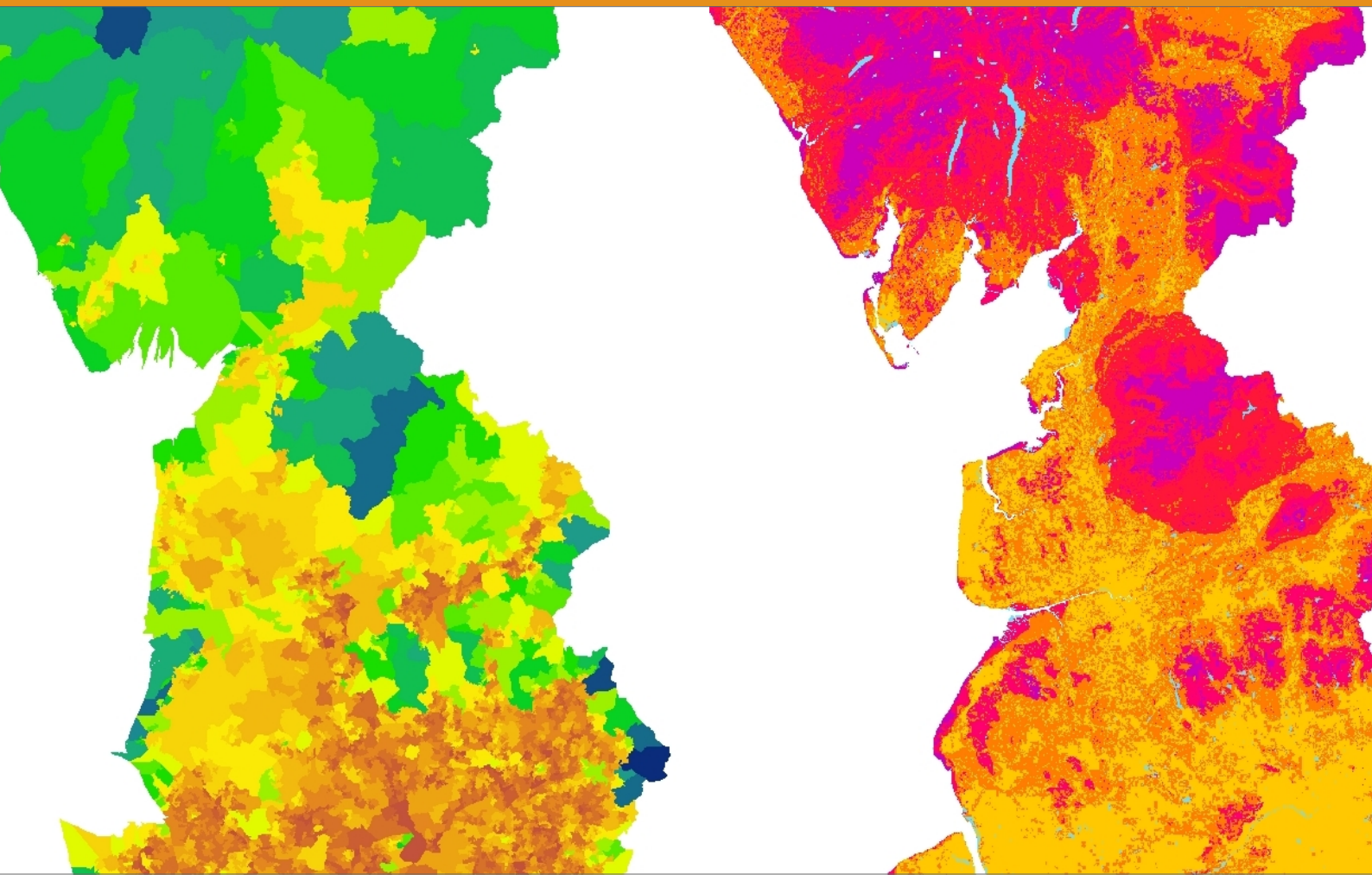
CRITICAL CLIMATE CHANGE FUNCTIONS OF GREEN INFRASTRUCTURE FOR SUSTAINABLE ECONOMIC DEVELOPMENT IN THE NORTH WEST OF ENGLAND



Northwest REGIONAL DEVELOPMENT AGENCY

NATURAL ENGLAND

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This project has received European Regional Development Funding through INTERREG IV B.

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ForeStClim

Preface

This is one of a series of reports produced between January 2008 and December 2012 as part of the ForeStClim project. ForeStClim is an EU-funded environmental project addressing forests and climate change. The short name stands for "Transnational Forestry Management Strategies in Response to Regional Climate Change Impacts". This project has received European Regional Development Funding through INTERREG IVB NWE. ForeStClim has a total budget of 11.6 million Euros of which 5.7 million Euros are being provided by the European Regional Development Fund (ERDF).

ForeStClim brings together 21 partners with a wide range of experts from United Kingdom, Germany, France, The Netherlands and Luxemburg. The main aim of this transnational co-operation is to develop proactive and adaptive regional forestry management and forest protection strategies in the face of the expected climate change scenarios. Consequently, it will contribute to the economic and ecological stability of the forests in North-West Europe (NWE).

The Mersey Forest is partner 13 and involved in the following areas of work:

- Work Package 1: Regional climate scenarios;
- Work Package 3: Ecological and economical sound forestry management strategies;
- Work Package 4: Regional implementation of management and risk strategies and stakeholder involvement.

This report is focused on Work Package 1 - Regional Climate Scenarios; delivering Output 1.3 - Production of a map of the different regions demonstrating the predicted impacts of climate change on a number of variables identified as being particularly relevant by the stakeholder community; from Action 1.5 - Deriving interactions between plant physiology / changed forest features and the atmosphere by coupling models and/or implementing forest data into atmospheric models.

The work was undertaken by Dr Susannah Gill and produced as part of 'Action 4.3' of the North West Climate Change Action Plan (NWCCAP). The aim of the work is to highlight how and where the climate change mitigation and adaptation functions of existing and/or potential green infrastructure (GI) are critical for the short term sustainable economic development of the North West region. It focuses down to the sub-regional/district level. In particular, it identifies actions to be taken over the next three years (with some focus on the longer-term) to resolve climate change related issues at 'pinch points'.

This work along with other ForeStClim information and publications can be found on the project website www.forestclim.eu and also at www.greeninfrastructurenw.org.uk and The Mersey Forest's website www.merseyforest.org.uk. We are interested in the ways that this report has been of use to you and can be contacted through our website.

Paul Nolan

Director, The Mersey Forest

Critical Climate Change Functions of Green Infrastructure for Sustainable Economic Development in the North West

Produced as part of 'Action 4.3' of the North West Climate Change Action Plan by Community Forests Northwest

October 2008

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Contents

1. Introduction

Green infrastructure (GI) has been defined as "the region's life support system – the network of natural environmental components and green and blue spaces that lies within and between the North West's cities, towns and villages which provides multiple social, economic and environmental benefits"[1].

The Natural Economy North West (NENW) project has identified eleven interlinked groups of economic benefits[2] provided by GI: climate change adaptation and mitigation, flood alleviation and water management, quality of place, health and well-being, land and property values, economic growth and investment, labour productivity, tourism, recreation and leisure, land and biodiversity, products from the land[3].

Action 4.3 of the NW Climate Change Action Plan[4], led by Community Forests North West, is to "undertake scoping studies to assess future regional risks, opportunities and priorities for the potential for green infrastructure, including regional parks, to adapt and mitigate for climate change impacts and commence implementation of findings". This is a 2-year project from April 2008 to March 2010. It will incorporate a number of activities including: identifying GI priorities for adaptation and mitigation; identifying research, policy and physical delivery; identifying climate change assets; a detailed study of two strategically important areas; and producing a regional GI Climate Change Action Plan.

NWDA have asked for aspects of this work to be 'fast-tracked' in order to inform the production of the NW Single Integrated Regional Strategy (SIRS). This report presents this 'fast-tracked' work. The aim of the work is to highlight how and where the climate change mitigation and adaptation functions of existing and/or potential green infrastructure (GI) are critical for the short term sustainable economic development of the NW region. It focuses down to the sub-regional/district level. In particular, it identifies actions to be taken over the next three years (with some focus on the longer-term) to resolve climate change related issues at 'pinch points'.

'Pinch points' have been interpreted here as being areas of regional economic importance/interest where there are potential considerations[5] for GI climate change functionality. Actions will seek GI solutions to these considerations. For example, areas of Salford can be seen as a 'pinch point'. It has been identified as a housing market renewal area with significant restructuring and development taking place, yet it is also subject to flood risk. A potential action could be to invest in GI upstream in the catchment to slow down flood waters, reducing risk and enabling development.

The work presented here is complimentary to the 'Environmental Considerations of Sustainable Economic Growth (ECOSEG)' study undertaken by URS Consultants. ECOSEG looked at four types of critical infrastructure: energy, water, waste, and transport. Green infrastructure should also be considered to be critical infrastructure.

It must be noted that the work presented here has been undertaken within a short timeframe. As such, it has relied on readily available datasets and understanding of the climate change functionality of GI. There is ongoing work by the sub-regional partnerships to develop GI plans,

[1] North West Green Infrastructure Guide (version 1.1). Prepared by the North West Green Infrastructure Think Tank. www.greeninfrastructurenw.co.uk
[2] Whilst the list is of economic benefits, it arguably covers the social and environmental benefits as well.
[3] Ecotec (2008). The Economic Benefits of Green Infrastructure: A review of the evidence base for the economic value of investing in green infrastructure.
[4] NW CCAP
[5] The term 'pinch point' tends to have negative connotations, suggesting that environmental considerations are always a negative – something that prevents economic growth. However, the work of the NENW programme has demonstrated that GI has economic benefits.

which will incorporate climate change related functions. It is also anticipated that further work through action 4.3 of the NW Climate Change Action Plan will refine this work.

It must also be noted that the starting point for this work is the climate change adaptation and mitigation benefits of GI. However, it is closely linked to other benefits – notably flood alleviation and water management, tourism, land and biodiversity, and products from the land. Indeed, GI by its definition is multi-functional, so whilst we are only considering climate change functionality here, the SIRS needs to reflect the other functions of GI.

2. Overview of Method

The method used the following broad stages:

- Identification and mapping of regional economic priorities (section 3);
- Identification of climate change risks and opportunities for regional economic priorities (section 3.1);
- Identification and mapping of climate change mitigation and adaptation functions of GI, and clipping these to the regional economic priority areas (section 4);
- Mapping the combined climate change mitigation and adaptation functionality of GI (section 5);
- Identification of emerging storylines for each sub-region (section 6);
- Identification of potential GI actions (section 7);
- Identification of future refinements to the process (section 8).

3. Regional Economic Priorities

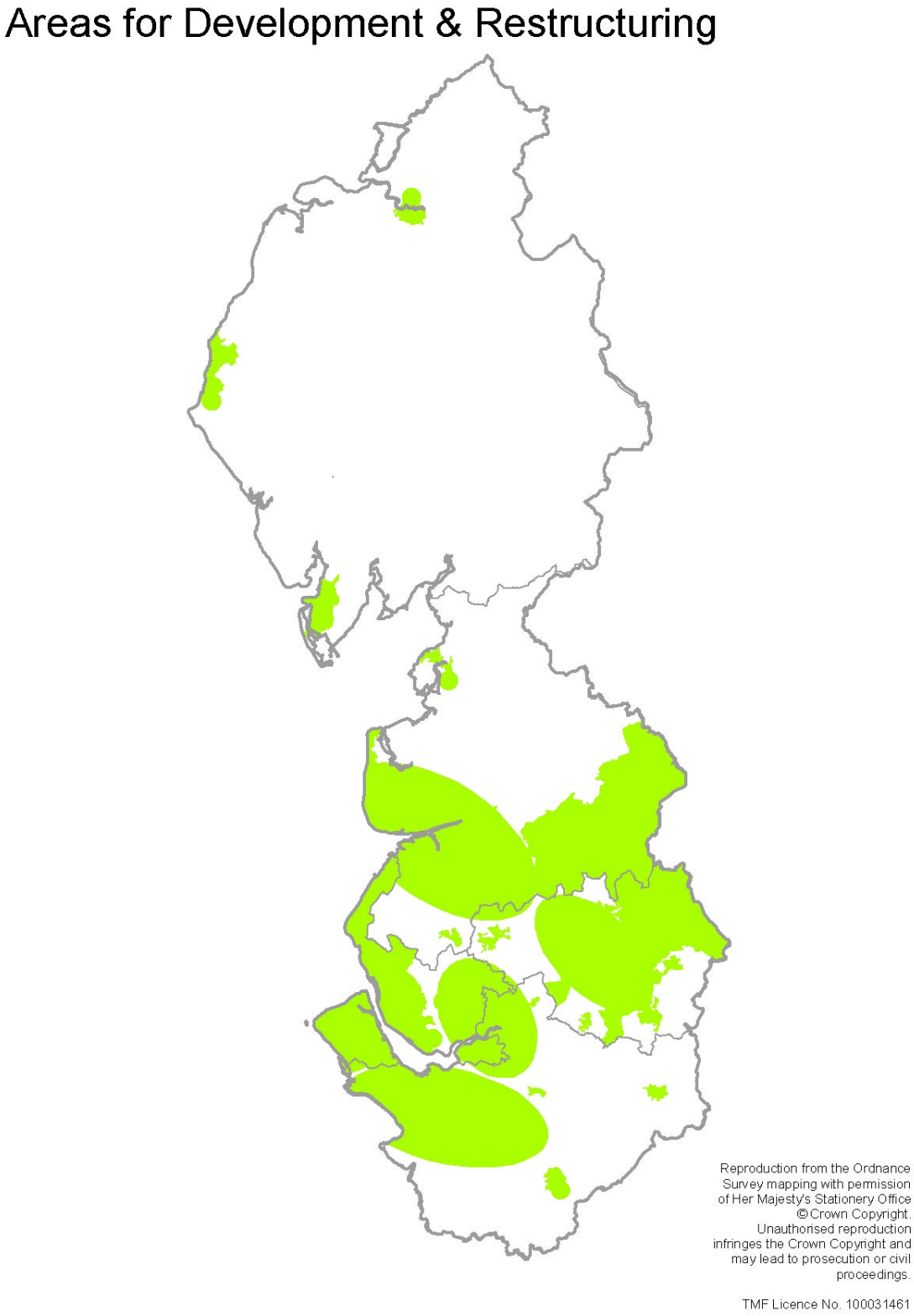
Three broad 'regional economic priorities' (based on themes from the Regional Economic Strategy and Regional Spatial Strategy as well as newer programmes and initiatives) were identified as being relevant to the climate change mitigation and adaptation functions of GI (section 4). These were:

- **Areas for development and restructuring** (figure 1) – this is mapped by combining growth points and growth point partnership areas[6] (figure 1a), housing market renewal districts and other areas needing similar intervention[7] (figure 1b), regional centres, towns and cities[8] (figure 1c), knowledge nuclei sites and regional investment sites[9] (figure 1d);
- **Areas of tourism significance** (figure 2) – this is mapped using attack brands (the Lake District, Manchester, Liverpool and Chester) and other areas aspiring to attack brand status (Blackpool)[10] (figure 2a), National Parks and Areas of Outstanding Natural Beauty[11] (figure 2b), Regional Parks[12] (figure 2c), Southport (which is aspiring to be a 'classic resort')[13], World Heritage Sites (Hadrian's Wall and Liverpool Waterfront), Lancaster and Carlisle[14] and English Heritage Historic Parks and Gardens (figure 2d).

[6] CLG (2008). Second Round Growth Points – Partnerships for Growth. Department for Communities and Local Government: London.
[7] NWRA (2006). The North West Plan – Submitted Draft Regional Spatial Strategy (RSS) for the North West of England. North West Regional Assembly: Wigan, p10.
[8] RSS. p.16.
[9] RSS. p.22.
[10] Transformational action 101 in NWDA (2006). Regional Economic Strategy (RES), p.46. Also in NWDA (revised 2007). The Strategy for Tourism in England's Northwest 2003-2010 – Developing the Visitor Economy. Northwest Regional Development Agency: Warrington, p15.
[11] Referred to as a regional tourism asset in RES, p.15.
[12] Action 116 in RES, p.48.
[13] Action 102 in RES, p.46.
[14] Action 115 in RES, p.48.

- **Areas of high quality agricultural land** (figure 3) – mapped using grade 1 and 2 agricultural land[15].

Figure 1.



[15] Defra. Agricultural Land Classification dataset.

Figure 1a.

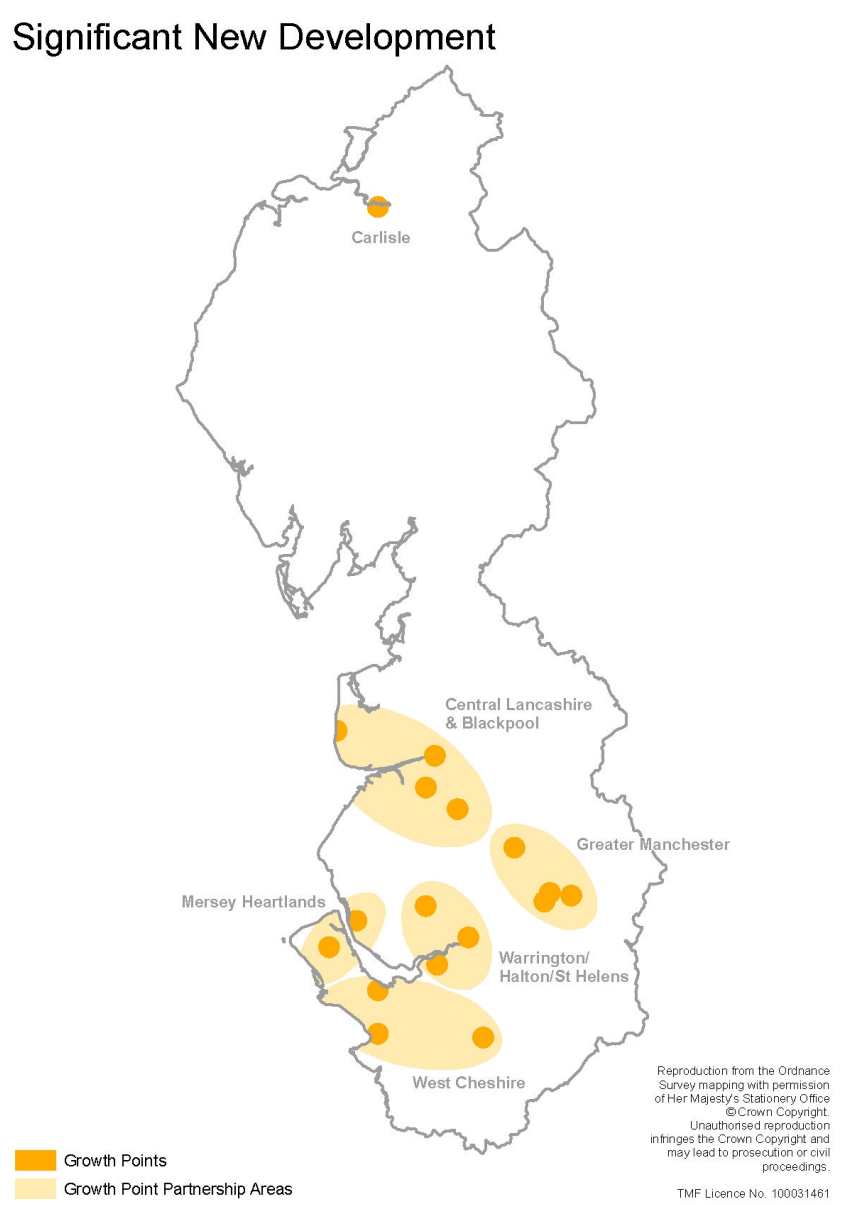


Figure 1b.

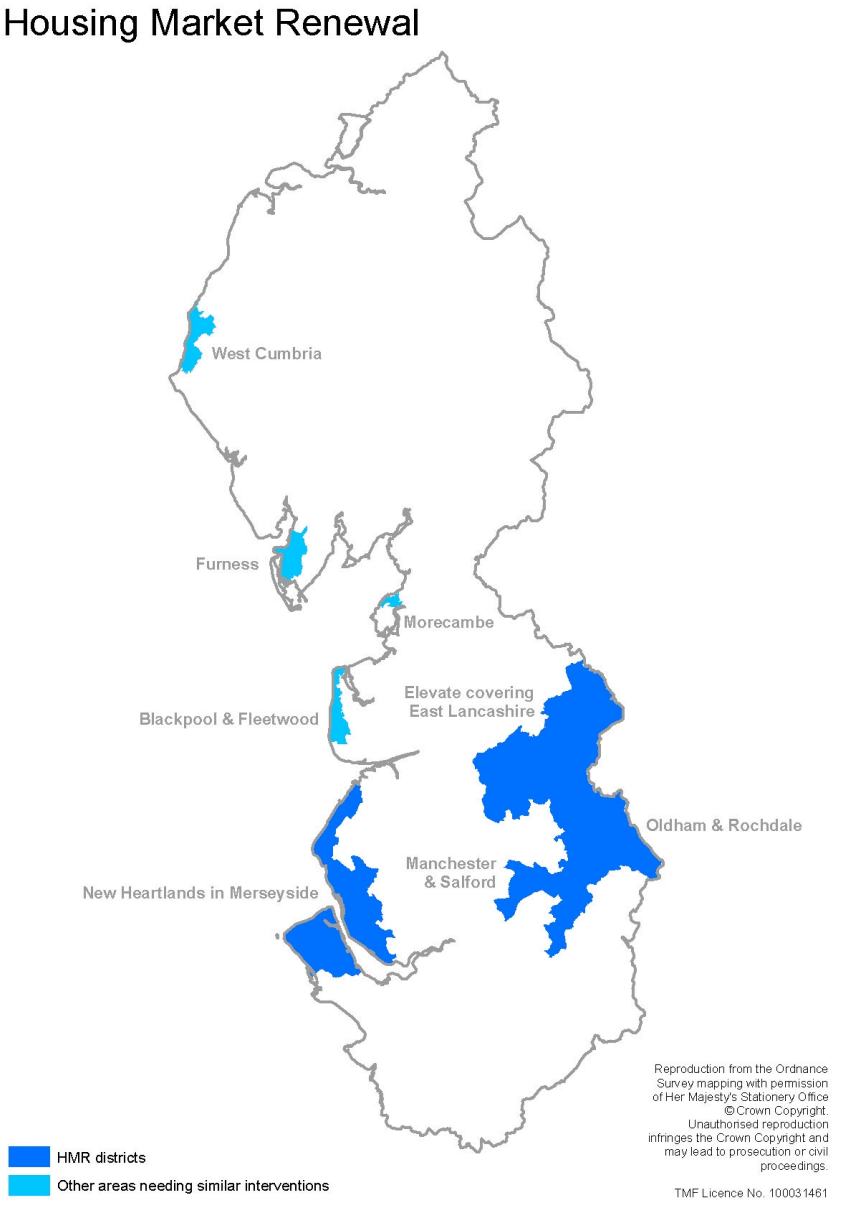


Figure 1c.

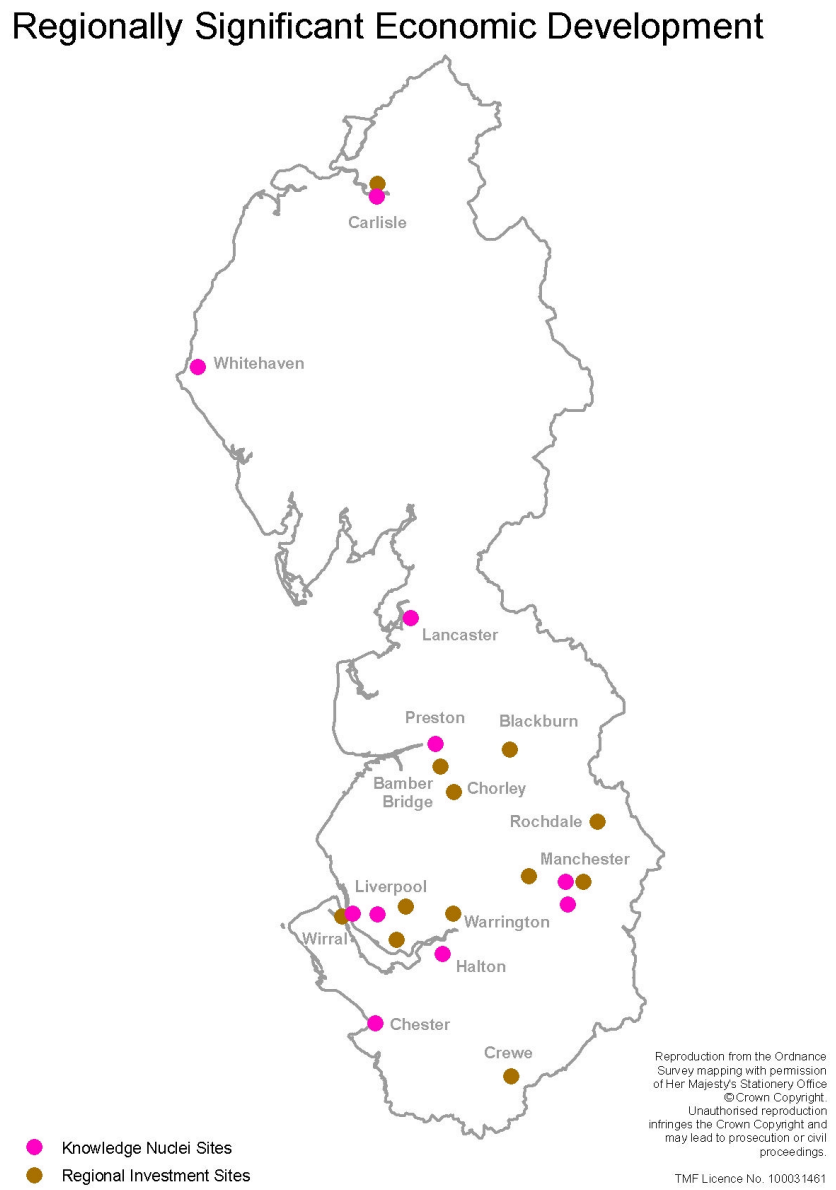


Figure 1d.

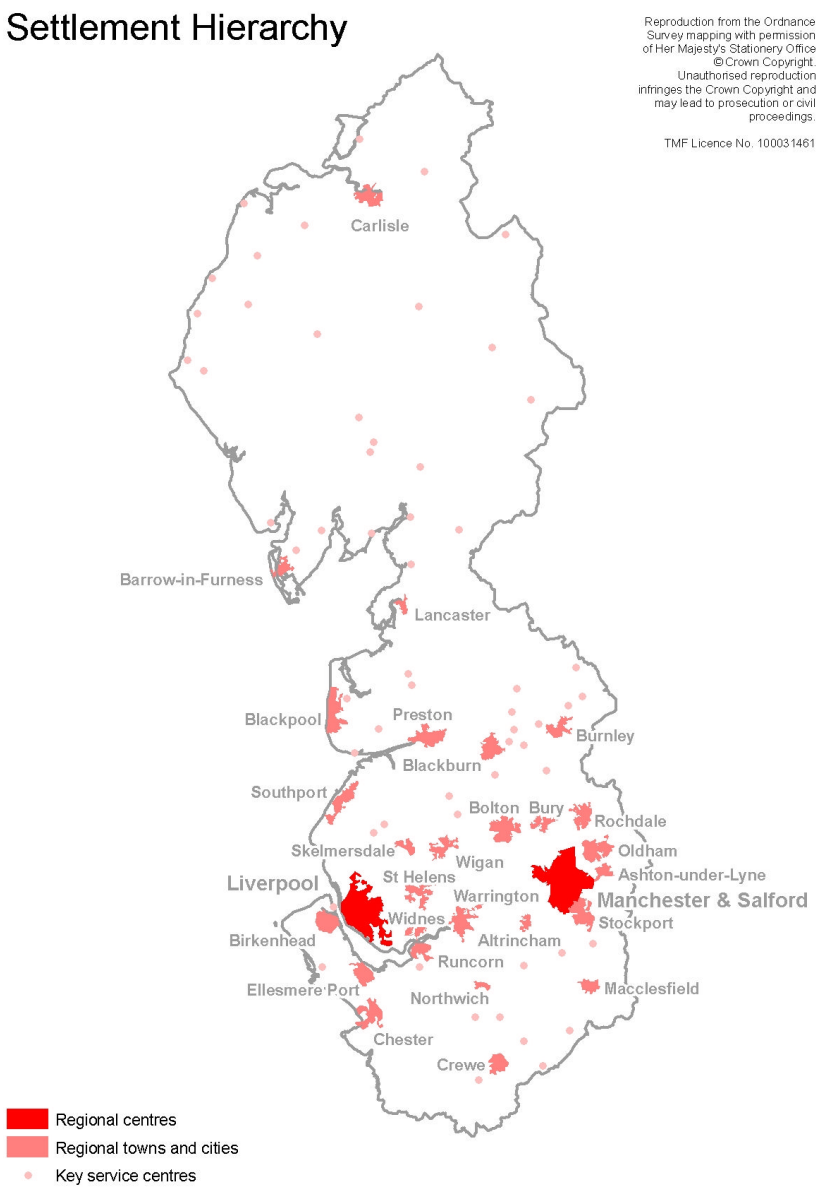


Figure 2.

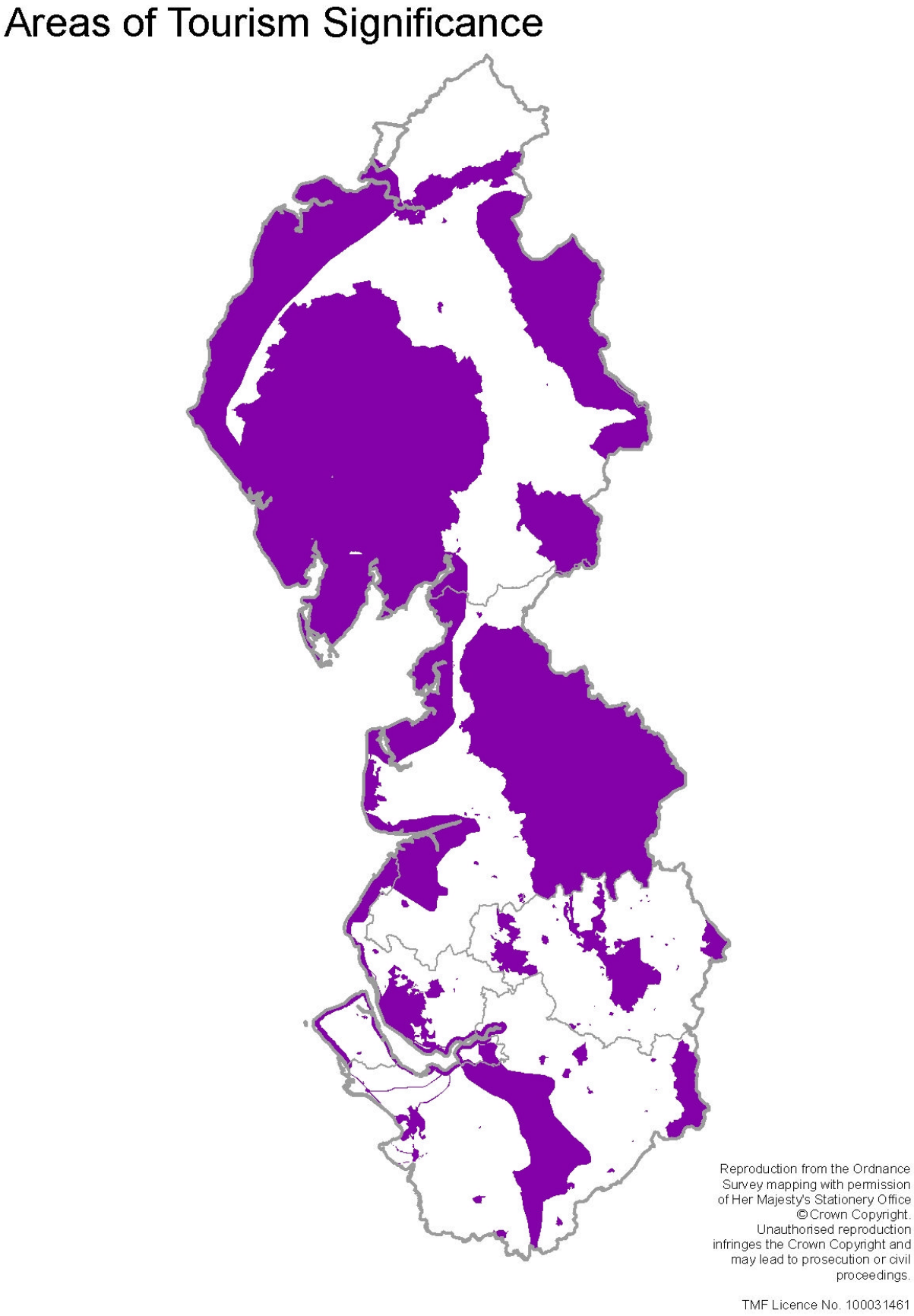

Areas of Tourism Significance
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Figure 2a.

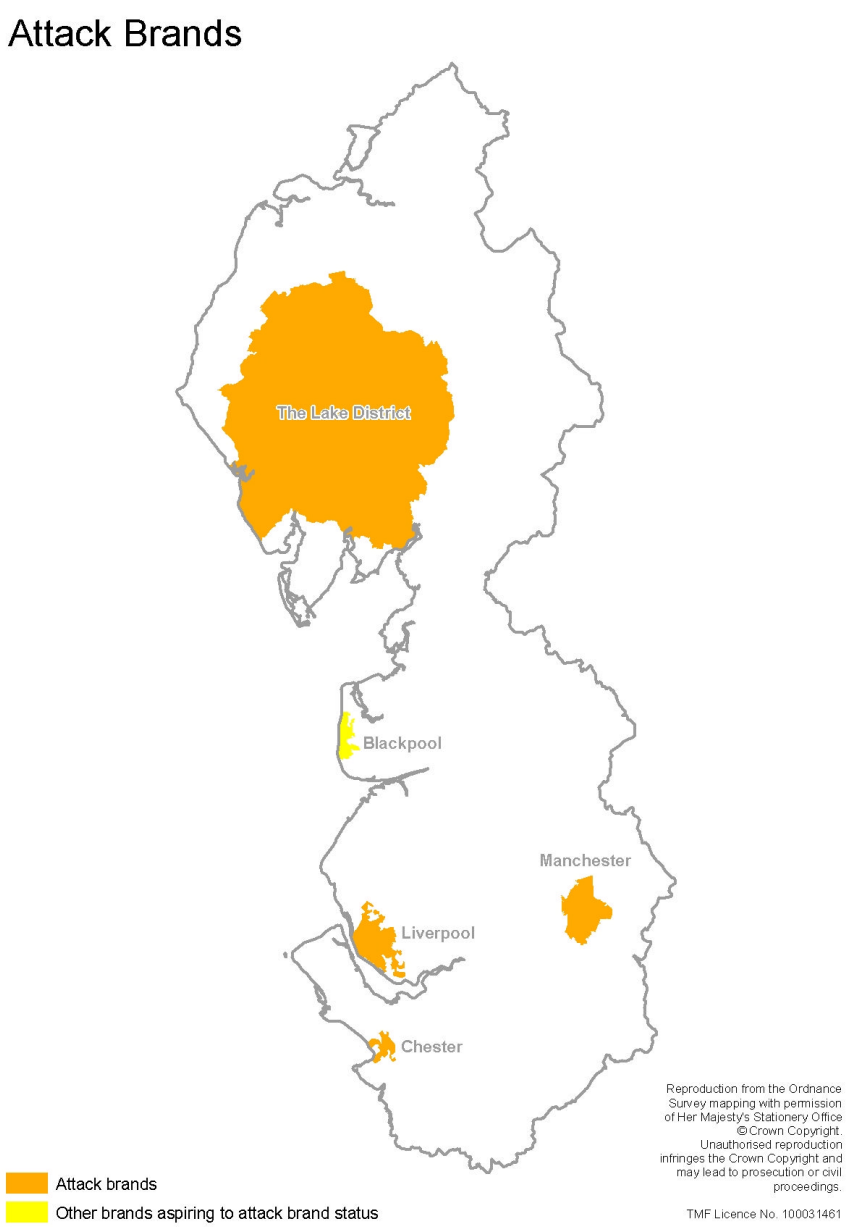


Figure 2b.

Figure 2c.

Regional Parks

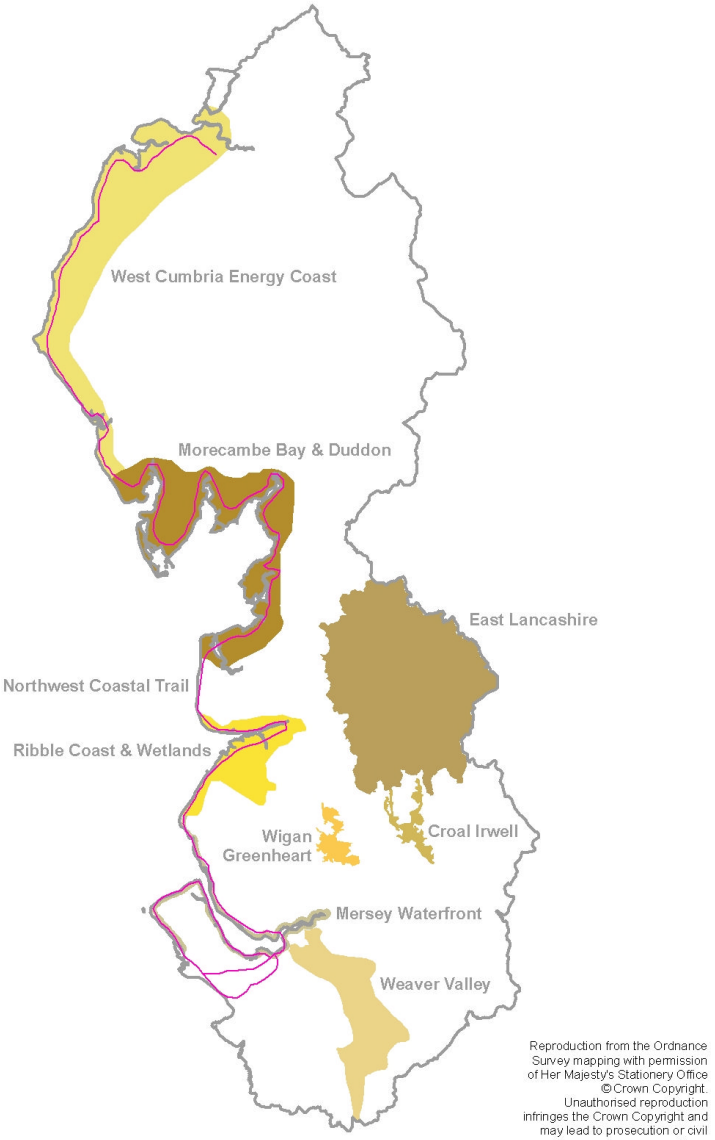
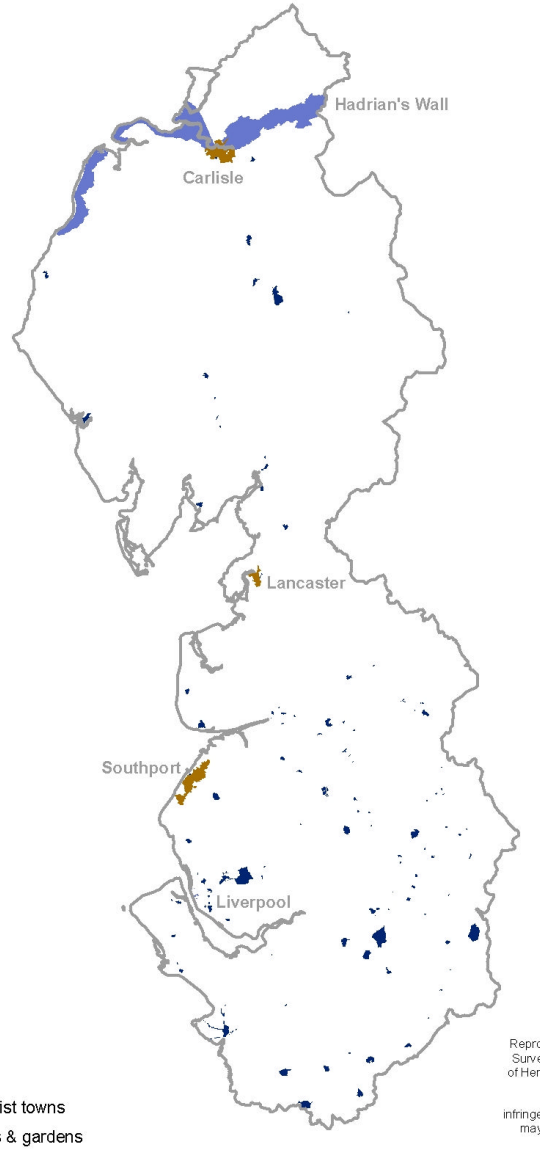


Figure 2d.

Other Areas of Tourism Significance



Additional tourist towns
Heritage parks & gardens
World Heritage Sites

Figure 3.

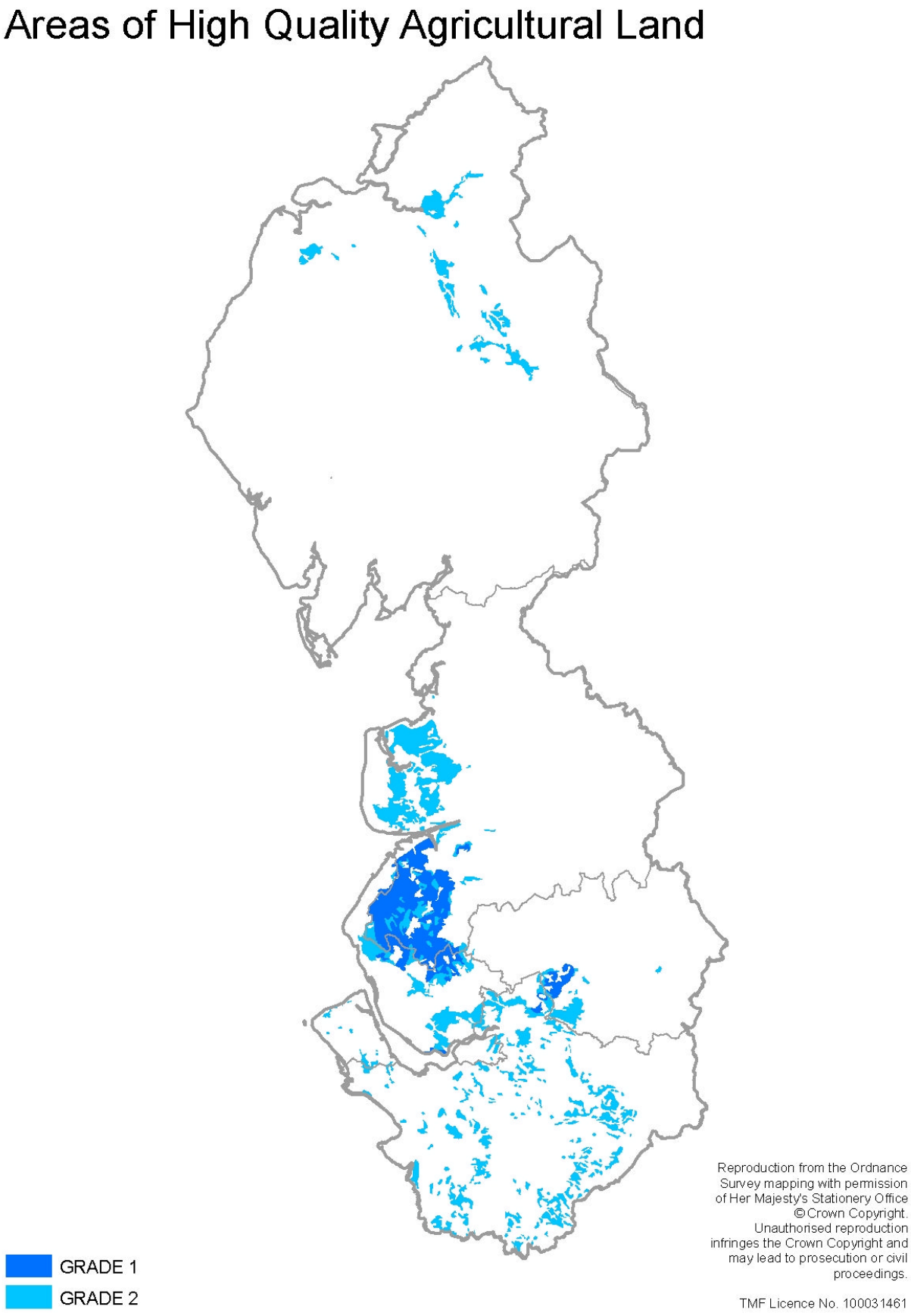

Areas of High Quality Agricultural Land
GRADE 1
GRADE 2
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Table 1 breaks down the 'regional priorities' according to their occurrence within the sub-regions and districts of the North West. This is helpful in prioritising the sub-regions according to each 'regional priority'. However, it must be stressed that it is in terms of the area (in km^2) covered within each sub-region or district; it is worth bearing in mind the distribution of land in the North West, with Cumbria accounting for almost half of the North West and Merseyside only 5% (figure 4). Other factors will need to be taken into account when prioritising. Thus, the greatest area covered by areas of:

- Development and restructuring is in Lancashire (1407 km^2), this is followed by Greater Manchester (833 km^2), Cheshire (800 km^2), Merseyside (646 km^2), and Cumbria (146 km^2);
- Tourism significance is in Cumbria (4327 km^2), followed by Lancashire (2019 km^2), Cheshire (510 km^2), Merseyside (254 km^2), and Greater Manchester (244 km^2);
- High quality agricultural land is in Lancashire (447 km^2), Cheshire (278 km^2), Merseyside (149 km^2), Cumbria (106 km^2), and Greater Manchester (50 km^2).

Figure 4. Proportion of land in the North West

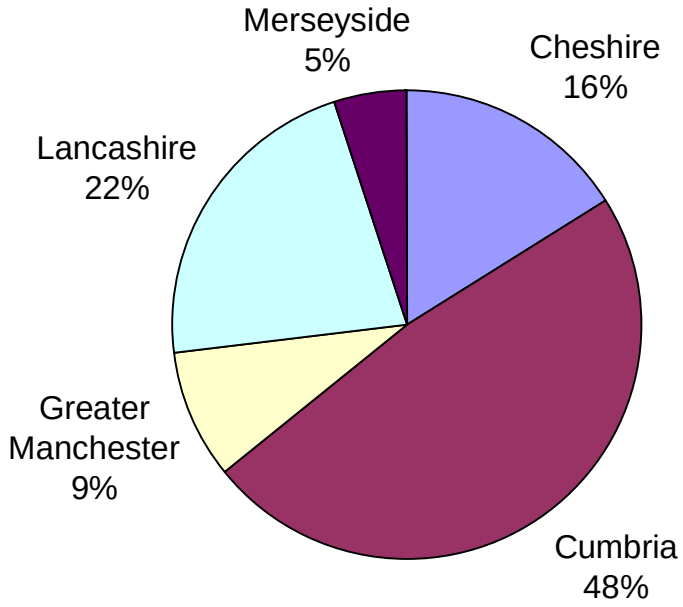

Table 1. Coverage (km^2) of regional priority areas in the districts and sub-regions of the North West

District/Sub-Region	Area (km^2)	Regional priority coverage (km^2 in district/sub-region)		
		Development	Tourism	Agriculture
Chester	447	273	31	52
Congleton	210	0	38	36
Crewe and Nantwich	427	57	136	57
Ellesmere Port & Neston	88	83	14	5
Macclesfield	521	11	102	35
Vale Royal	380	253	177	40
Warrington	181	123	13	53
Cheshire	**2253**	**800**	**510**	**278**
Allerdale	1271	29	1083	12
Barrow-in-Furness	74	54	74	0
Carlisle	1022	33	279	31
Copeland	727	31	679	0
Eden	2144	0	1027	62
South Lakeland	1548	0	1183	0
Cumbria	**6786**	**146**	**4327**	**106**
Bolton	140	105	19	0
Bury	99	68	28	0
Manchester	116	116	78	0
Oldham	138	138	28	0
Rochdale	158	158	3	0
Salford	97	97	21	18
Stockport	125	28	1	0
Tameside	103	18	8	1
Trafford	106	45	3	23
Wigan	188	60	55	7
Greater Manchester	**1270**	**833**	**244**	**50**
Blackburn with Darwen	137	137	137	0
Blackpool	36	36	27	2
Burnley	111	111	111	0
Chorley	203	198	5	17
Fylde	160	160	44	77
Hyndburn	73	73	73	0
Lancaster	566	26	413	6
Pendle	169	169	169	0
Preston	143	71	25	1
Ribble Valley	582	1	582	0
Rossendale	138	138	138	0
South Ribble	114	101	39	12
West Lancashire	347	146	114	248
Wyre	282	41	143	83
Lancashire	**3059**	**1407**	**2019**	**447**
Halton	79	70	38	16
Knowsley	87	40	18	31
Liverpool	110	110	94	5
Sefton	152	152	68	43
St. Helens	136	117	0	45
Wirral	158	158	37	9
Merseyside	**721**	**646**	**254**	**149**

3.1 Climate Change Risks and Opportunities for Regional Economic Priorities

Climate change will have both positive and negative impacts – or opportunities and risks – for the three regional economic priorities. In this section we begin to highlight the potential opportunities (table 2) and risks (table 3) for the regional priorities for which GI could be part of the solution. These can be linked to the action plan in section 5 via the 'GI function'.

Table 2. Climate change related opportunities for regional priorities and how GI can help to realise opportunities

Priority	Climate change opportunity	How GI can help realise opportunity	GI function
Development and restructuring	Increased demand for outdoor areas / outdoor living	Provision of a variety of green infrastructure and public space	Moderating urban heat island
			Reducing the need to travel by car
	Flooding – development near to flood risk area	Increase interception, infiltration and storage within the development to reduce flood risk to nearby area	Reducing flood risk
	Development sensitive to species movement requirements could help ability of species to adapt to change	Connecting and provision of habitats and corridors, increased permeability of landscape	Allowing species movement
Tourism	Increased demand for outdoor tourism	Provision of high capacity tourism resource near to people	Reducing visitor pressure on vulnerable landscape
			Reducing the need to travel by car
High quality agricultural land	Wider range of crops can be grown	Providing areas for agriculture	Food production
	Increase carbon store	Agricultural practices and management to increase carbon stored on high quality land, and potentially change of land use on lower quality land	Carbon storage and sequestration
	Agriculture sensitive to species movement requirements could help ability of species to adapt to change	Connecting and provision of habitats and corridors, increased permeability of landscape	Allowing species movement
	Flooding – reducing downstream flooding	Increase interception, infiltration and storage within lower quality agricultural land reduce flood risk to nearby area	Reducing flood risk

Table 3. Climate change related risks to regional priorities and how GI can help reduce risk

Priority	Climate change risk	How GI can help reduce risk	GI function
Development and restructuring	Flooding	Reduce rate and volume of runoff by increasing rainwater interception, conveyance and storage, and infiltration…	Reducing flood risk
	- in flood risk area	…upstream in the catchment	
	- passes on flood risk	…within the development	
	Human discomfort due to heat	Evaporative cooling and shading to moderate temperature extremes…	Moderating the urban heat island
	- in buildings	Shading, green roofs, and facades	
	- in external environment	Provision of a variety of green infrastructure including public spaces	
	Development contributes directly/indirectly to increased greenhouse gas emissions	Carbon sequestration and storage	Carbon sequestration and storage
		Provision of walking and cycling routes for daily commuting and recreation, and recreation areas	Reducing the need to travel by car
		Use of timber (especially locally sourced) as an alternative to materials with higher embedded energy	Material substitution
		Use of woodfuel for heating as an alternative to fossil fuels	Direct fossil fuel substitution
		Food production within and close to development to reduce food miles	Food production
	Development contributes negatively to ability of species to adapt to change	Provision of habitats and corridors, increased permeability of landscape	Allowing species movement
Tourism	Urban tourism becomes less attractive in summers due to urban heat island	Evaporative cooling and shading to moderate temperature extremes	Moderating the urban heat island
	Increased visitors put pressure on vulnerable landscapes	Management of tourism resource	Reducing visitor pressure on vulnerable landscapes
	Flooding – tourist attractions in flood risk areas	Reduce rate and volume of runoff by increasing rainwater interception, conveyance and storage, and infiltration in the catchment	Reducing flood risk
High quality agricultural land	Increased soil erosion leading to decreased quality	Provide wind shelter, reduce runoff, increase infiltration, and improve soil strength and stability	Reducing soil erosion
	Flooding	Reduce rate and volume of runoff by increasing rainwater interception, conveyance and storage, and infiltration…	Reducing flood risk
	- in flood risk area	…upstream in the catchment	
	- passes on flood risk	…within the agricultural land	
	Agriculture contributes directly/indirectly to increased greenhouse gas emissions	Carbon sequestration and storage	Carbon sequestration and storage
		Food production within and close to where people live to reduce food miles	Food production
	Agriculture contributes negatively to ability of species to adapt to change	Provision of habitats and corridors, increased permeability of landscape	Allowing species movement

4. Climate Change Mitigation and Adaptation Functions of Green Infrastructure

The climate change mitigation and adaptation functions of GI are listed in table 4. This sets out where this functionality is most critical alongside the dataset used here to map each at the regional level. Given the timeframe for completing this work, the mapping has used readily available datasets. Thus, there is scope to improve the mapping if other datasets become available. For example, in terms of flood risk reduction, the Environment Agency's flood zones dataset is used. This captures fluvial and tidal flood events, but not pluvial flood events (e.g. from overwhelmed drains) which are becoming more common.

The sub-sections below cover each of the GI climate change mitigation and adaptation function in turn. For each function, there is a discussion setting out the context for each function at the regional level as well as in the relevant priority areas (i.e. those listed in tables 2 and 3 in relation to each of the regional priorities). This is then followed by suggested actions.

Table 4. Climate change mitigation and adaptation functions of green infrastructure

Function	Where is this most critical	How it was mapped
Mitigation		
Carbon sequestration and storage	Where carbon density in soils and vegetation is highest	National carbon density dataset (data courtesy of R. Milne, Centre for Ecology and Hydrology) (figure 6)
Direct fossil fuel substitution	Less critical – areas growing alternative fuels could be sited elsewhere	Not mapped here
Material substitution	Less critical – areas growing alternative materials could be sited elsewhere	Not mapped here
Reducing need to travel by car – high quality local recreation areas and green walking/cycling routes	In proximity to people in urban areas Connecting residential areas to town/local centres, work places, etc	Countryside Rights of Way Act open access land dataset (Natural England), Woods For People dataset (Woodland Trust), Sustrans routes (figure 7)
Food production	Near and in (e.g. allotments) urban areas Best quality agricultural land	Agricultural Land Classification dataset (Defra) (figure 8)
Adaptation		
Moderating urban heat island – evaporative cooling, shading, cold air drainage	In urban areas In particular town centres and areas where people congregate, highly built-up areas, areas of highest socio-economic vulnerability (elderly, young, poor health, low income) Shading of tree canopies, in particular those with large mature crowns Corridors into urban areas in the direction of the prevailing wind	For vulnerable people: Census 2001 Age Structure dataset (Office for National Statistics), Indices of Multiple Deprivation dataset (Department for Communities and Local Government) (figure 9) For settlements: Regional centres, towns and cities (RSS p.16) (see figure 1d)
Reducing flood risk – rainwater interception, infiltration, conveyance and storage (and buffering in coastal areas)	Floodplains in urban areas and upstream (also potentially downstream where rivers are tidal) Soils with best infiltration capacity Tree canopies	Flood Zones dataset (Environment Agency) (figure 10)
Reducing soil erosion	Where soils are most vulnerable and productive	Soil erosion risk (data courtesy of Gina Cavan, University of Manchester) (figure 11)
Allowing species movement – habitats and corridors	Around and through the conurbations of the Mersey Belt Through agricultural land	Ecological network dataset (Roger Catchpole, Natural England) (figure 12)
Reducing visitor pressure on vulnerable landscapes – creation of high capacity areas	In and near urban areas	Landscape capacity (data courtesy of Gina Cavan, University of Manchester) (figure 13)

4.1 Carbon Sequestration and Storage

Carbon is stored in soils and vegetation. In the UK soils contain more carbon than vegetation[16]. However, it must be stressed that different soil types have different carbon contents (e.g. peat stores more carbon than sand). Different types of vegetation also store different amounts of carbon (e.g. forests generally have significantly higher above-ground carbon reservoirs than other vegetation types[17]). Depending on their nature, changes to land use and/or management practices can lead to increases or decreases in the amount of carbon stored in both soils and vegetation.

In the UK, Defra publishes statistics (for each local authority and region) on CO_2 emissions by end user. This includes net emissions from 'land use, land use change and forestry (LULUCF)' which includes both sources (emissions) and sinks (removals) of atmospheric CO_2[18] (emissions are generally from soils and liming of soils and removals are through forest growth). Figure 5a shows the total CO_2 emissions by end user for the North West, with LULUCF activities accounting for only 1% of the total. Figure 5b shows the emissions and removals of CO_2 from LULUCF activities in the North West, with net emissions of 697 kt CO_2 (by end user, 2005). The aim should be for a net removal; in the UK, LULUCF activities lead to a net removal of emissions from the atmosphere. This would involve maintaining existing carbon stores and seeking to sequester carbon where opportunities arise.

Figure 6 shows the carbon density of soils and vegetation across the North West; figures 6a and 6b show this in areas of development and restructuring and in areas of high quality agricultural land, respectively. Soils and vegetation in the North West store 2.5 MtC, with a mean density of 178 tC/ha. This ranges from 0 tC/ha to 1146 tC/ha in South Lakeland.

In areas of development and restructuring the mean carbon density is 133 tC/ha. This is lower than the regional average. However, the maximum carbon density within the development areas is 1090 tC/ha in Salford; representing areas of significant carbon storage. Other areas with significant carbon stores include West Lancashire and Fylde. New development should be avoided in areas of high carbon density as it would reduce the amount of carbon stored; such areas should be managed as long term carbon stores. New development should also mitigate any loss of carbon by contributing to carbon sequestration and storage opportunities elsewhere (e.g. planting woodland in suitable areas).

In areas of high quality agricultural land the mean carbon density is 251 tC/ha. This is higher than the regional average. The maximum carbon density within these areas is 1090 tC/ha in Salford; representing areas of significant carbon storage. Other areas with significant carbon stores include West Lancashire, Fylde and Wyre. It is important to ensure that agricultural practices maintain this carbon store, and seek to increase it through land and soil management (e.g. adding biochar or compost to soils, reduced tillage, managed grazing etc).

Actions for carbon sequestration and storage are to:

- Aim for net removal of CO_2 in the North West from land use, land use change and forestry
- Avoid new development in areas with highest carbon densities
- Maintain the carbon storage in high density areas, such as areas with a higher density than the NW mean of 178 tC/ha

[16] Milne and Brown (1997) Carbon in vegetation and soils of Great Britain. Journal of Environmental Management: 49, 413-433.
[17] Broadmeadow and Matthews (2003) Forests, carbon and climate change: the UK contribution. Forestry Commission Information Note 48.
[18] Emissions are generally from soils due to land use change and liming of soils and removals are through forest growth

- Increase carbon stored – e.g. through agricultural practices, woodland creation
- Offset carbon lost through new development by increasing carbon stores and/or maintaining the carbon stored in other areas
- Target areas to maintain and increase carbon stored – e.g. woodland creation in lower quality agricultural areas where it has potential to be multi-functional, management of areas of significant carbon stores

Figure 5a.

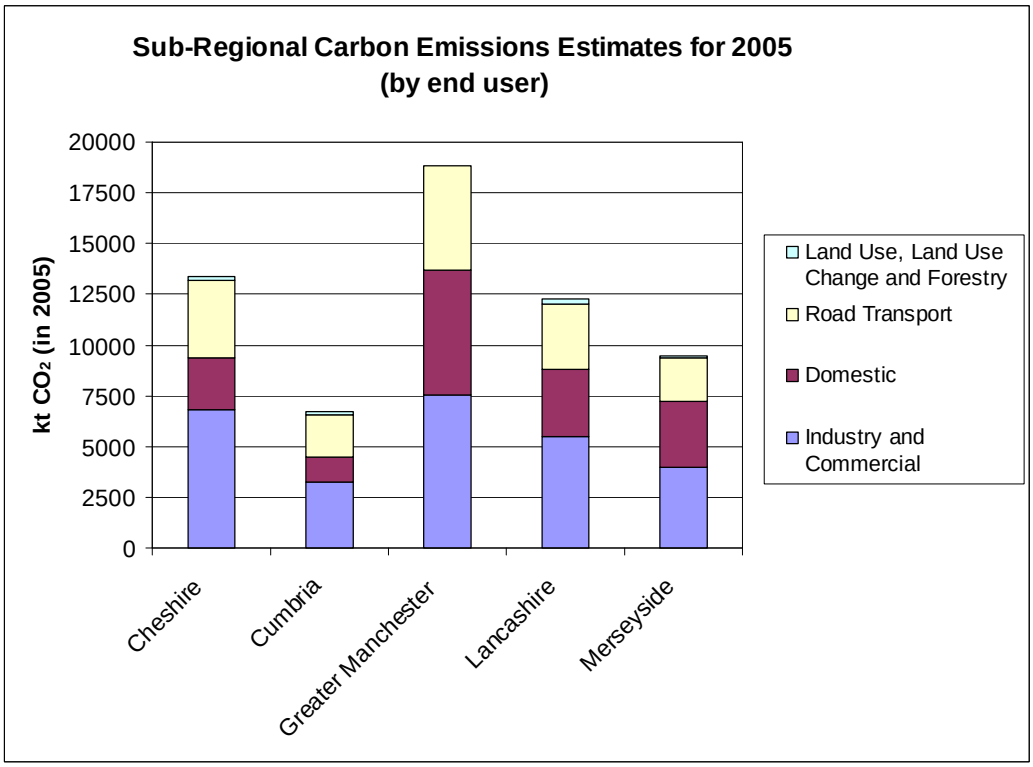

Figure 5b.

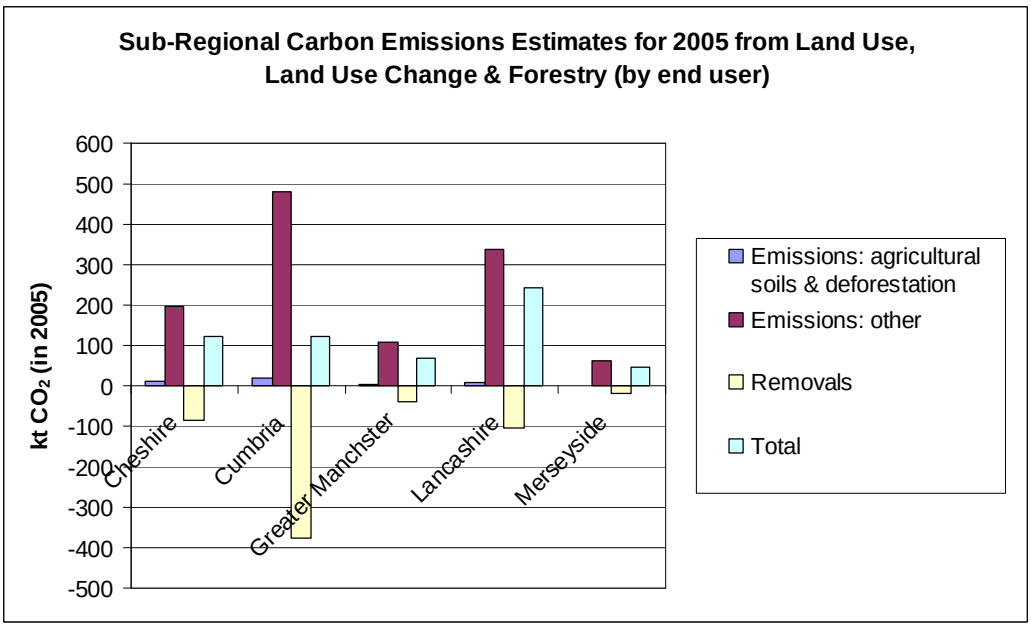

Figure 6.

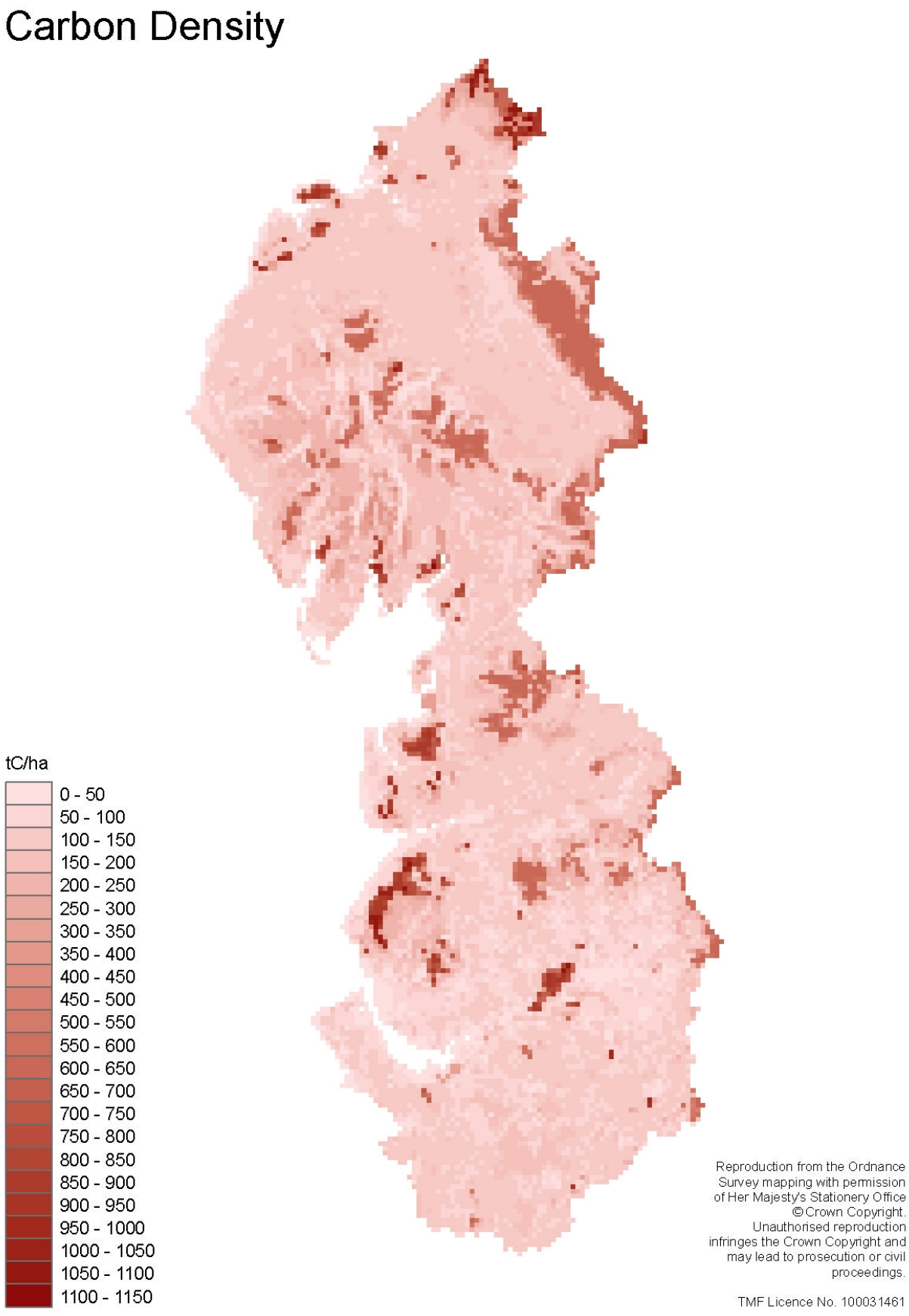
Carbon Density
tC/ha
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 400
400 - 450
450 - 500
500 - 550
550 - 600
600 - 650
650 - 700
700 - 750
750 - 800
800 - 850
850 - 900
900 - 950
950 - 1000
1000 - 1050
1050 - 1100
1100 - 1150
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Figure 6a.

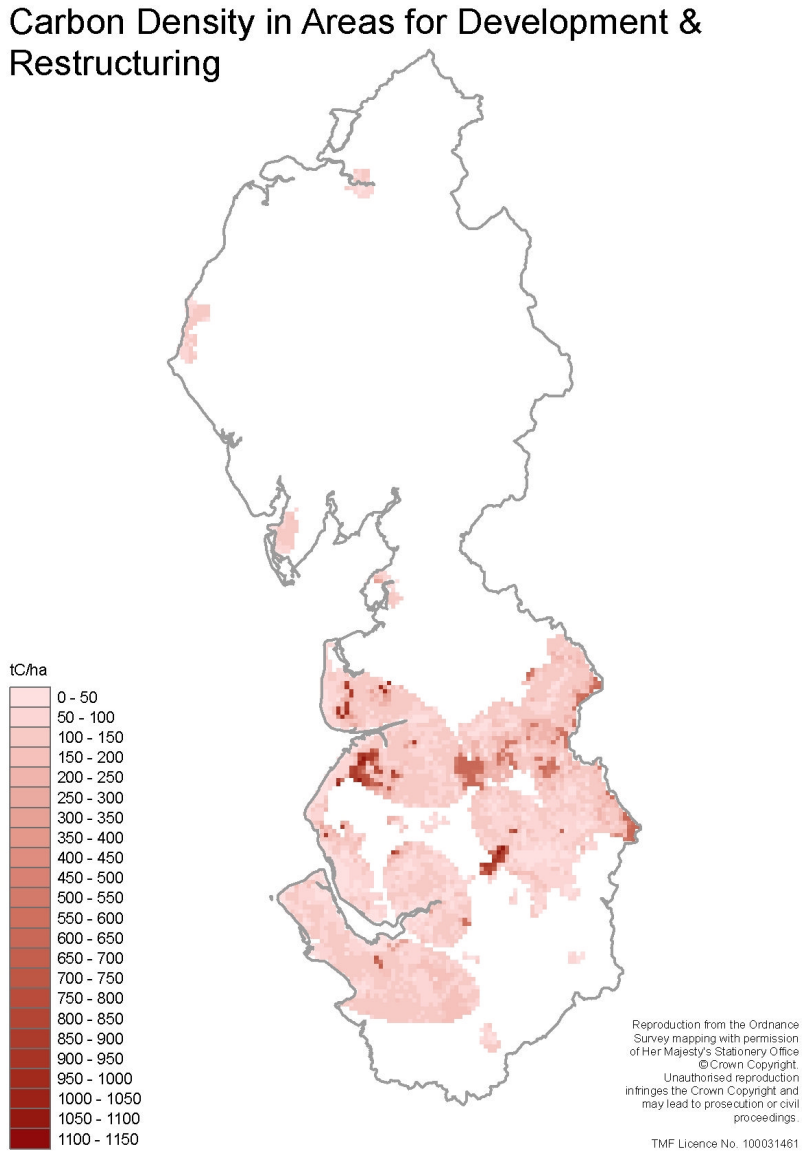
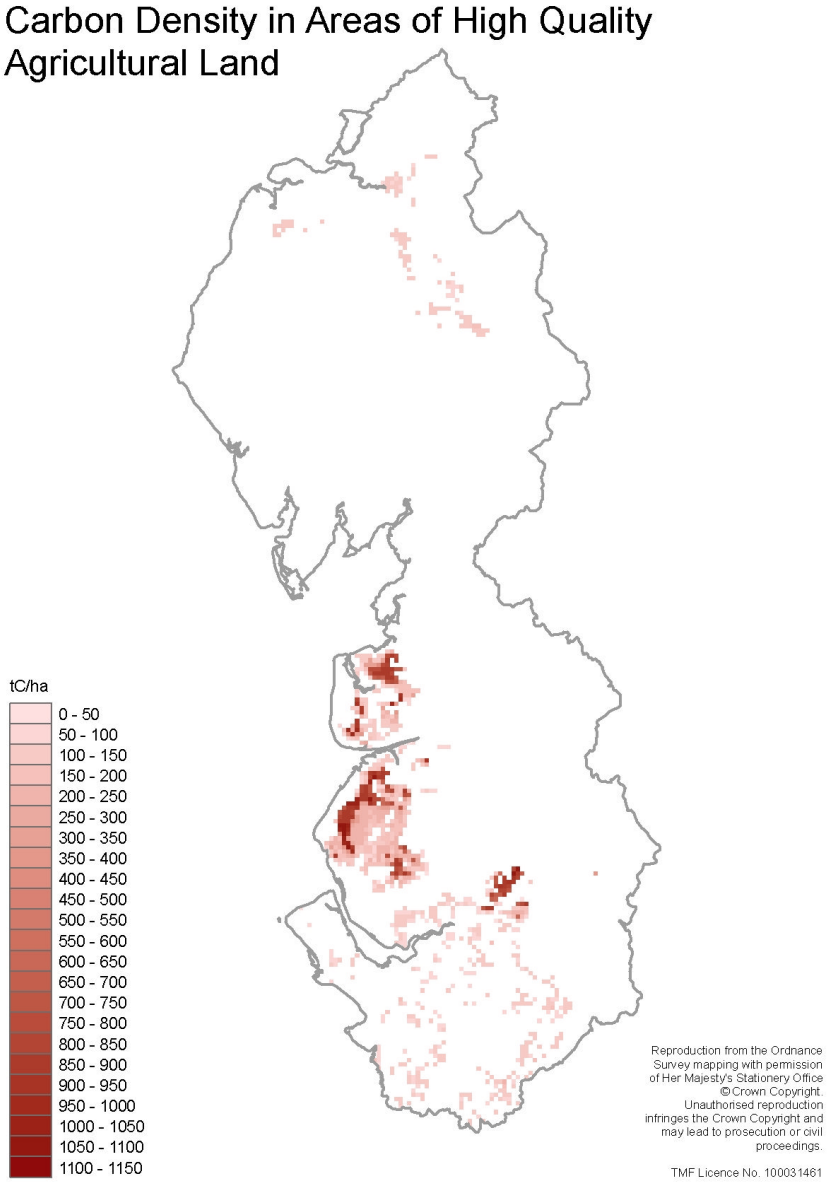


Figure 6b.



4.2 Reducing the Need to Travel by Car

Reducing the need to travel by car will help to decrease the amount of CO_2 emitted. There are two main mechanisms through which GI can reduce the need to travel by car: by providing high quality local recreation areas, and by providing green walking and cycling routes for both recreation and daily commuting.

Here we have used open access land, open access woodlands, and Sustrans cycling routes, as a proxy for local recreation areas. We have not in this instance mapped green walking and cycling routes in relation to daily commuting. Whilst this issue needs to be highlighted at a regional level, it may be best dealt with at a local to city / sub regional level, using locally available datasets. It is likely that local authorities will have better datasets of recreation, walking and cycling opportunities (and how these link to residential and employment neighbourhoods) in their areas.

Figure 7 shows open access land near to urban areas in the North West; figures 7a and 7b show it in relation to areas of development and restructuring and areas of tourism significance, respectively.

In the North West there are 363,266 ha of open access land[19], of which 79,117 ha (21.8% of the North West total) is within 5 km of urban areas and 134,649 ha (37.1% of the North West total) is within 10 km of urban areas. This means that the majority of the resource, located primarily in Cumbria, is not that near to the urban areas.

In areas of development and restructuring, there are 58,924 ha (or 16.2% of the North West total) of open access land. However, the majority of this is in east Lancashire, meaning that some of the development areas have little open access land. As new development takes place and areas are redeveloped there is a need to preserve open access land as well as taking the opportunities to provide high quality local recreation areas. Local green routes for walking and cycling, thereby reducing the need to travel by car on a daily basis, have not been mapped here. However, it is important that this is included in plans and as development and restructuring takes place.

In areas of tourism significance there are 269,781 ha (or 74.3% of the North West total) of open access land. Whilst a lot of the National Parks and Areas of Outstanding Natural Beauty are covered by open access land providing significant tourism and recreation opportunities, there may be a need to improve access in some of the other areas of tourism significance. This mapping would need to be repeated using more localised datasets in order to determine the access in these areas.

Actions for reducing the need to travel by car are to:

- Protect and create high quality recreation areas and local walking and cycling routes (for recreation and commuting) in and near to urban areas, particularly during development and restructuring
- Protect and create local walking and cycling routes (for recreation and commuting) connecting rural areas, as well as rural to urban areas
- Highlight this as an issue to be addressed in local, city/sub-regional plans

[19] Using Natural England's Countryside and Rights of Way dataset, Woodland Trust's Woods for People dataset, and Sustrans routes.

Figure 7.

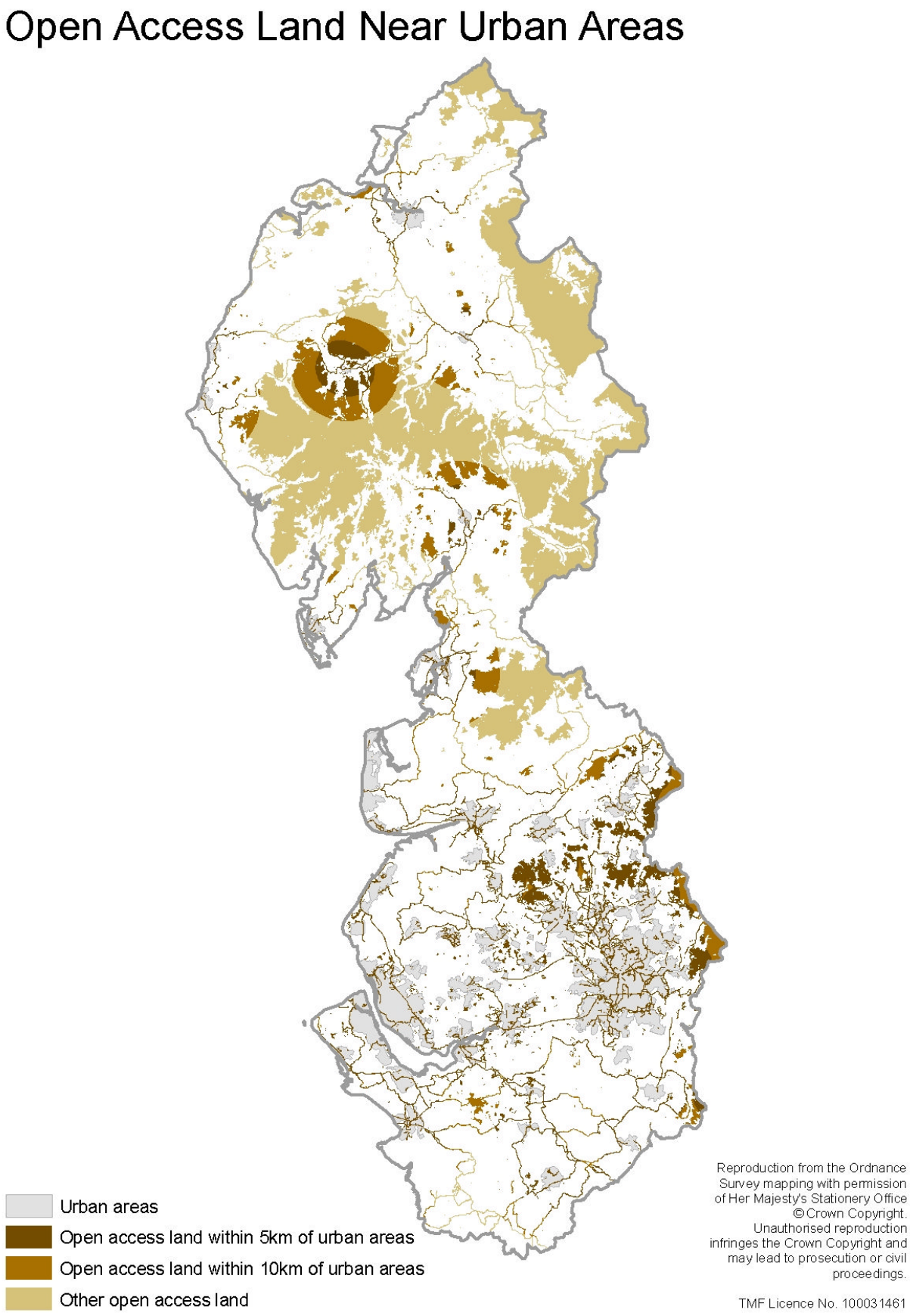

Open Access Land Near Urban Areas
Urban areas
Open access land within 5km of urban areas
Open access land within 10km of urban areas
Other open access land
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Figure 7a.

Figure 7b.

4.3 Food Production

Food production in proximity to markets can help to reduce 'food miles', thereby helping to decrease the amount of CO_2 emitted as a result of the transportation of food. Grade 1 and 2 agricultural land is the highest quality land and is the most versatile in terms of food production.

Figure 8 shows agricultural land in the North West in relation to urban areas; figure 8a shows its occurrence within areas of development and restructuring.

In the North West there are 29,109 ha of grade 1 agricultural land and 73,791 ha of grade 2 agricultural land. Most of this is close to urban areas, especially in West Lancashire, Fylde, Salford, Trafford, Warrington, St Helens and Knowsley. 85% of grade 1 land in the North West is within 5 km of urban areas, whilst all of it is within 10 km; 59% and 88% of grade 2 land is within 5 km and 10 km of urban areas, respectively. Within 10 km of urban areas there are also 349,444 ha, 149,148 ha and 102,741 ha of grade 3, 4, and 5 land, respectively.

Areas of development and restructuring include 46% and 39% of the North West's grade 1 and 2 land, respectively. This is predominantly in the Growth Point Partnership Areas of Central Lancashire and Blackpool, Warrington / Halton / St Helens, and West Cheshire.

It is important to avoid new development on this high quality land. However, there is also a significant resource in terms of local food supply to be tapped into, making these potentially attractive and sustainable places to live.

It should be noted that the agricultural land classification does not pick up the quality of urban and urban-fringe soils. These could potentially be very productive as older settlements were often at the centre of good farmland. They are also subject to planning policies and development pressures leading to their cumulative loss.

Actions for food production are to:

- Protect highest quality agricultural land from development and restructuring
- Enhance quality of grade 3 land, particularly where it is in proximity to markets
- Link agricultural land to local markets, including in development and restructuring areas
- Promote agricultural practices which reduce greenhouse gas emissions (e.g. organic, low tillage, etc)

Figure 8.

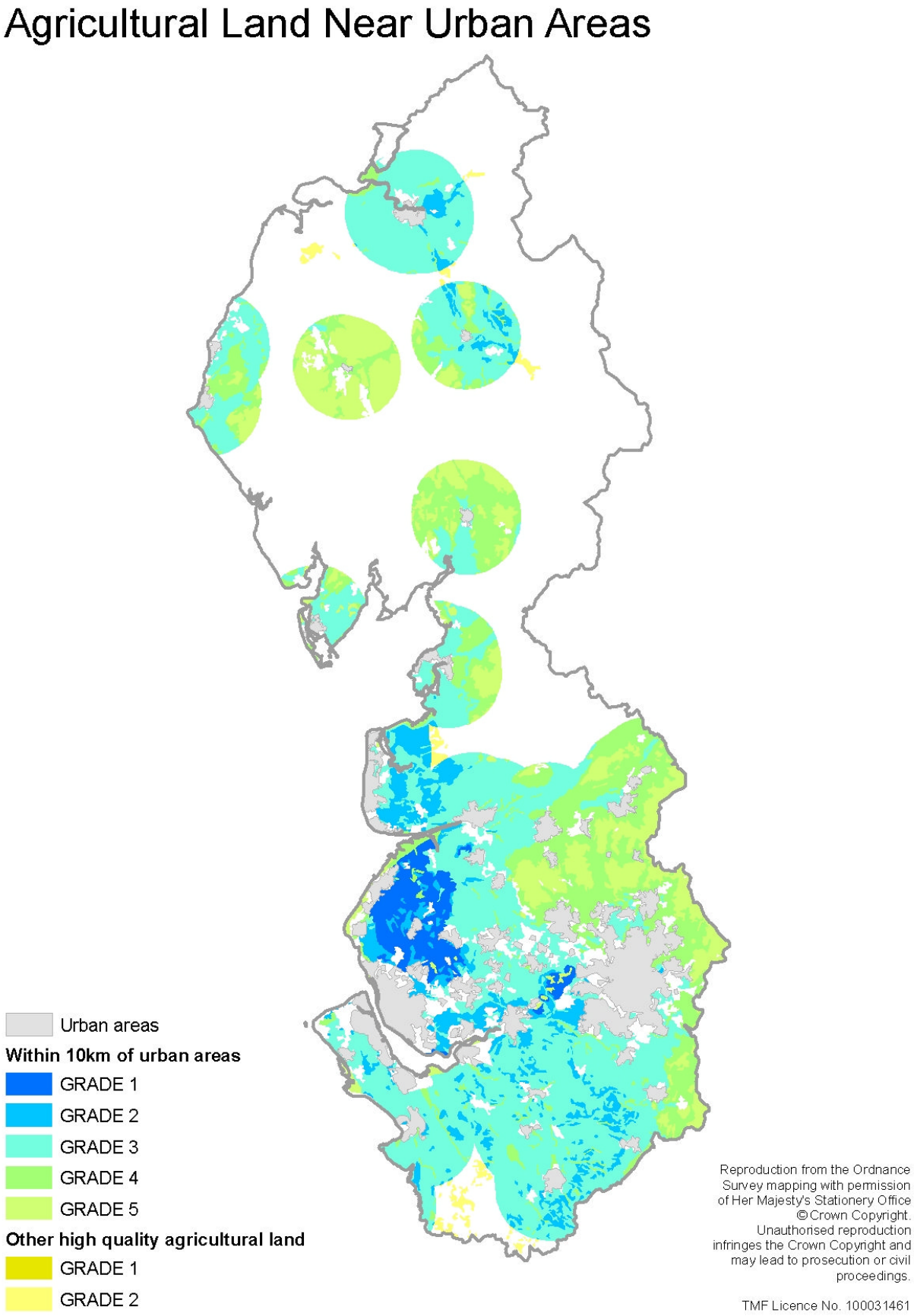
Agricultural Land Near Urban Areas
Urban areas
Within 10km of urban areas
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
Other high quality agricultural land
GRADE 1
GRADE 2
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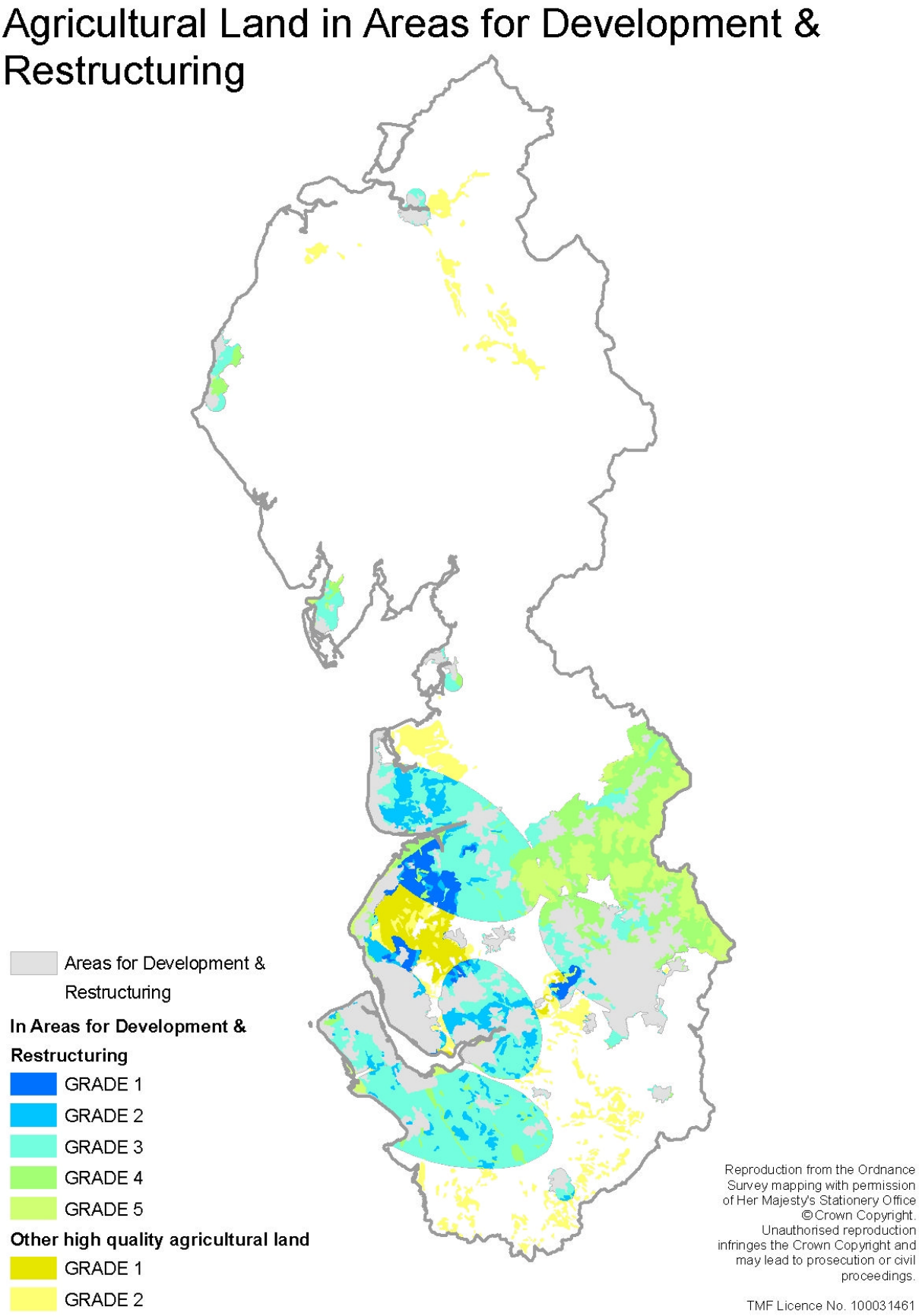
Figure 8a.


Agricultural Land in Areas for Development & Restructuring
Areas for Development & Restructuring
In Areas for Development & Restructuring
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
Other high quality agricultural land
GRADE 1
GRADE 2
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4.4 Moderating Urban Heat Island

Climate change will bring warmer average temperatures as well as more extreme events such as more heatwaves and of a longer duration. This will be felt particularly in urban areas where the urban heat island is already a recognized phenomenon. The most vulnerable areas will be densely built up areas with a low green (and in particular tree) cover, such as town centres and high density residential areas. The most vulnerable people to heat stress and potentially mortality will be the elderly, the young, those in ill health and the poor.

GI has the potential to help adapt urban areas to cope with these increased temperatures by providing evaporative cooling and shading (particularly from trees with large mature canopies), as well as providing opportunities for cold air drainage and air flows. Modelling work has suggested that adding 10% green cover to built-up areas in Greater Manchester keeps surface temperatures at a 1961-1990 baseline level up until the 2080s High emissions scenario[20].

This has implications for development and restructuring in creating places where people will be comfortable to live and work, as well as for tourism in creating comfortable and attractive places to visit.

Figure 9 shows the location of vulnerable people in the North West, particularly those in urban areas. Figures 9a and 9b show areas of development and restructuring in relation to vulnerable people and settlements, respectively. Figure 8c shows settlements in areas of tourism significance.

Greater Manchester and Merseyside have the most vulnerable people in urban areas, whilst Lancashire has significant areas. Development and restructuring areas have significant vulnerable populations, and by definition include all of the regional centres, towns and cities. Liverpool, Manchester, Blackpool, Chester, Carlisle, Southport and Lancaster will be important as they have been identified as areas of tourism significance. Other regional towns and cities falling in areas of tourism significance include Barrow-in-Furness, Blackburn, Burnley, Crewe and Northwich, as well as parts of Bolton, Bury, Preston, Runcorn and Warrington.

Development and restructuring should seek to protect assets such as city and town centre parks and open spaces in densely built up areas and areas where there are vulnerable populations. It should also ensure that there is no overall loss of green cover and that it is increased wherever possible. Creative greening approaches (such as street trees, green roofs, green facades) will help to enhance green cover, again with particular attention to town centres, areas with low green cover, and areas with vulnerable populations. During development and restructuring opportunities should be taken to ensure a water supply for vegetation, to sustain its functionality during drought.

Actions for moderating urban heat island are to:

- Protect assets such as city / town centre parks, open spaces in built up areas, and areas with vulnerable populations
- Ensure no net loss of green cover and increase it wherever possible
- Undertake creative greening to enhance green cover, with particular attention to town centres, areas with low green cover, and vulnerable populations
- Maintain and increase cover of large canopied trees for shade provision
- Where possible, protect GI assets which encourage air flow into urban areas
- Align new development and restructuring so that it encourages air flow into urban areas
- Ensure a water supply for vegetation

[20] Gill, S.E, Handley, J.F., Ennos, A.R., Pauleit, S. (2007) Adapting Cities for Climate Change: The Role of the Green Infrastructure. Built Environment, 33(1), 115-133.

Figure 9.

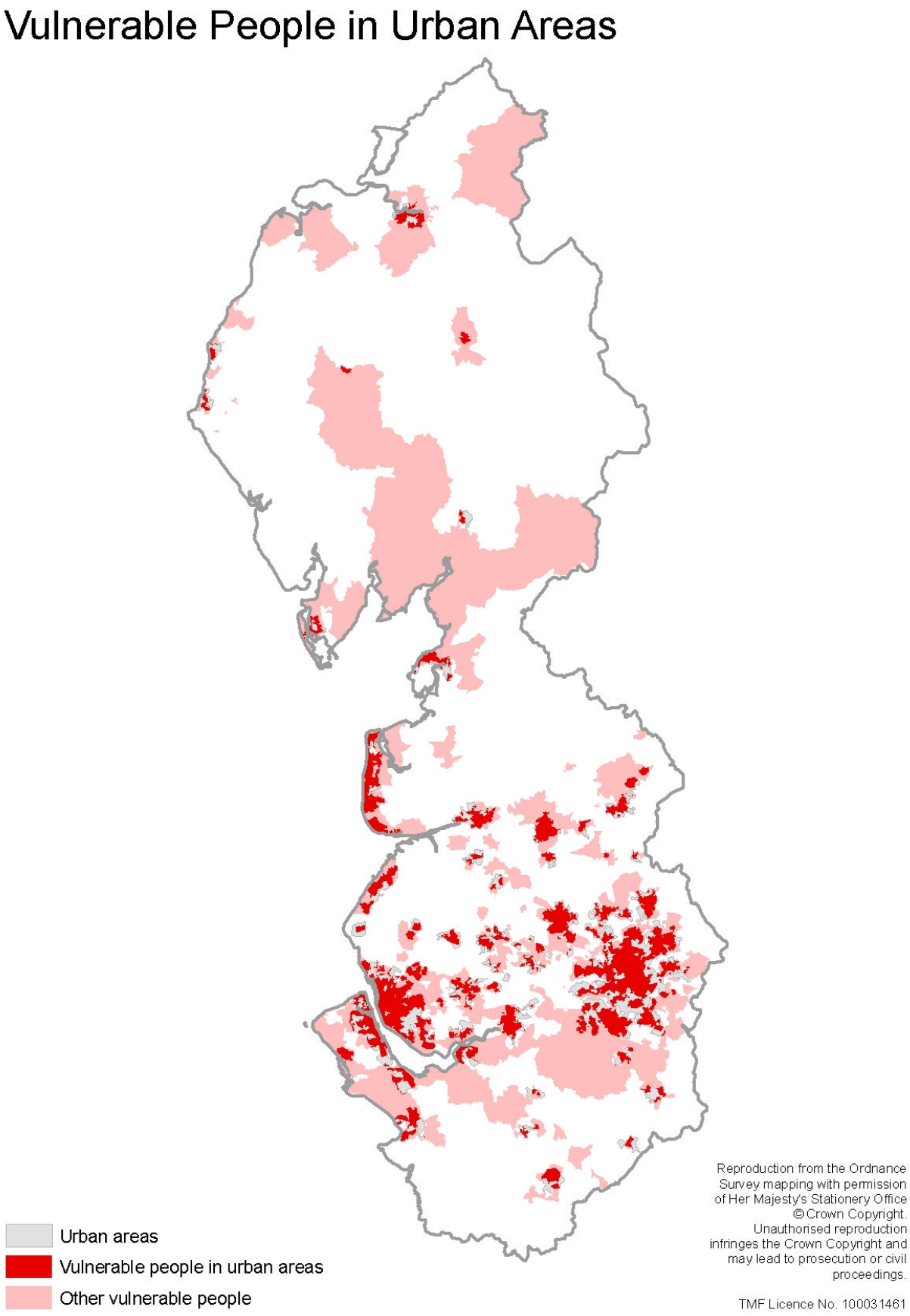
Vulnerable People in Urban Areas
Urban areas
Vulnerable people in urban areas
Other vulnerable people
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Figure 9a.

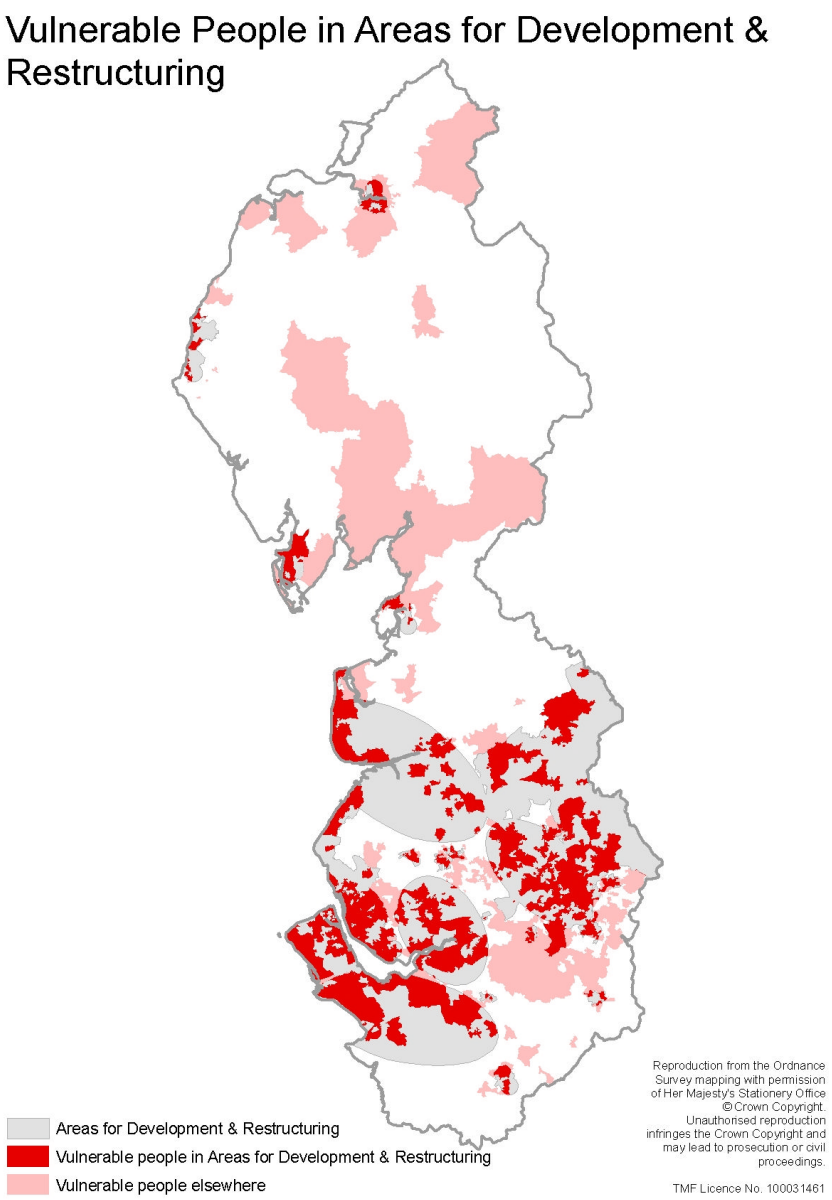


Figure 9b.

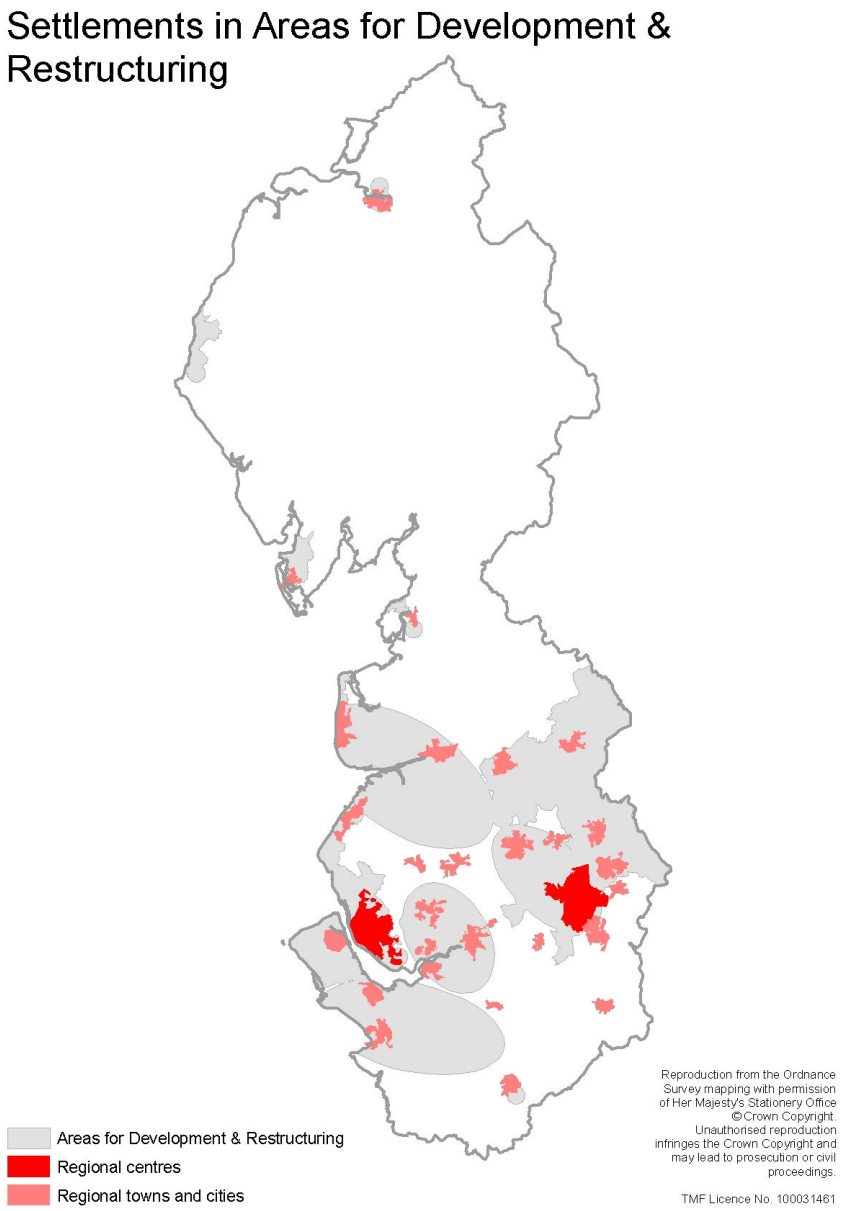
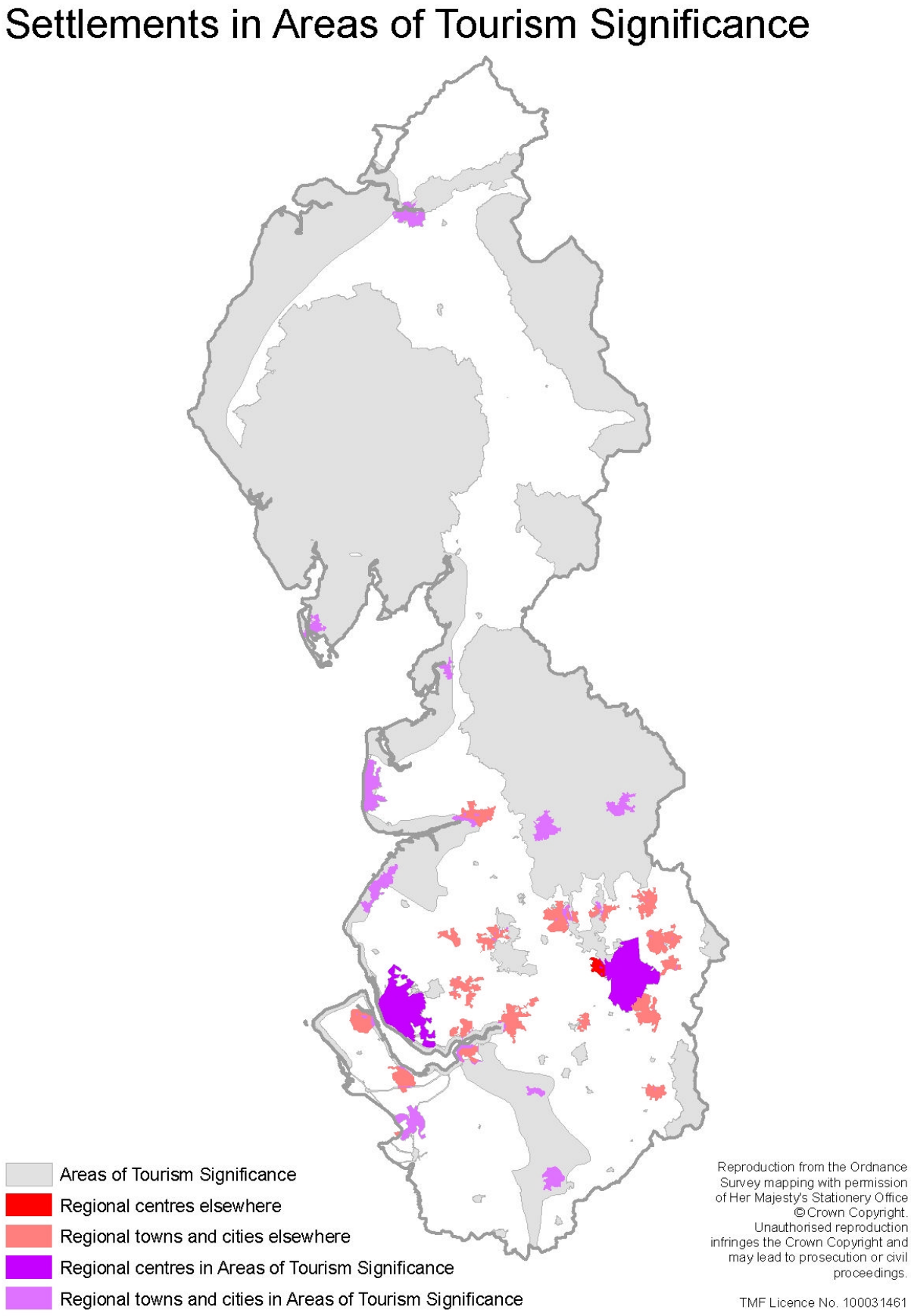


Figure 9c.


Settlements in Areas of Tourism Significance
Areas of Tourism Significance
Regional centres elsewhere
Regional towns and cities elsewhere
Regional centres in Areas of Tourism Significance
Regional towns and cities in Areas of Tourism Significance
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4.5 Reducing Flood Risk

Climate change will alter the seasonality of precipitation, with increased winter and decreased summer precipitation. In addition, precipitation events will be more intense. This could lead to increased flood risk. As well as riverine and coastal flooding, there will also be increased risk from overwhelmed drains. This flood risk will have implications for development and restructuring, tourism and agriculture.

In this instance we have only been able to map riverine and coastal flood risk using the Environment Agency's data. Figure 10 shows the flood zones in the North West; figures 10a, 10b, and 10c show these in areas for development and restructuring, areas of tourism significance, and areas of high quality agricultural land, respectively.

In the North West 103,292 ha are within flood zone 3 (1 in 100 year fluvial flood risk, 1 in 200 year tidal risk) and 126,206 ha within flood zone 2 (1 in 1,000 year risk). In areas for development and restructuring 32,204 ha and 39,791 ha are in flood zones 3 and 2, respectively; in areas of tourism significance 17,739 ha and 21,257 ha are in flood zones 3 and 2, respectively; in areas of high quality agricultural land 16,058 ha and 20,240 ha are in flood zones 3 and 2, respectively.

Soils with high infiltration capacity are also particularly important in reducing flood risk, but we have not been able to map these in this instance. Increasing impervious surface cover on such soils will increase surface runoff (and hence flood risk). It may also decrease water recharge into aquifers, such as under the Sefton sand dunes.

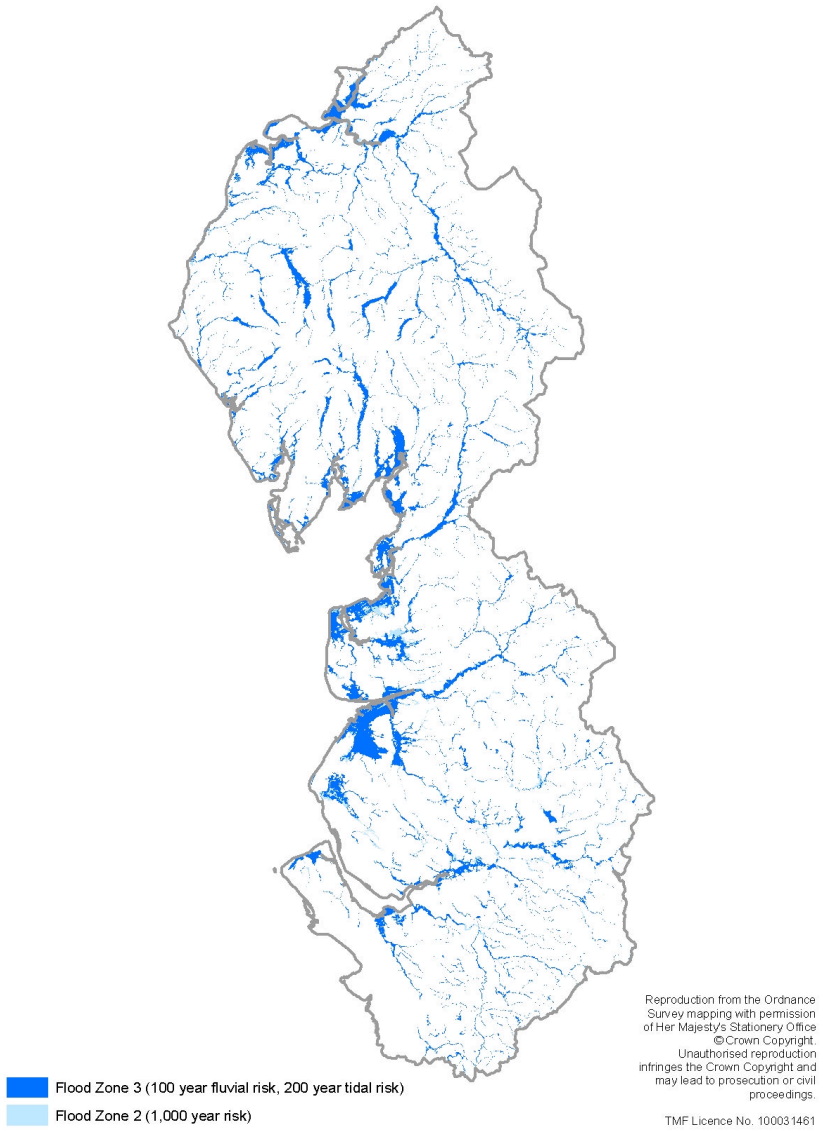
Development should be avoided wherever possible in flood risk areas. Where it does occur within flood risk areas, it should be designed for flood resilience. In addition flood risk reduction opportunities upstream should be taken, for example, through GI interventions such as floodplain restoration and woodland creation. This will require careful hydrological modeling and comparison of the advantages and disadvantages of a 'GI solution' as opposed to an 'engineered solution' (for example, a GI solution can have multiple benefits yet is likely to require working across local authority boundaries, whereas an engineered solution is more tried and tested and may have more public support). All development and restructuring should be designed so that it does not pass on flood risk to areas downstream, this is especially important upstream of flood risk areas. Opportunities should be taken through development and restructuring to reduce flood risk downstream, for example through SUDS, GI and woodland creation. This, again, will require careful hydrological modeling.

Actions for reducing flood risk are to:

- Protect flood zones from new development
- If development and restructuring occurs within flood risk areas it should be designed for flood resilience
- Explore areas upstream of flood risk area where it may be possible to reduce flood risk through GI and woodland creation, and take opportunities where they exist
- Design all development and restructuring so that it does not pass on flood risk, especially where it is upstream of flood risk areas
- Take opportunities through development and restructuring to reduce flood risk downstream, through SUDS, GI and woodland creation
- Development should be avoided, where possible, in areas where the soil has a high infiltration rate and should not increase the proportion of impervious surface cover on such soils

Figure 10.

Flood Zones



Data: Environment Agency

Figure 10a.

Flood Zones in Areas for Development & Restructuring

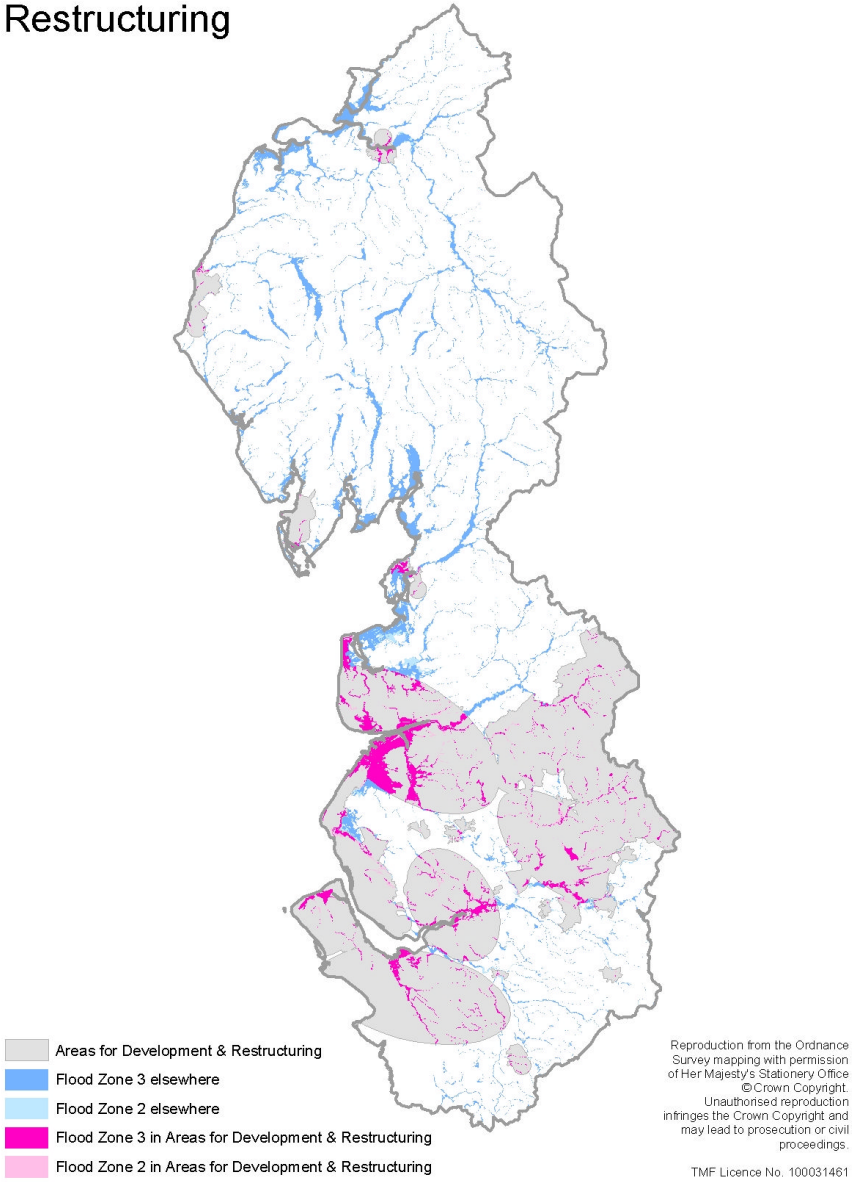


Figure 10b.

Flood Zones in Areas of Tourism Significance

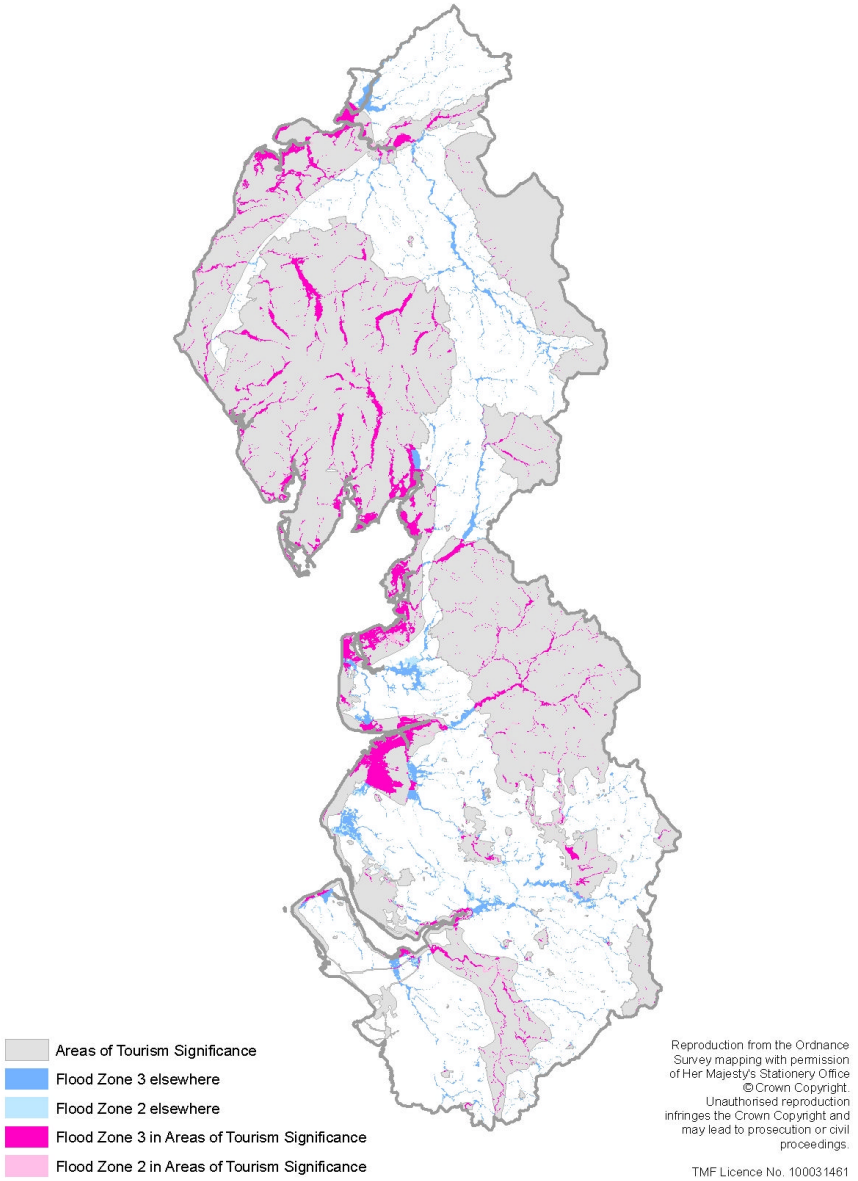
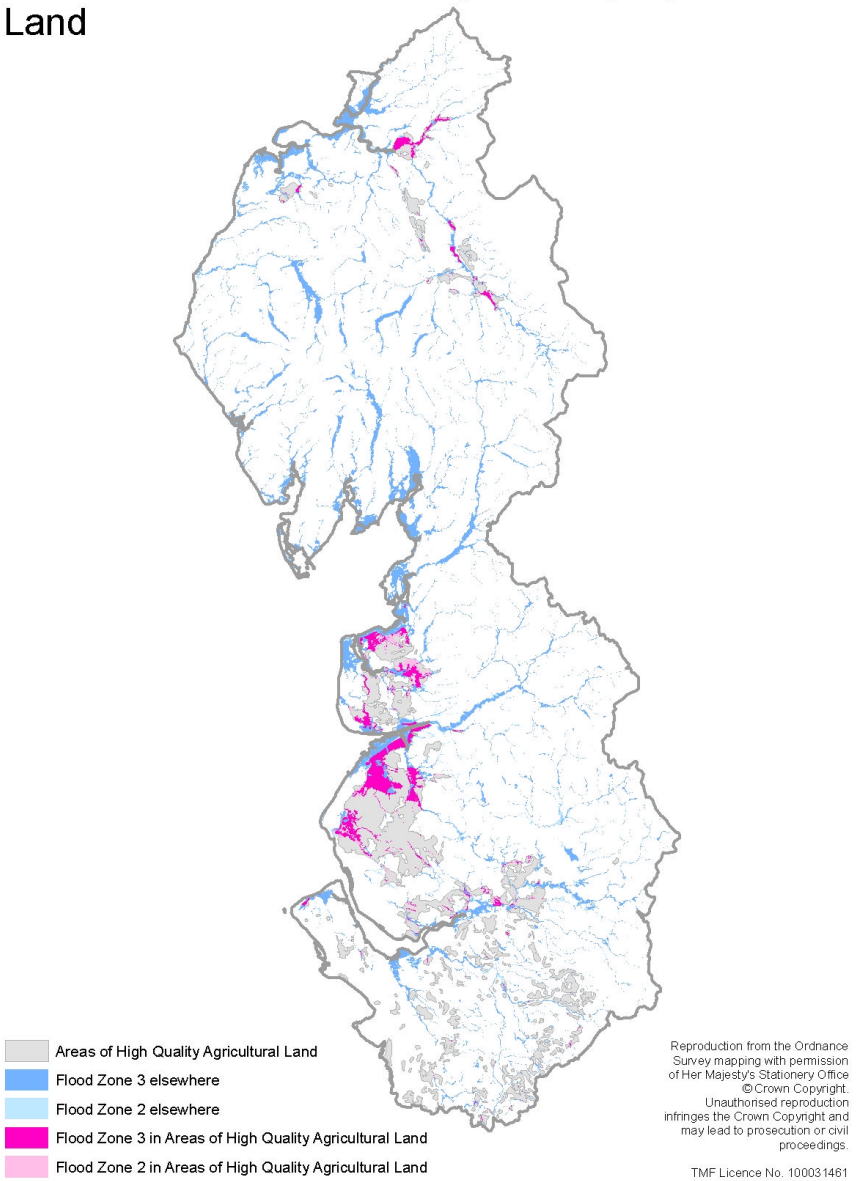


Figure 10c.

Flood Zones in Areas of High Quality Agricultural Land



4.6 Reducing Soil Erosion

Climate change could increase soil erosion through increased precipitation events. Land cover and management can help to reduce soil erosion. Therefore agriculture has the potential to have a positive and/or negative impact on soil erosion. In high quality agricultural areas it is important to protect the soils.

Figure 11 shows the soil erosion risk across the North West; figure 11a shows this in areas of high quality agricultural land. Soil erosion risk here combines soil erodability (taking into account soil texture and slope), soil erosivity (taking into account precipitation and temperature), and land cover vulnerability[21].

It is apparent that the Lake District, as well as other upland areas, have a high or very high soil erosion risk. Lowland areas tend to have a lower risk. The main high quality agricultural areas with a very high or high soil erosion risk are in West Lancashire, Fylde and Wyre in Lancashire and Salford in Greater Manchester.

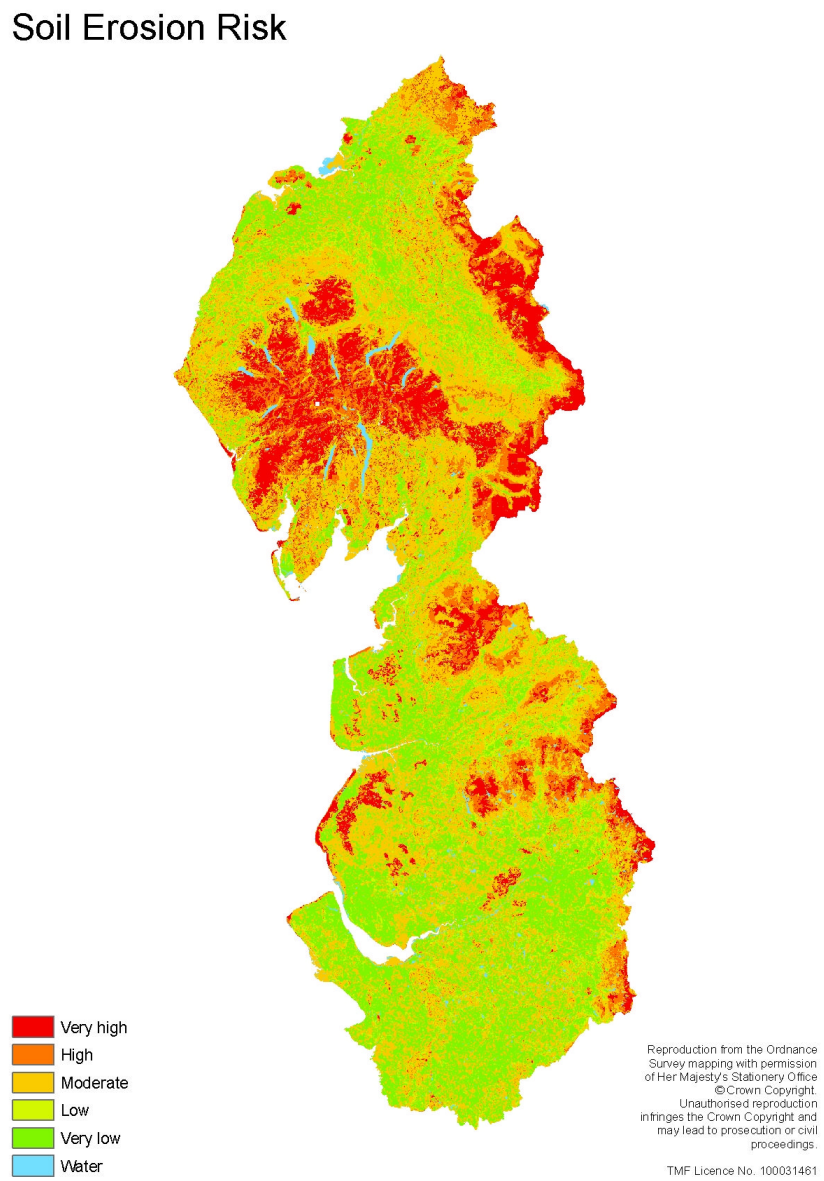
This suggests the need to ensure that agricultural practices in these areas reduce soil erosion risk.

Actions for reducing soil erosion are to:

- Encourage agricultural practices to reduce soil erosion, particularly where there is a high or very high risk
- In other areas where there is a high or very high risk of soil erosion use land cover change and management techniques to reduce the risk.

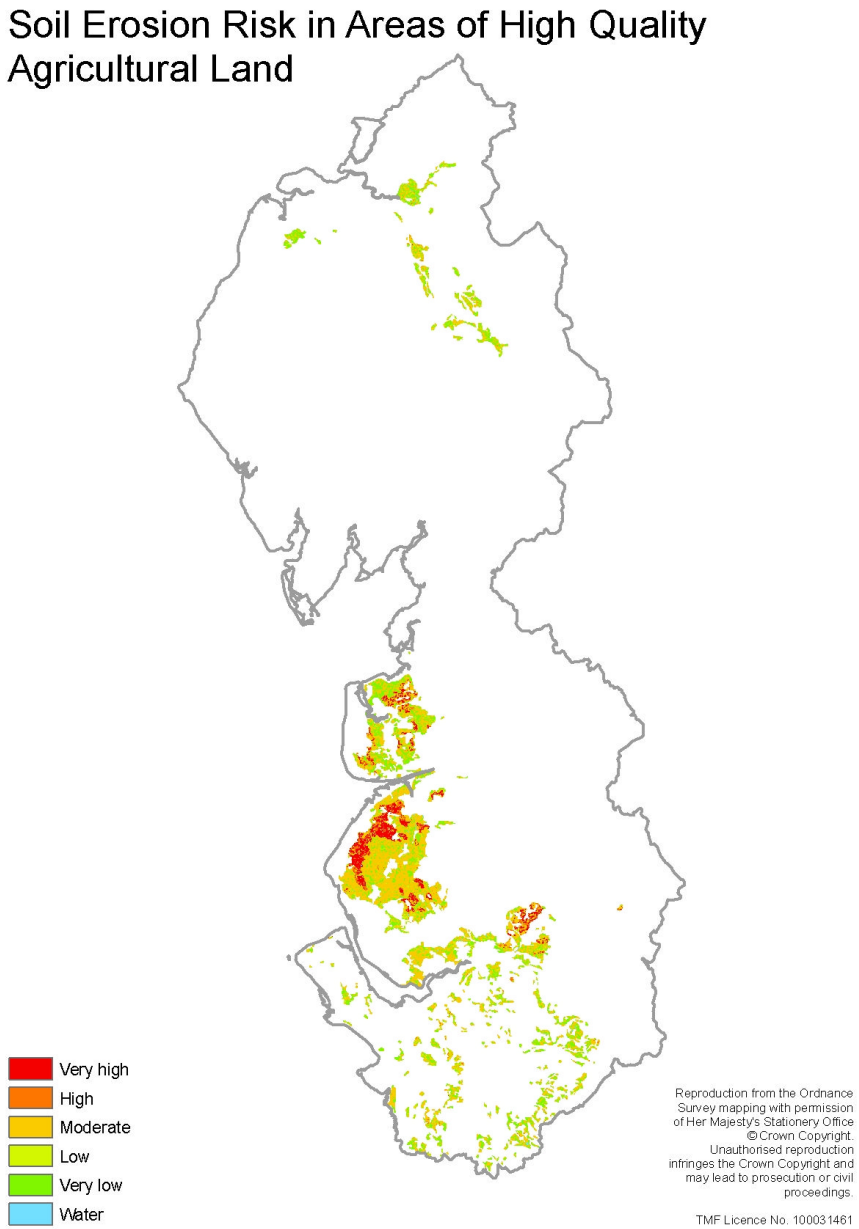
[21] Cavan, G., Handley, J. and Lindley,S. Climate change, tourism and landscape impacts: a regional analysis. Presentation.

Figure 11.



Data: Courtesy of Gina Cavan, University of Manchester

Figure 11a.



4.7 Allowing Species Movement

As the climate changes species will need to move northwards and upwards to find new 'climate spaces'. They may be limited in their ability to do this by a number of factors, including the permeability of the landscape for their movement. North-south corridors may aid species movement, whilst east-west barriers could restrict it. Development and restructuring and agriculture both have the potential to have positive and/or negative impacts on ecological networks.

Figure 12 shows the ecological network map, with a 500 m buffer, of the North West; figures 12a and 11b show this for areas of development and restructuring, and high quality agricultural land, respectively.

According to these, ecological networks cover 23.5% of the North West. 15.7% of the North West's ecological networks are in areas of development and restructuring, whilst 1.5% are in areas of high quality agricultural land.

If a 500 m buffer is created around all existing ecological networks then 65.4% of the North West is covered. This would increase the total NW ecological network by 178.9%. If the buffering only took place in areas for development and restructuring then the total North West ecological network still increases by 45.4%, whereas if it is only in high quality agricultural land then it increases by 11.2%.

This suggests the importance of protecting existing ecological networks and in creating new habitat to buffer and connect the networks, particularly when undergoing new development and restructuring.

Actions for allowing species movement are to:

- Protect existing ecological networks in new development and restructuring areas
- Maximise opportunities for creating new habitats and filling gaps in ecological networks during new development and restructuring, with particular attention to north-south connectivity
- Manage agricultural land to protect existing ecological networks
- Maximise opportunities for creating new habitats and filling gaps in ecological networks in agricultural landscapes, with particular attention to north-south connectivity

Figure 12.

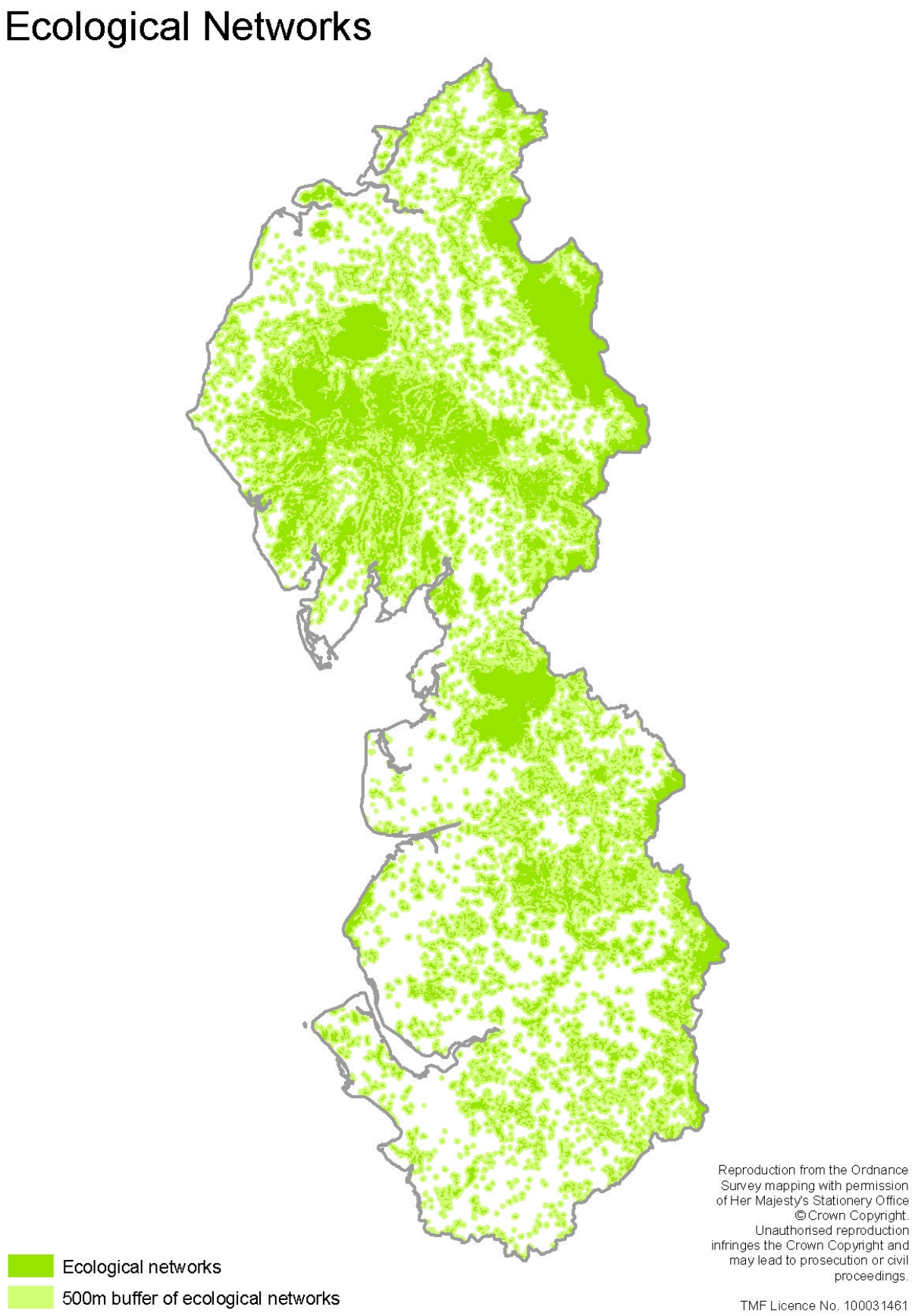

Ecological Networks
Ecological networks
500m buffer of ecological networks
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Figure 12a.

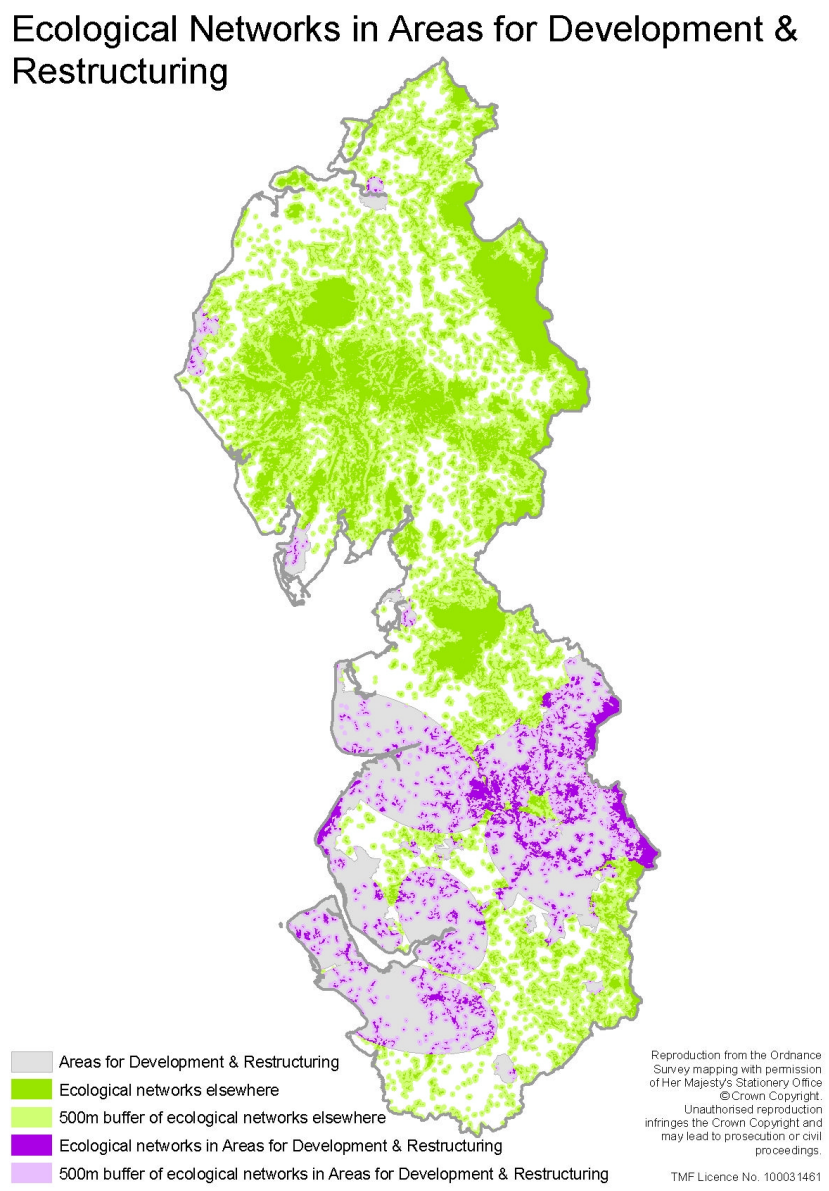
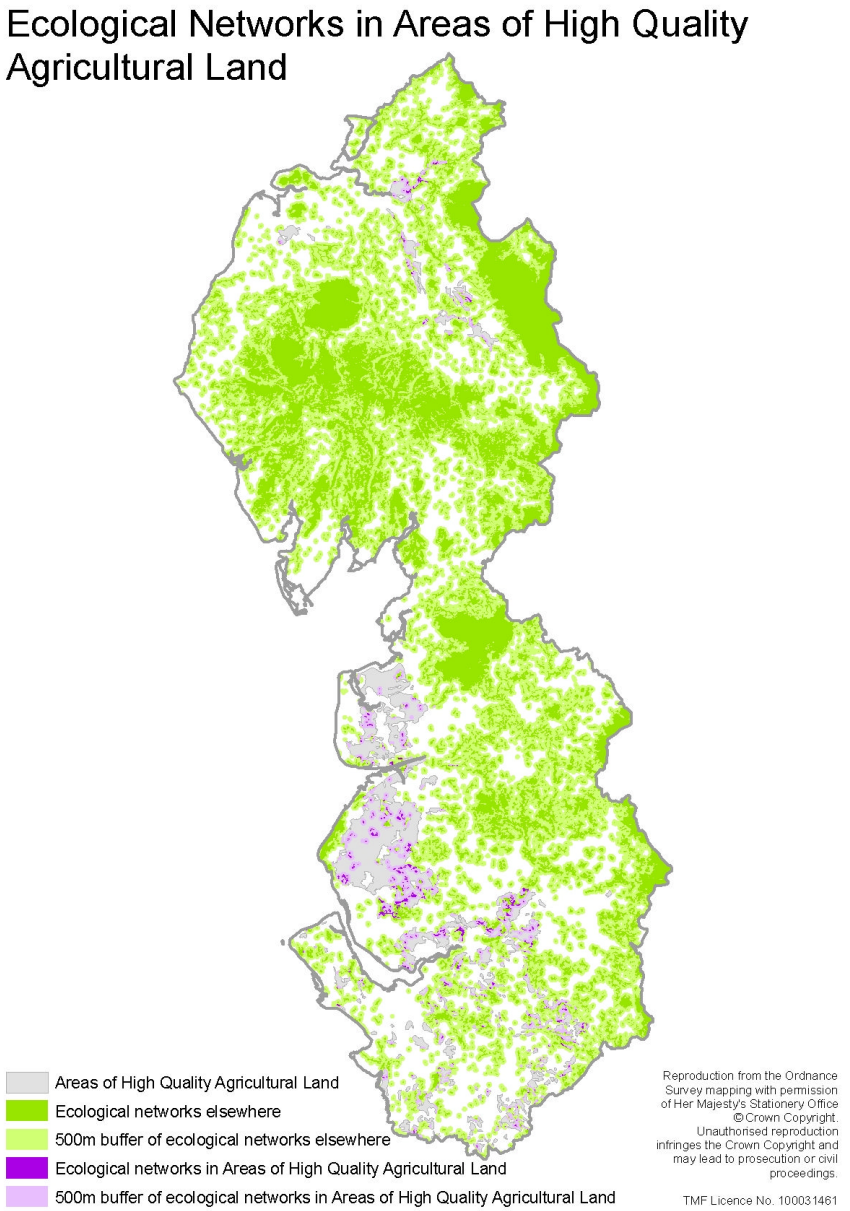


Figure 12b.



4.8 Reducing Visitor Pressure on Vulnerable Landscapes

A report on 'Climate Change and the Visitor Economy'[22] found that the relationship between climate and visitor demand is complicated. However, warmer drier summers and an extended season in the UK, combined with a decline in the popularity of Mediterranean locations and increasingly hot conditions in urban areas, could stimulate a boom in visitor numbers for outdoor based recreation, with a focus around water based activities. Some landscapes, such as the rural uplands, will be vulnerable both to climate change itself, as well as to the increased visitor pressure placed on them. Careful management of the adverse effects on valuable landscapes will be needed to avoid tensions between sustaining their integrity and continuing to allow recreational opportunities.

Figures 13 and 14 show the landscape capacity across the region and in areas of tourism significance, respectively. Landscape capacity[23] here is concerned with the ability to accommodate use by walkers[24] (as a proxy for increased visitor pressure). It combines:

- Landscape character sensitivity – using soil erosion vulnerability, which in turn combines soil erodability (taking into account soil texture and slope), soil erosivity (taking into account precipitation and temperature), and land cover vulnerability
- Visual sensitivity – using tranquillity
- Landscape value – using designated sites.

Much of the National Parks and Areas of Outstanding Natural Beauty have a low or very low landscape capacity. Areas with a higher landscape capacity include the urban areas of Blackpool, Carlisle, Chester, Lancaster, Liverpool, Manchester. The Regional Parks tend to include areas with a higher landscape capacity, yet there are significant areas of lower landscape capacity in parts of East Lancashire, Ribble Coast and Wetlands, Morecambe Bay and Duddon, and the West Cumbria Energy Coast, as well as along the Northwest Coastal Trail.

This suggests that visitor pressure will need to be very carefully managed in the National Parks and Areas of Outstanding Natural Beauty, and especially where these correspond to high urban populations. In creating the tourism resource as part of the Regional Parks, attention should be paid to the landscape capacity.

Actions for reducing visitor pressure on vulnerable landscapes:

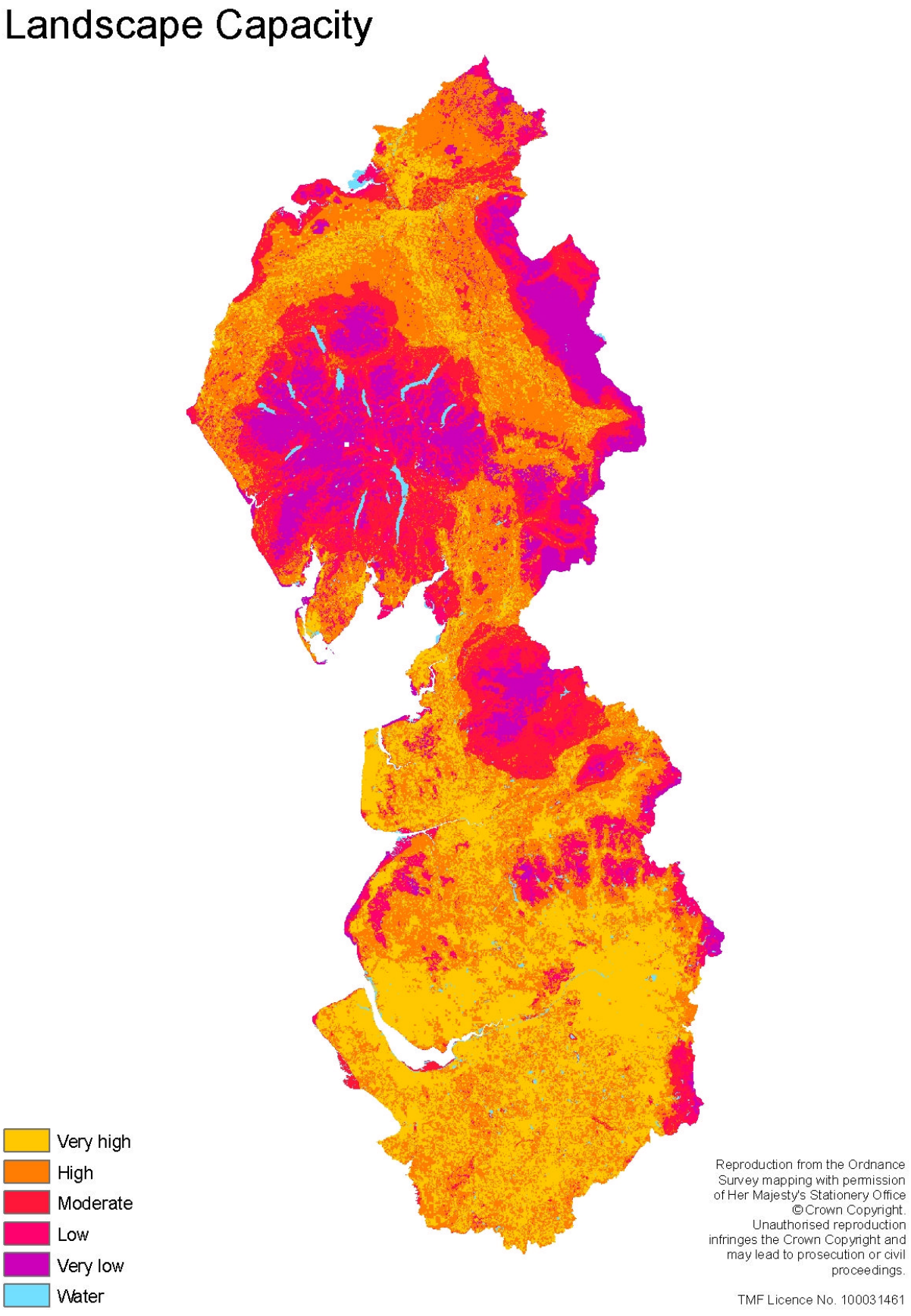
- Manage visitor pressure in lower capacity areas – e.g. maintain footpaths, change to less vulnerable land cover such as woodland (where appropriate), etc
- Create tourism resources in high capacity landscapes, particularly near to urban areas, to divert pressure from lower capacity landscapes

[22] McEvoy, D., Handley, J.F., Cavan, G., Aylen, J., Lindley, S., McMorrow, J. and Glynn, S. (2006). Climate change and the visitor economy: the challenges and opportunities for England's Northwest, Sustainability Northwest (Manchester) and UKCIP (Oxford).
http://www.snw.org.uk/tourism/downloads/CCVE_Challenges_And_Opportunities.pdf

[23] Swanwick (2002) identifies: landscape capacity to accommodate a specific type of change = landscape character sensitivity + visual sensitivity + landscape value
Swanwick, C. (2002). Techniques and criteria for judging capacity and sensitivity. Countryside Agency and Scottish National Heritage, Wetherby and Edinburgh.

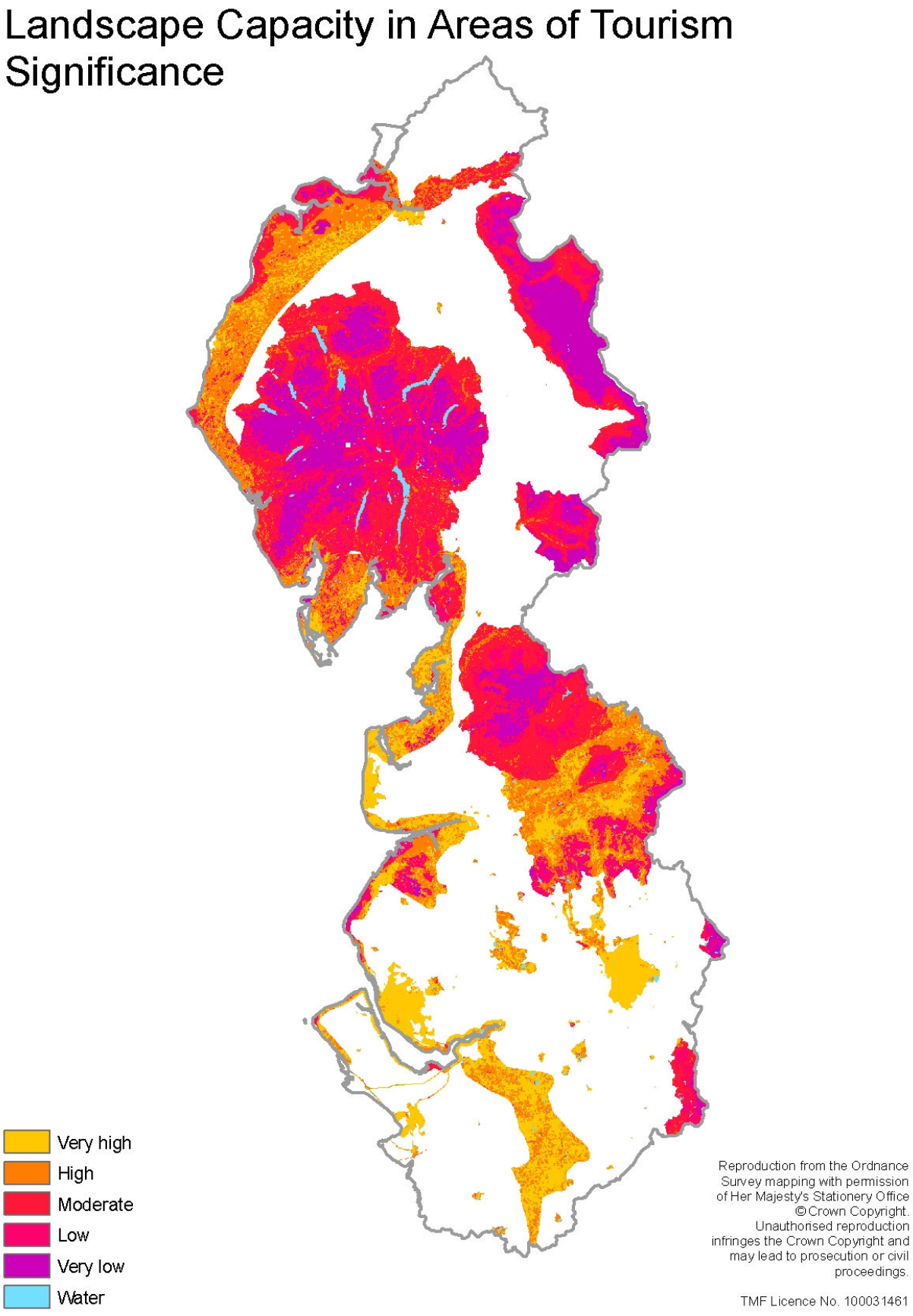
[24] Cavan, G., Handley, J. and Lindley,S. Climate change, tourism and landscape impacts: a regional analysis. Presentation.

Figure 13.



Data: Courtesy of Gina Cavan, University of Manchester

Figure 13a.


Landscape Capacity in Areas of Tourism Significance
Very high
High
Moderate
Low
Very low
Water
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5. Composite Green Infrastructure Climate Change Functions

Section 4 helps us to understand where each GI function is most critical. However, GI by its definition, is concerned with multifunctionality. In this section we attempt to combine the GI climate change functions in a meaningful way into composite maps for the region and each priority area.

In order to combine the functions we selected thresholds for each function (table 5). The thresholds essentially cut off points (using the datasets mapped in section 4) to say where each function is most critical. We used two sets of thresholds: the first is where the action is to 'preserve or protect' the GI function; the second is where the action is to 'increase or enhance' the GI function. In some instances the thresholds differ between these, whereas in others they are the same. In cases where the thresholds are the same, whether the action is to 'preserve or protect' or 'increase or enhance' will depend upon the existing GI resource (which has not been mapped in this instance) in the area of interest. For example, if the GI resource is high within a given city centre then the action may be to 'preserve or protect' this in order to moderate the urban heat island, whereas if there is little GI resource then the action may be to 'increase or enhance' it.

Thus, two sets of threshold maps were produced for each function (figures 14a and 14b). These maps are then a proxy for the areas where each function should be 'preserved or protected' and 'increased or enhanced'. They could also potentially be read as indicative of the areas in the North West where each function is most critical.

From this base, composite maps are produced. Figures 15a and 15b overlay the function threshold maps to show where there are a number of GI climate change functions to 'preserve or protect' or 'increase or enhance'. These maps are useful in starting to prioritise where these broad types of actions should take place in order to maximise climate change functionality. Figures 16a and 16b, 17a and 17b, and 18a and 18b, overlay the 'preserve or protect' and 'increase or enhance' function threshold maps as relevant to development and restructuring, tourism and high quality agricultural land, respectively. These maps are useful in starting to prioritise where these broad types of actions should take place in relation to economic priorities.

Tables 6a and 6b break down the GI climate change functions to 'preserve or protect' and 'increase or enhance' according to their occurrence within the sub-regions and districts of the North West. The sub-regions with the greatest coverage of each 'protect or preserve' function are:

- Carbon storage – Cumbria (2068 km^2), Lancashire (943 km^2)
- Reducing the need to travel by car – Lancashire (1706 km^2), Cheshire (1385 km^2)
- Food production – Lancashire (432 km^2), Cheshire (238 km^2)
- Moderating the urban heat island (vulnerable people) – Cumbria (1904 km^2), Cheshire (686 km^2)
- Moderating the urban heat island (settlements) – Greater Manchester (251 km^2), Merseyside (179 km^2)
- Reducing flood risk – Cumbria (557 km^2), Lancashire (419 km^2)
- Reducing soil erosion – Cumbria (2223 km^2), Lancashire (625 km^2)
- Allowing species movement – Cumbria (2132 km^2), Lancashire (599 km^2)
- Reducing visitor pressure on vulnerable landscapes – Cumbria (2341 km^2), Lancashire (639 km^2).

The sub-regions with the greatest coverage of each 'increase or enhance' function are:

- Carbon storage – Cumbria (6786 km^2), Lancashire (3059 km^2)
- Reducing the need to travel by car – Lancashire (1706 km^2), Cheshire (1385 km^2)

- Food production – Lancashire (1955 km^2), Cheshire (1536 km^2)
- Moderating the urban heat island (vulnerable people) – Cumbria (1904 km^2), Cheshire (686 km^2)
- Moderating the urban heat island (settlements) – Greater Manchester (251 km^2), Merseyside (179 km^2)
- Reducing flood risk – Cumbria (557 km^2), Lancashire (419 km^2)
- Reducing soil erosion – Cumbria (2223 km^2), Lancashire (625 km^2)
- Allowing species movement – Cumbria (5074 km^2), Lancashire (1871 km^2)
- Reducing visitor pressure on vulnerable landscapes – Lancashire (1347 km^2), Cumbria (1299 km^2).

However, these figures are only of limited use in prioritising at the regional level. Cumbria and Lancashire often have the greatest area of each function, but these sub-regions account for 70% of the North West. Factors other than the area covered, need to be taken into account when prioritising. For example, the number of visitors as a result of the proximity to major urban centres could mean that vulnerable landscapes on the fringes of Greater Manchester are a higher priority than those in Cumbria and Lancashire.

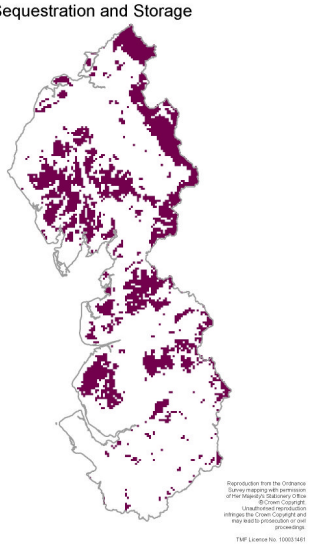
Tables 7a and 7b break down the area in each sub-region and district where there are a given number (from 0-8) of GI climate change functions to ‘preserve or protect’ and ‘increase or enhance’. According to this there is a maximum of 7 GI climate change functions to both ‘protect or preserve’ and ‘increase or enhance’ in any area. In terms of ‘preserve or protect’ functions, these areas are found in Lancashire (West Lancashire) and Merseyside (Knowsley and Sefton). In terms of ‘increase or enhance’ functions, these areas are found in Cheshire (Macclesfield, Vale Royal, Ellesmere Port and Neston, Congleton and Warrington), Cumbria (South Lakeland, Carlisle, Allerdale, Barrow-in-Furness, and Eden), Lancashire (Preston, Blackpool, South Ribble, Chorley, Lancaster, Pendle, and Ribble Valley), and Greater Manchester (Rochdale, Stockport, Bury, Tameside, and Wigan). There are significant areas with low levels of GI climate change functionality to ‘preserve or protect’ and ‘increase or enhance’. These areas are primarily found in parts of Cumbria (in particular in Allerdale and Eden), Cheshire (in particular in Chester and Crewe and Nantwich) and Lancashire (in particular in Lancaster and Ribble Valley). Greater Manchester and Merseyside tend not to have the lowest levels of GI climate change functionality.

Table 5. GI function thresholds for composite function mapping

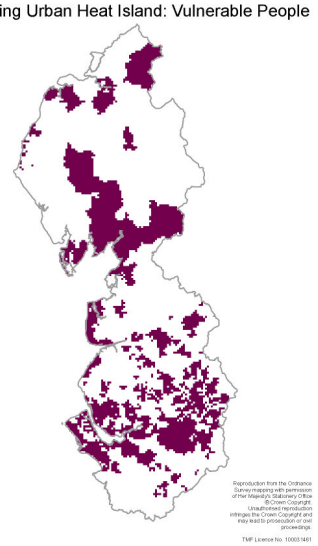
	Threshold	
Function	**Action to 'Preserve or Protect' GI function**	**Action to 'Increase or Enhance' GI function**
Carbon sequestration and storage	Carbon density > NW mean (178 tC/ha)	All areas
Reducing need to travel by car	5 km buffer of urban areas	5 km buffer of urban areas
Food production	Grade 1 and 2 land within 10 km buffer of urban areas	Grade 3 land within 10 km buffer of urban areas
Moderating urban heat island: vulnerable people	Middle layer super output areas with > NW 75th %ile: · people aged 75+ (~8.6%) OR · people aged 0-4 (~6.5%) OR Lower layer super output areas with > NW 75th %ile: · income deprivation index (0.25) OR · health deprivation index (1.28)	Middle layer super output areas with > NW 75th %ile: · people aged 75+ (~8.6%) OR · people aged 0-4 (~6.5%) OR Lower layer super output areas with > NW 75th %ile: · income deprivation index (0.25) OR · health deprivation index (1.28)
Moderating urban heat island: settlements	Regional centres, towns and cities	Regional centres, towns and cities
Reducing flood risk	Flood zone 2	Flood zone 2
Reducing soil erosion	Risk is high / very high	Risk is high / very high
Allowing species movement	Existing ecological network	500 m buffer of ecological network
Reducing visitor pressure on vulnerable landscapes	Low / very low landscape capacity	High / very high landscape capacity within 5 km of urban areas

Figure 14a. ‘Preserve or protect’ GI climate change function threshold maps

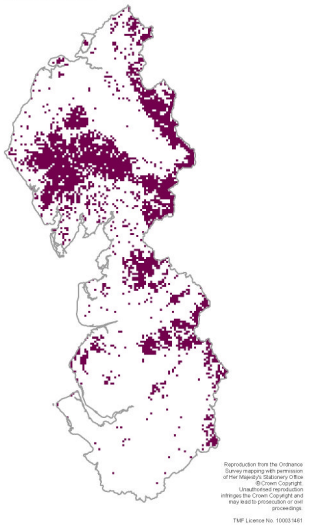
Carbon Sequestration and Storage



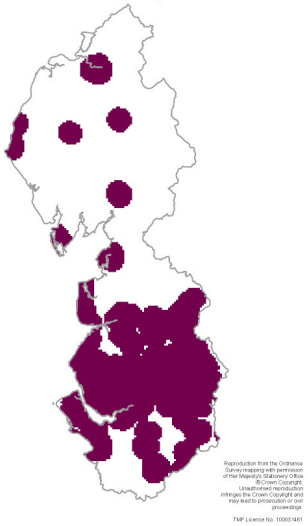
Moderating Urban Heat Island: Vulnerable People



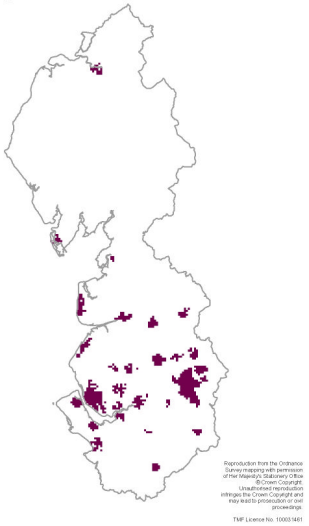
Reducing Soil Erosion



Reducing the Need to Travel by Car

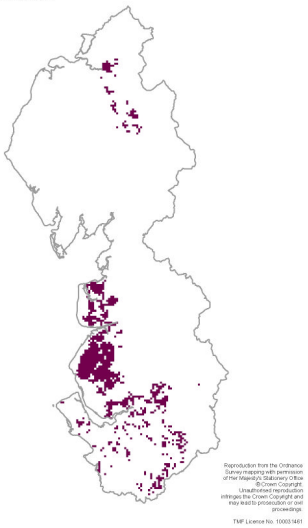


Moderating Urban Heat Island: Settlements

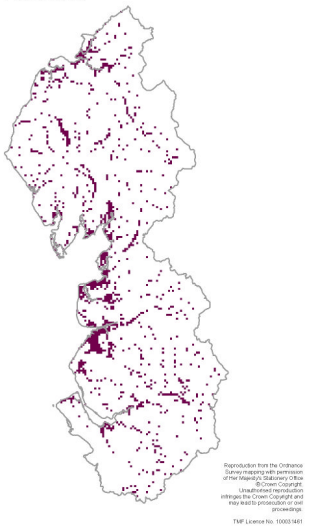


Allowing Species Movement

Food Production



Reducing Flood Risk



Reducing Visitor Pressure on Vulnerable Landscapes

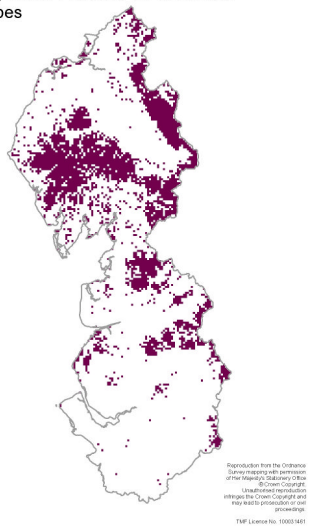
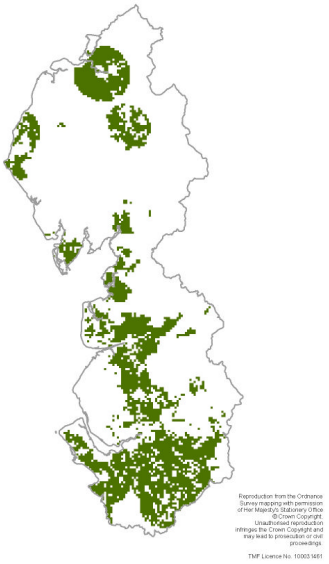


Figure 14b. 'Increase or enhance' GI climate change function threshold maps

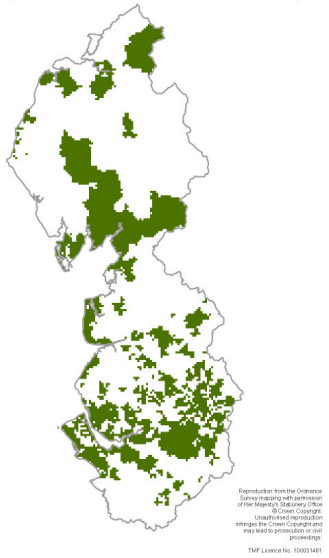
Carbon Sequestration and Storage

Reducing the Need to Travel by Car

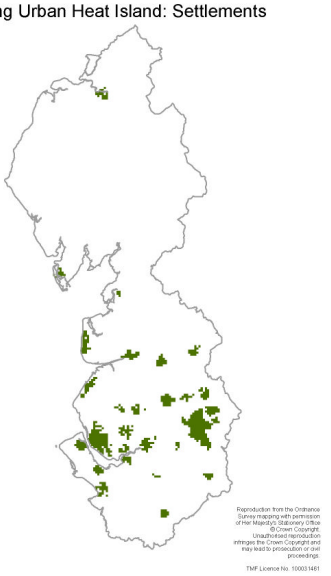
Food Production



Moderating Urban Heat Island: Vulnerable People



Moderating Urban Heat Island: Settlements



Reducing Flood Risk

Reducing Soil Erosion

Allowing Species Movement

Reducing Visitor Pressure on Vulnerable Landscapes

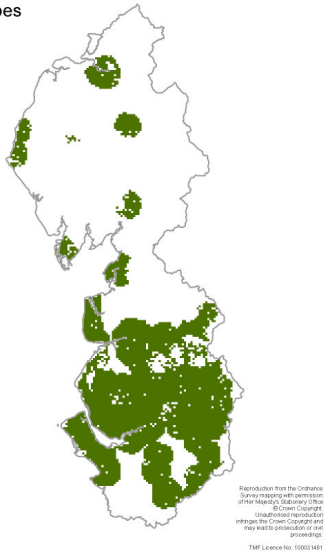


Table 6a. 'Preserve or protect' GI climate change function area (km^2) (using thresholds)

District/Sub-region	'Preserve or protect' GI climate change function area (km^2 in district/sub-region)								
	Carbon sequestration & storage	Reducing need to travel by car	Food production	Moderating the UHI: vulnerable people	Moderating the UHI: settlements	Reducing flood risk	Reducing soil erosion	Allowing species movement	Reducing visitor pressure on vulnerable landscapes
Chester	11	192	29	81	22	15	6	20	4
Congleton	6	135	36	29	0	9	3	21	1
Crewe and Nantwich	16	171	41	26	15	22	5	18	5
Ellesmere Port & Neston	1	85	5	75	17	12	0	4	0
Macclesfield	30	354	35	271	10	18	62	100	44
Vale Royal	23	267	40	129	5	26	9	45	2
Warrington	13	180	53	75	26	31	4	18	2
Cheshire	**100**	**1385**	**238**	**686**	**95**	**134**	**90**	**226**	**58**
Allerdale	259	167	0	366	0	140	322	379	342
Barrow-in-Furness	1	63	0	55	10	9	14	4	13
Carlisle	312	201	27	386	19	104	153	202	198
Copeland	261	97	0	12	0	52	337	221	346
Eden	687	131	47	48	0	97	773	860	810
South Lakeland	549	159	0	1037	0	153	624	466	632
Cumbria	**2068**	**818**	**75**	**1904**	**29**	**557**	**2223**	**2132**	**2341**
Bolton	15	140	0	62	29	4	13	33	9
Bury	5	98	0	32	12	7	9	28	5
Manchester	3	116	0	95	75	14	0	13	0
Oldham	40	110	0	43	26	4	46	49	37
Rochdale	30	146	0	66	21	7	47	40	38
Salford	27	97	18	43	20	11	13	11	10
Stockport	2	121	0	66	26	10	4	22	0
Tameside	14	103	1	54	17	4	15	34	9
Trafford	18	106	23	62	8	13	2	5	2
Wigan	8	188	7	64	16	14	5	18	3
Greater Manchester	**162**	**1225**	**50**	**587**	**251**	**87**	**155**	**252**	**113**
Blackburn with Darwen	69	134	0	36	19	5	47	43	42
Blackpool	1	36	2	33	26	6	0	1	0
Burnley	34	109	0	12	15	5	45	34	42
Chorley	34	178	17	33	0	21	26	37	25
Fylde	36	114	77	37	0	31	9	7	8
Hyndburn	14	73	0	21	0	3	15	9	11
Lancaster	183	144	5	128	6	90	116	161	138
Pendle	39	127	0	70	0	5	41	38	40
Preston	8	107	1	27	24	15	2	9	2
Ribble Valley	155	79	0	40	1	31	145	164	148
Rossendale	60	135	0	30	0	3	75	33	66
South Ribble	6	107	12	22	0	22	2	9	3
West Lancashire	208	290	248	27	10	99	69	20	73
Wyre	95	72	69	87	2	83	33	33	40
Lancashire	**943**	**1706**	**432**	**604**	**103**	**419**	**625**	**599**	**639**
Halton	1	79	16	58	24	7	1	6	0
Knowsley	11	87	31	52	8	5	1	12	1
Liverpool	1	110	5	94	82	4	0	7	0
Sefton	29	152	43	66	25	27	23	24	24
St. Helens	28	136	45	52	21	8	7	14	5
Wirral	0	150	9	98	20	14	4	15	3
Merseyside	**70**	**713**	**149**	**420**	**179**	**63**	**36**	**78**	**34**

Table 6b. 'Increase or enhance' GI climate change function area (km^2) (using thresholds)

District/Sub-region	'Increase or enhance' GI climate change function area (km^2 in district/sub-region)								
	Carbon sequestration & storage	Reducing need to travel by car	Food production	Moderating the UHI: vulnerable people	Moderating the UHI: settlements	Reducing flood risk	Reducing soil erosion	Allowing species movement	Reducing visitor pressure on vulnerable landscapes
Chester	447	192	346	81	22	15	6	152	190
Congleton	210	135	148	29	0	9	3	129	130
Crewe and Nantwich	427	171	324	26	15	22	5	153	169
Ellesmere Port & Neston	88	85	31	75	17	12	0	27	66
Macclesfield	521	354	310	271	10	18	62	387	313
Vale Royal	380	267	296	129	5	26	9	218	259
Warrington	181	180	80	75	26	31	4	84	172
Cheshire	**2253**	**1385**	**1536**	**686**	**95**	**134**	**90**	**1151**	**1299**
Allerdale	1271	167	538	366	0	140	322	859	60
Barrow-in-Furness	74	63	33	55	10	9	14	25	44
Carlisle	1022	201	477	386	19	104	153	681	169
Copeland	727	97	176	12	0	52	337	556	78
Eden	2144	131	523	48	0	97	773	1725	109
South Lakeland	1548	159	208	1037	0	153	624	1227	109
Cumbria	**6786**	**818**	**1955**	**1904**	**29**	**557**	**2223**	**5074**	**569**
Bolton	140	140	31	62	29	4	13	101	129
Bury	99	98	15	32	12	7	9	82	93
Manchester	116	116	8	95	75	14	0	55	115
Oldham	138	110	0	43	26	4	46	105	95
Rochdale	158	146	18	66	21	7	47	116	114
Salford	97	97	16	43	20	11	13	49	86
Stockport	125	121	33	66	26	10	4	73	120
Tameside	103	103	8	54	17	4	15	83	92
Trafford	106	106	17	62	8	13	2	36	102
Wigan	188	188	115	64	16	14	5	86	182
Greater Manchester	**1270**	**1225**	**260**	**587**	**251**	**87**	**155**	**785**	**1129**
Blackburn with Darwen	137	134	13	36	19	5	47	112	91
Blackpool	36	36	5	33	26	6	0	9	34
Burnley	111	109	11	12	15	5	45	96	67
Chorley	203	178	123	33	0	21	26	129	155
Fylde	160	114	54	37	0	31	9	53	106
Hyndburn	73	73	2	21	0	3	15	47	60
Lancaster	566	144	210	128	6	90	116	391	109
Pendle	169	127	9	70	0	5	41	111	88
Preston	143	107	109	27	24	15	2	54	105
Ribble Valley	582	79	153	40	1	31	145	452	72
Rossendale	138	135	0	30	0	3	75	124	70
South Ribble	114	107	73	22	0	22	2	57	103
West Lancashire	347	290	47	27	10	99	69	138	222
Wyre	282	72	118	87	2	83	33	98	64
Lancashire	**3059**	**1706**	**926**	**604**	**103**	**419**	**625**	**1871**	**1347**
Halton	79	79	11	58	24	7	1	34	76
Knowsley	87	87	7	52	8	5	1	44	85
Liverpool	110	110	0	94	82	4	0	37	108
Sefton	152	152	2	66	25	27	23	62	118
St. Helens	136	136	43	52	21	8	7	81	130
Wirral	158	150	45	98	20	14	4	73	142
Merseyside	**721**	**713**	**108**	**420**	**179**	**63**	**36**	**332**	**659**

Figure 15a.

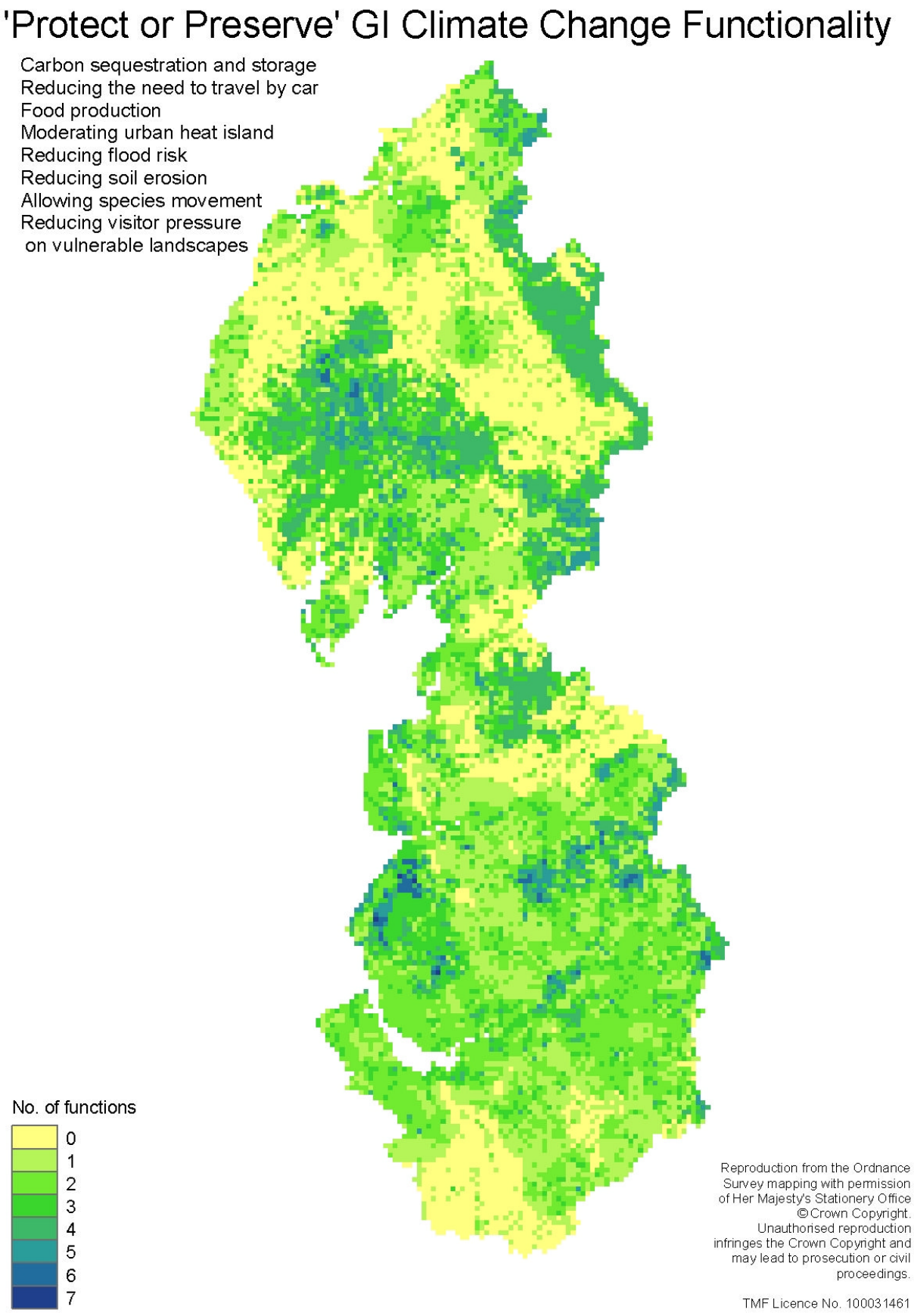

'Protect or Preserve' GI Climate Change Functionality
Carbon sequestration and storage
Reducing the need to travel by car
Food production
Moderating urban heat island
Reducing flood risk
Reducing soil erosion
Allowing species movement
Reducing visitor pressure
on vulnerable landscapes
No. of functions
0
1
2
3
4
5
6
7
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Figure 15b.

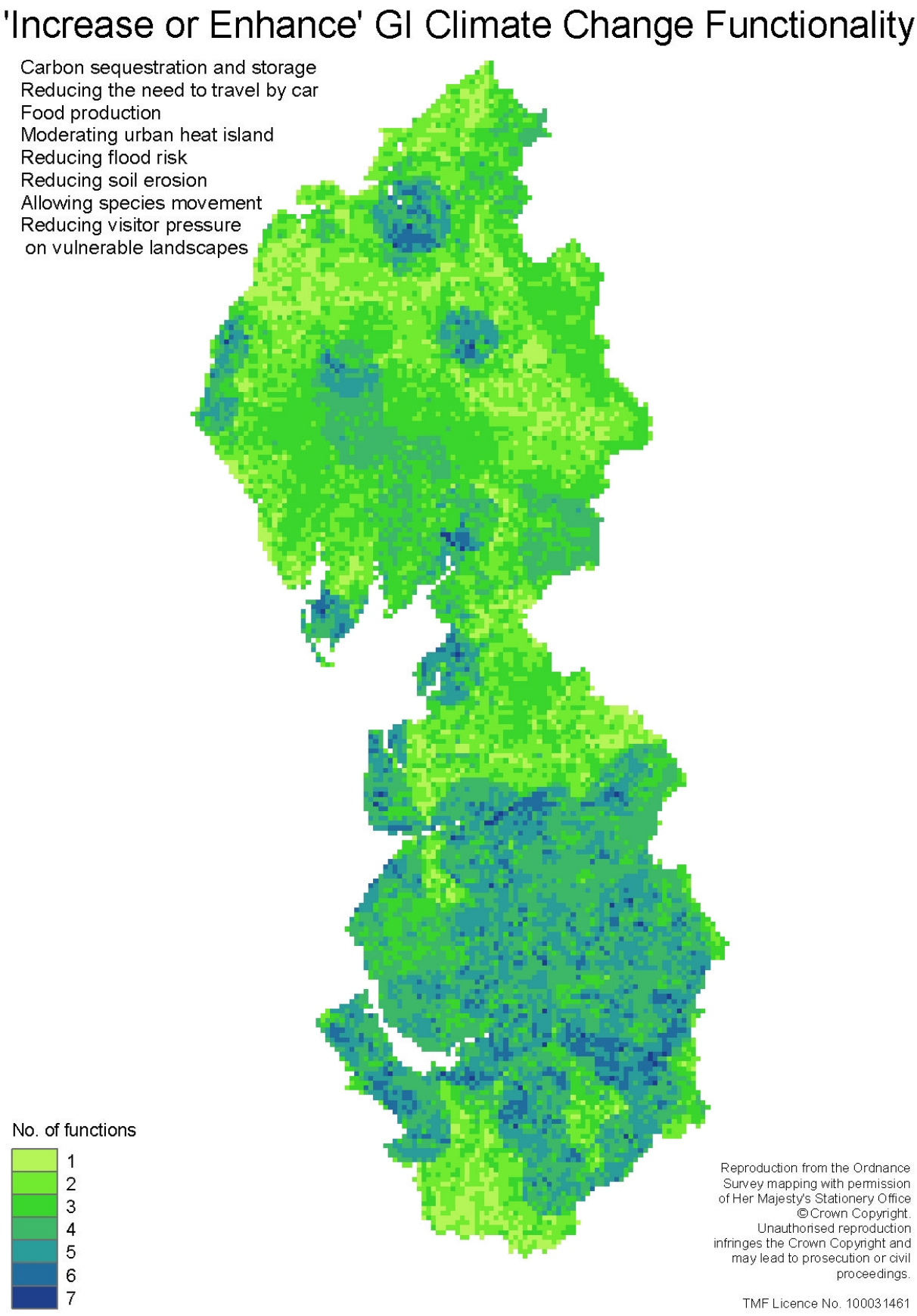
'Increase or Enhance' GI Climate Change Functionality
Carbon sequestration and storage
Reducing the need to travel by car
Food production
Moderating urban heat island
Reducing flood risk
Reducing soil erosion
Allowing species movement
Reducing visitor pressure
on vulnerable landscapes
No. of functions
1
2
3
4
5
6
7
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Table 7a. Area (km^2) where there are 0-8 GI climate change functions to 'preserve or protect' (using thresholds)

	Area (km^2 in district/sub-region) with each number of GI climate change functions to 'preserve or protect'								
District/Sub-Region	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Chester	218	110	101	10	1	1	0	0	0
Congleton	46	102	53	7	0	0	0	0	0
Crewe and Nantwich	208	134	71	9	0	1	0	0	0
Ellesmere Port & Neston	0	9	55	18	2	0	0	0	0
Macclesfield	26	189	219	65	13	5	0	0	0
Vale Royal	50	161	132	29	7	0	0	0	0
Warrington	1	49	75	45	8	2	0	0	0
Cheshire	**549**	**754**	**706**	**183**	**32**	**9**	**0**	**0**	**0**
Allerdale	509	270	122	136	143	70	11	0	0
Barrow-in-Furness	0	15	34	13	7	1	0	0	0
Carlisle	245	305	218	110	100	25	0	0	0
Copeland	187	170	84	164	114	0	0	0	0
Eden	853	355	208	239	476	5	0	0	0
South Lakeland	110	434	301	305	282	101	2	0	0
Cumbria	**1905**	**1548**	**967**	**966**	**1122**	**202**	**13**	**0**	**0**
Bolton	0	49	61	20	6	4	2	0	0
Bury	0	31	47	14	6	1	0	0	0
Manchester	0	2	91	21	1	1	0	0	0
Oldham	0	32	50	31	19	3	0	0	0
Rochdale	0	43	55	29	21	6	4	0	0
Salford	0	21	37	21	10	7	1	0	0
Stockport	3	28	74	14	5	0	0	0	0
Tameside	0	24	46	19	7	3	4	0	0
Trafford	0	22	52	19	13	0	0	0	0
Wigan	0	92	75	17	0	3	1	0	0
Greater Manchester	**3**	**344**	**588**	**205**	**86**	**28**	**12**	**0**	**0**
Blackburn with Darwen	0	20	48	21	26	21	1	0	0
Blackpool	0	2	26	6	1	0	0	0	0
Burnley	0	30	31	14	22	12	0	0	0
Chorley	9	105	48	17	13	7	4	0	0
Fylde	21	40	48	32	10	4	1	0	0
Hyndburn	0	28	28	7	6	3	0	0	0
Lancaster	135	122	132	78	82	5	0	0	0
Pendle	20	45	47	21	21	14	0	0	0
Preston	25	75	33	5	4	0	0	0	0
Ribble Valley	250	111	76	69	74	0	0	0	0
Rossendale	0	30	26	27	35	15	5	0	0
South Ribble	1	61	37	9	4	0	1	0	0
West Lancashire	13	46	59	143	34	21	28	2	0
Wyre	54	73	78	46	23	5	0	0	0
Lancashire	**528**	**788**	**717**	**496**	**356**	**108**	**40**	**2**	**0**
Halton	0	6	54	14	3	0	0	0	0
Knowsley	0	10	53	12	9	1	1	1	0
Liverpool	0	2	91	11	2	1	0	0	0
Sefton	0	24	60	33	15	13	0	1	0
St. Helens	0	42	49	32	7	4	2	0	0
Wirral	0	40	88	21	1	0	0	0	0
Merseyside	**0**	**125**	**395**	**123**	**36**	**19**	**3**	**2**	**0**

Table 7b. Area (km^2) where there are 0-8 GI climate change functions to 'increase or enhance' (using thresholds)

	Area (km^2 in district/sub-region) with each number of GI climate change functions to 'increase or enhance'								
District/Sub-Region	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Chester	0	70	140	55	75	78	25	0	0
Congleton	0	6	33	42	63	55	9	1	0
Crewe and Nantwich	0	77	138	60	90	54	4	0	0
Ellesmere Port & Neston	0	0	1	12	34	25	9	2	0
Macclesfield	0	5	45	97	126	139	96	8	0
Vale Royal	0	8	38	50	120	117	44	3	0
Warrington	0	0	1	20	63	78	18	1	0
Cheshire	**0**	**166**	**397**	**334**	**571**	**545**	**205**	**15**	**0**
Allerdale	0	214	442	325	191	80	8	1	0
Barrow-in-Furness	0	0	7	5	26	19	11	1	0
Carlisle	0	84	294	327	168	86	42	2	0
Copeland	0	65	212	362	50	28	1	0	0
Eden	0	266	838	898	61	60	13	1	0
South Lakeland	0	40	255	678	489	55	13	5	0
Cumbria	**0**	**670**	**2048**	**2594**	**984**	**329**	**87**	**10**	**0**
Bolton	0	0	0	7	73	53	7	0	0
Bury	0	0	0	7	54	30	7	1	0
Manchester	0	0	0	1	48	56	11	0	0
Oldham	0	0	7	35	55	33	5	0	0
Rochdale	0	0	2	25	68	55	6	2	0
Salford	0	0	1	12	52	26	6	0	0
Stockport	0	0	3	10	53	37	19	2	0
Tameside	0	0	0	6	41	48	7	1	0
Trafford	0	0	0	22	46	32	6	0	0
Wigan	0	0	0	9	90	75	14	1	0
Greater Manchester	**0**	**0**	**13**	**132**	**580**	**445**	**89**	**7**	**0**
Blackburn with Darwen	0	0	1	8	92	31	5	0	0
Blackpool	0	0	0	1	20	9	3	2	0
Burnley	0	0	1	10	74	21	4	0	0
Chorley	0	4	10	18	81	79	11	1	0
Fylde	0	17	25	30	48	30	7	0	0
Hyndburn	0	0	1	13	43	15	1	0	0
Lancaster	0	39	173	187	64	74	16	1	0
Pendle	0	10	18	40	60	35	3	1	0
Preston	0	4	22	11	63	32	7	4	0
Ribble Valley	0	76	242	183	28	25	25	1	0
Rossendale	0	0	0	13	88	32	4	0	0
South Ribble	0	0	3	13	43	43	9	2	0
West Lancashire	0	13	26	119	130	58	2	0	0
Wyre	0	38	117	49	34	33	8	0	0
Lancashire	**0**	**201**	**637**	**696**	**867**	**517**	**106**	**11**	**0**
Halton	0	0	1	7	37	25	9	0	0
Knowsley	0	0	0	13	42	28	4	0	0
Liverpool	0	0	0	1	66	38	2	0	0
Sefton	0	0	1	40	70	29	6	0	0
St. Helens	0	0	0	18	55	51	12	0	0
Wirral	0	0	4	17	56	56	17	0	0
Merseyside	**0**	**0**	**6**	**96**	**325**	**227**	**50**	**0**	**0**

Figure 16a.

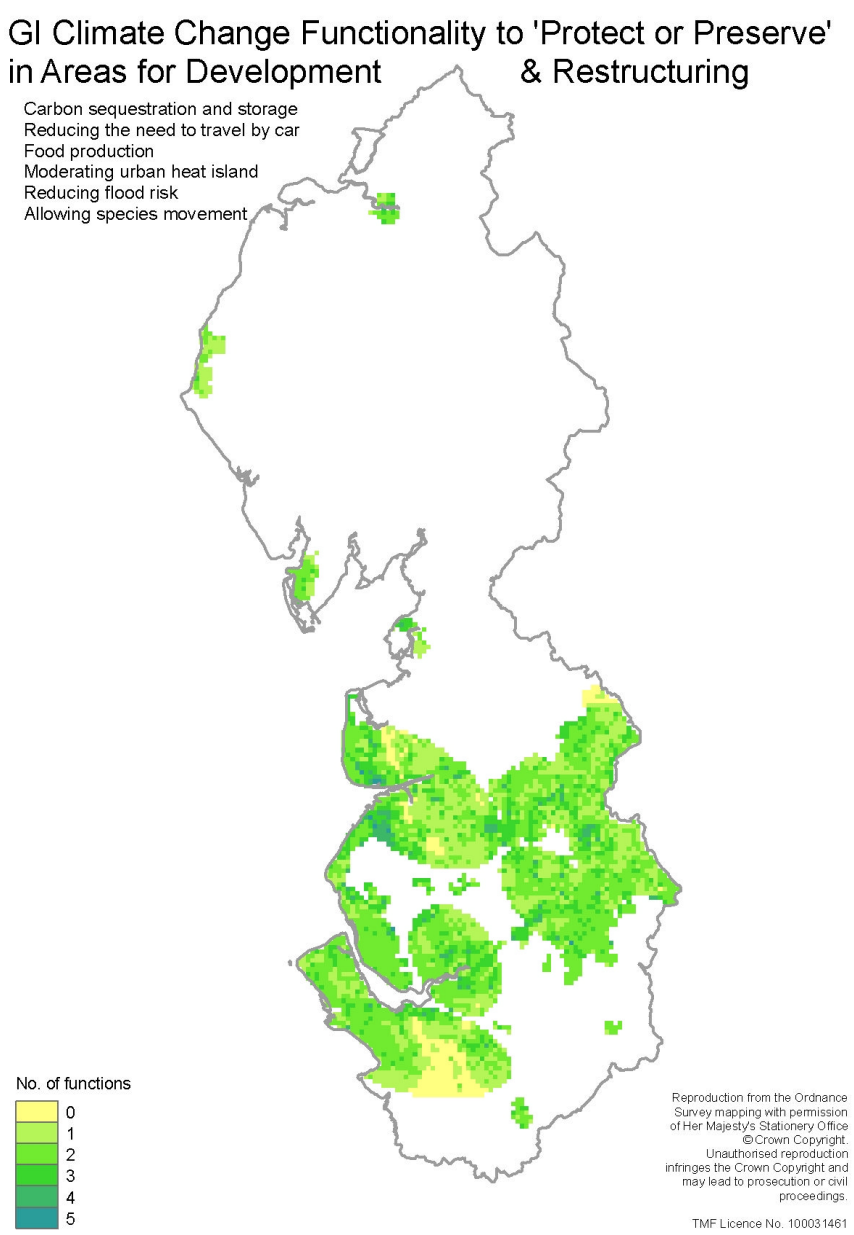


Figure 16b.

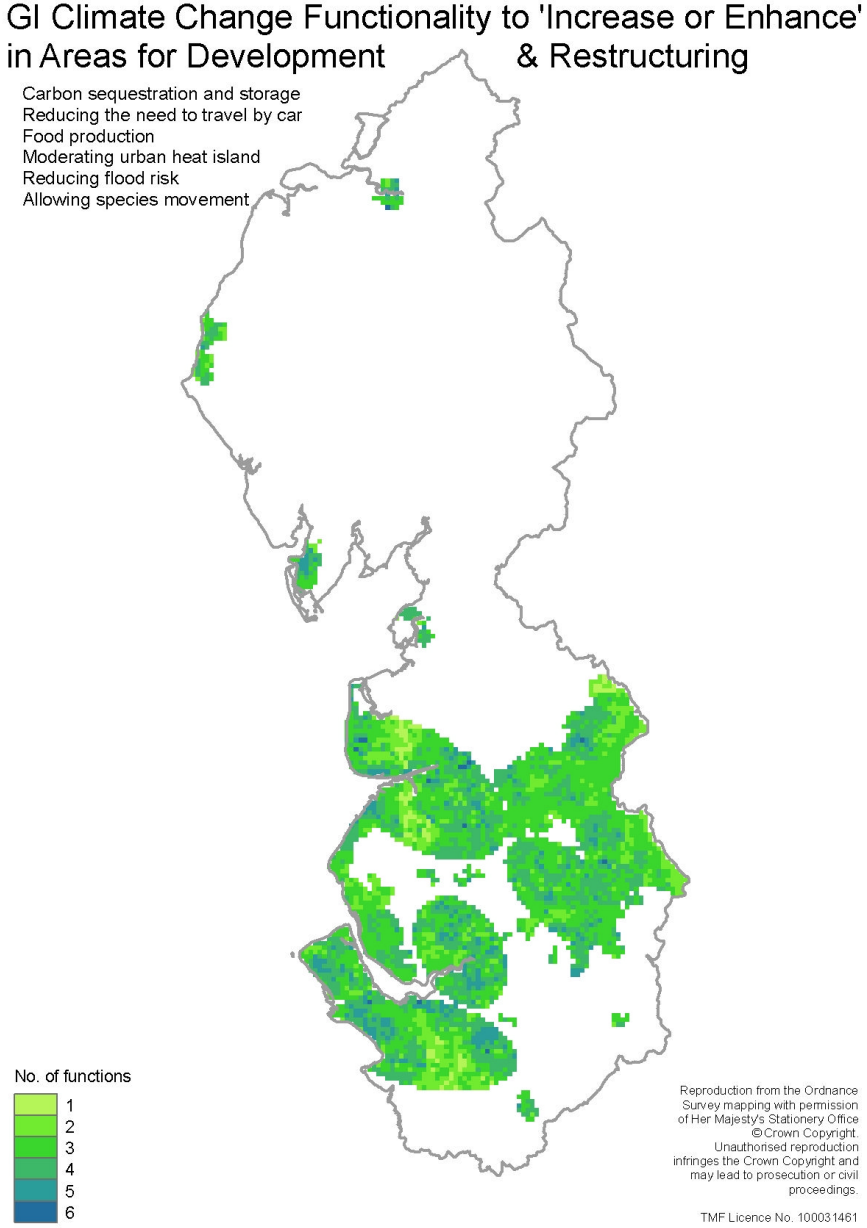


Figure 17a.

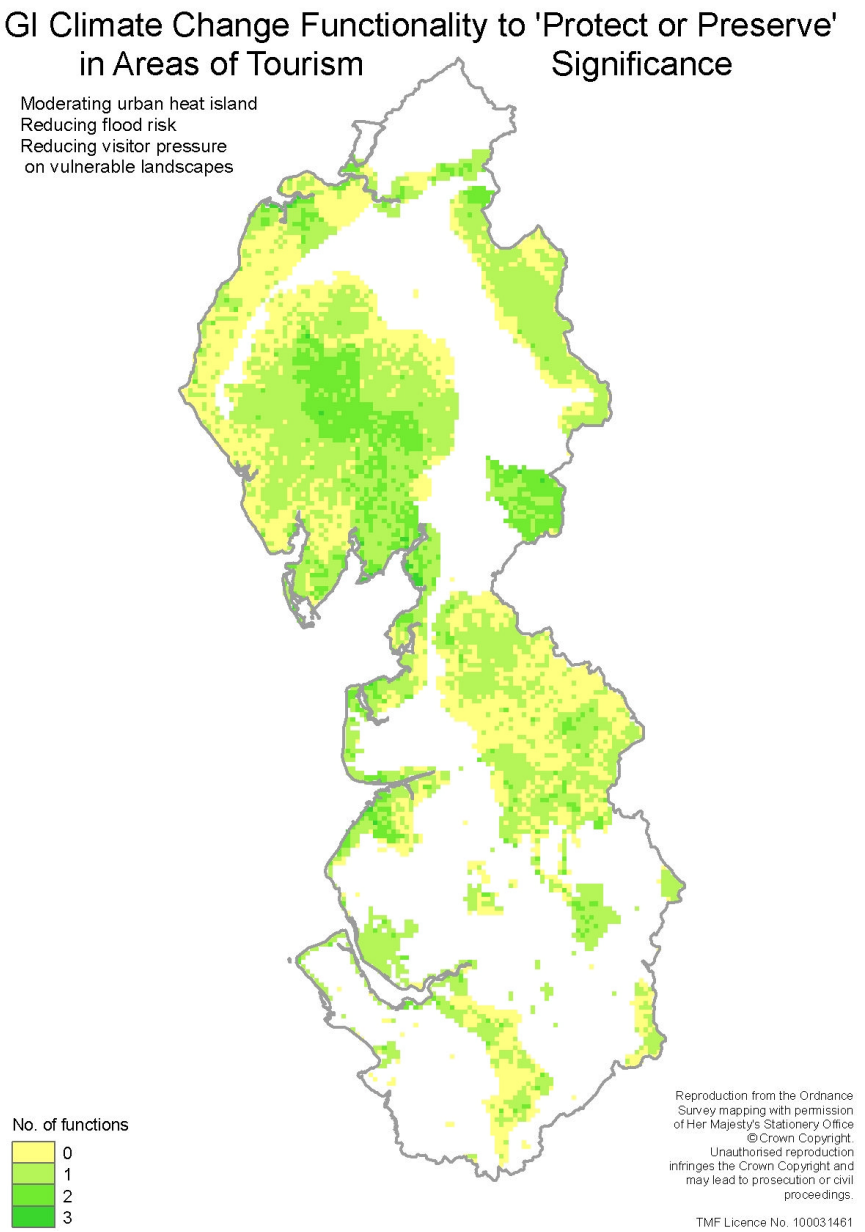


Figure 17b.

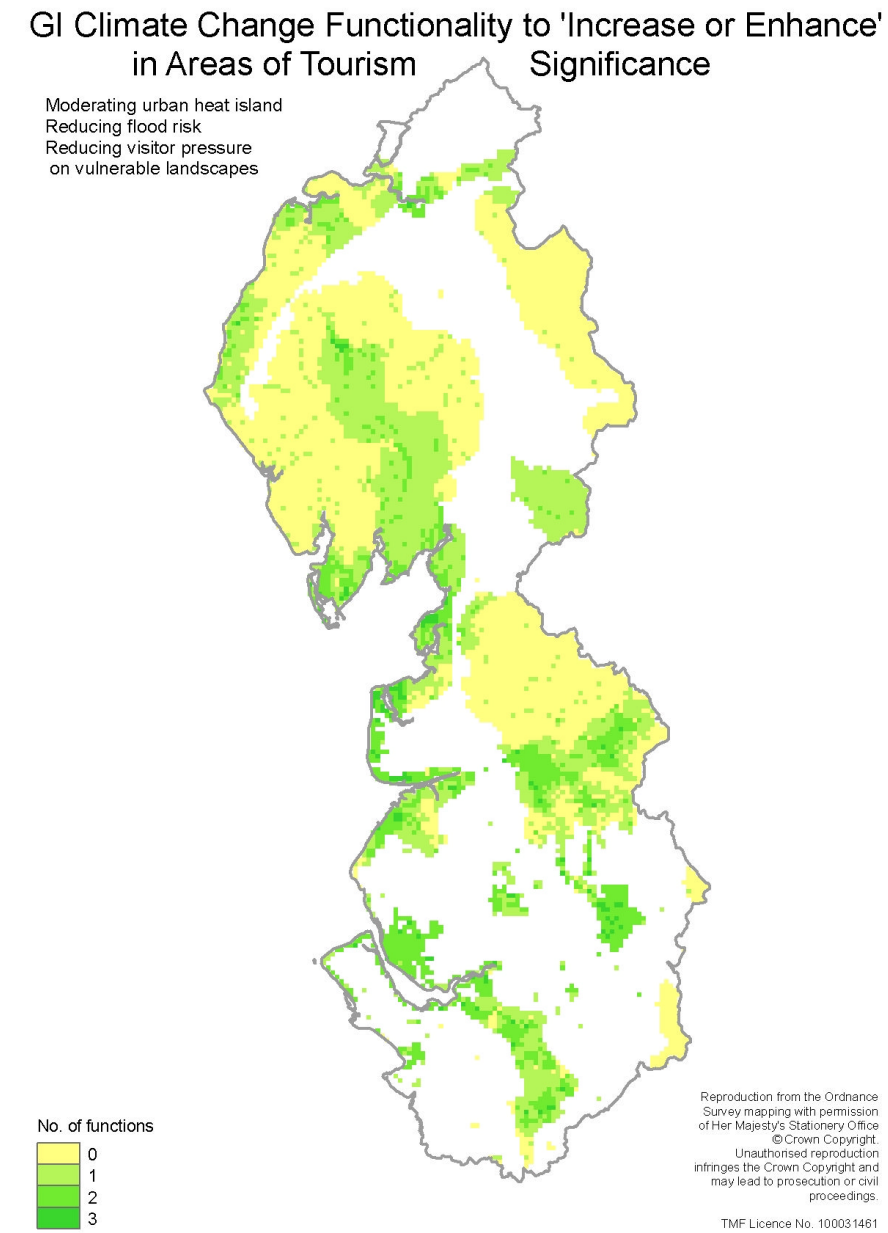


Figure 18a.

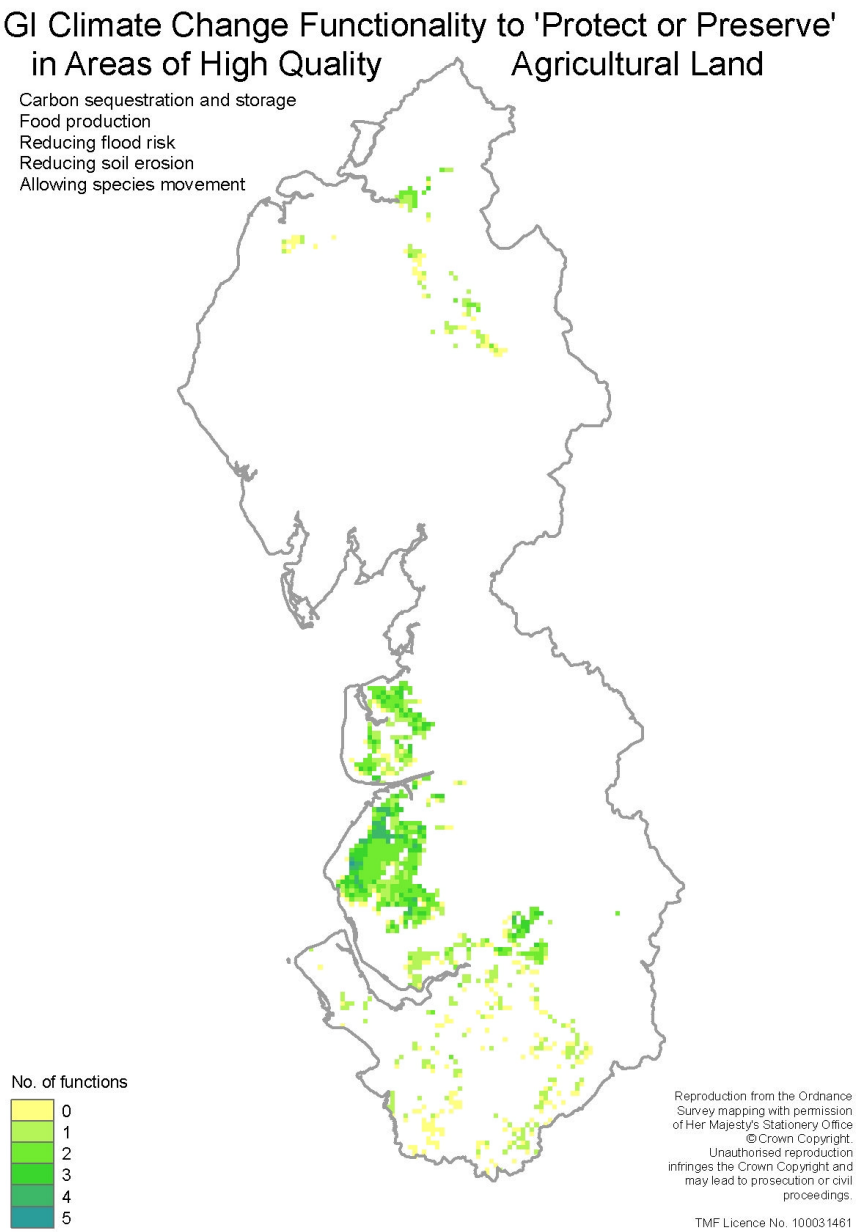
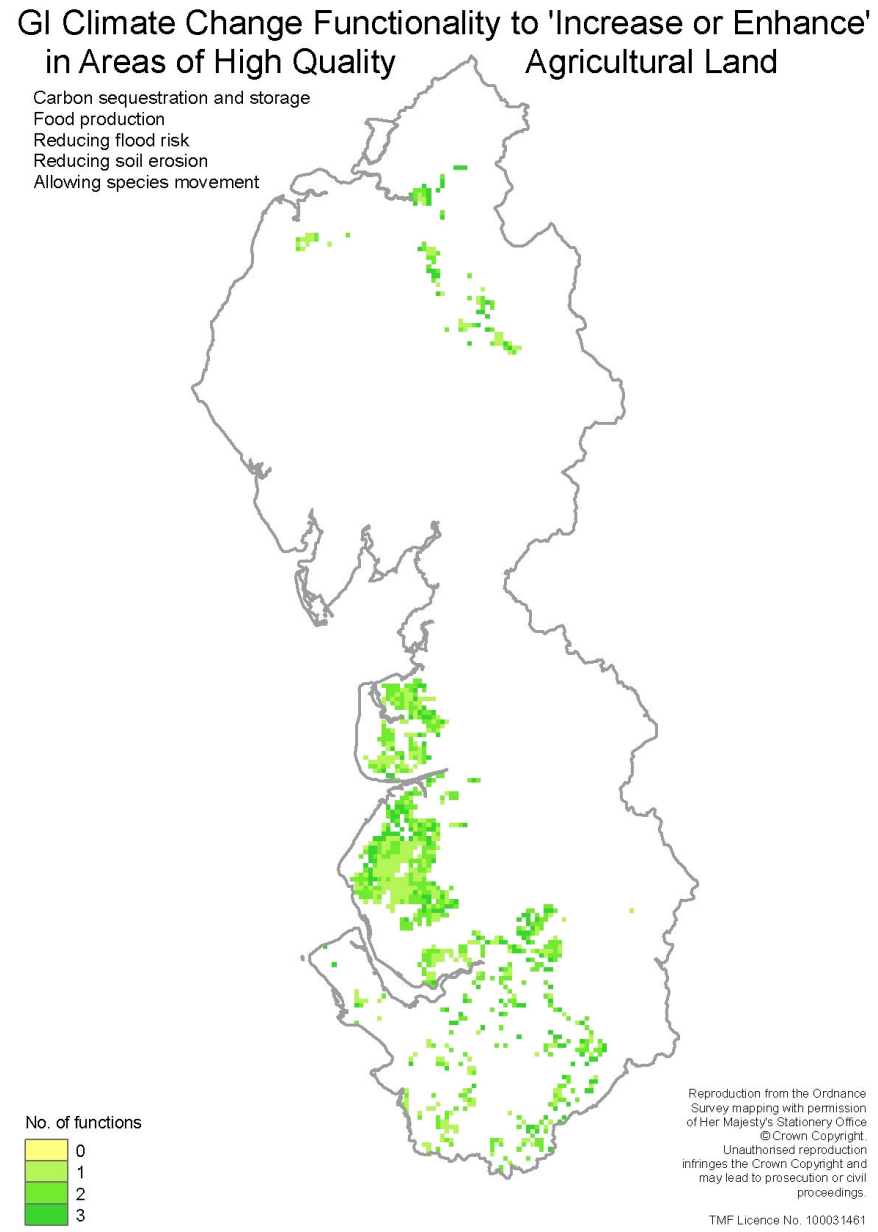


Figure 18b.



6. Emerging Sub-Regional Storylines

This section uses the information presented in sections 3-5, as well as that presented in tables 8-12 below, to begin to tell storylines for each of the sub-regions of the North West. In tables 8-12 the following colour coding is applied:

Greater than or equal to NW average + 10%
Greater than or equal to sub-regional average + 10%

It must be stressed that the emerging storylines are in terms of the percentage of the sub-region or district covered. Thus, this tends to favour both the districts and functions with cover the largest areas. Functions which may be crucial in an area, despite a low geographical coverage, tend not to be picked up. The obvious example is in terms of flood risk, where the geographical area covered by floodplains is relatively small in comparison with some of the other functions, yet the cost of flooding (socially, economically and environmentally) can be high. Thus, there are factors other than area covered which need to be taken into account, for example, the number of properties likely to be flooded. Further consideration needs to be given as to how to best prioritise issues, for example, through stakeholder prioritisation, applying weightings, undertaking a costed risk assessment, etc. Whilst the approach used here is a helpful way to begin to prioritise, it is by no means the only or best way. Thus, the storylines should be read with caution.

The emerging storylines initially set out the regional economic priorities (as mapped in section 3) as they occur in the sub-regions. This helps to identify the relative importance of the regional economic priorities in terms of the potential area covered. It does not cover their importance in terms of their contribution to the economy. However, it helps to identify areas where there is potential change for which the climate change functionality of GI should be a consideration. The emerging storylines then take each regional economic priority in turn, setting out (in terms of area covered) the most important districts within the sub-region for it, and the most important GI climate change functions, relevant to the regional economic priority, to both preserve or protect and increase or enhance within these districts. Finally, the emerging storylines set out the important GI climate change functions regardless of the focus on regional economic priorities.

The emerging storylines should be read alongside the climate change risks and opportunities for the regional economic priorities which the GI climate change functions identified can help to reduce or realise (set out in tables 2 and 3 in section 3.1). In terms of development and restructuring, the climate change risks are from flooding of the development, the development passing on flood risk to areas downstream, human discomfort due to heat in buildings and the external environment, the development contributing directly or indirectly to increased greenhouse gas emissions, the development contributing negatively to the ability of species to adapt to change. Climate change opportunities include an increased demand for outdoor areas and outdoor living, the development incorporating features to reduce flood risk to nearby areas, and the development being sensitive to requirements for species movement thereby helping in adaptation. In terms of tourism, the climate change risks are from the urban heat island effect making urban summer tourism less attractive, increased visitors putting pressure on vulnerable landscapes, and flooding of tourist attractions. Climate change opportunities include an increased demand for outdoor tourism. In terms of high quality agricultural land, the climate change risks are from increased soil erosion leading to decreased quality, flooding of the agricultural land or areas downstream, agriculture contributing directly or indirectly to increased greenhouse gas emissions, agriculture contributing negatively to the ability of species to adapt to change. Climate change opportunities are potentially a wider range of crops can be grown, agricultural practices to increase the carbon store, help the ability of species to adapt to change and reduce downstream flooding.

6.1 Cheshire

In Cheshire, the regional economic priorities (in terms of area covered) are development and restructuring, followed by tourism and high quality agricultural land. In a North West context, Cheshire is important in terms of high quality agricultural land, whilst some of the districts are important in terms of development and restructuring.

Development and restructuring is especially important in the districts of Ellesmere Port and Neston, followed by Warrington, Vale Royal (and also in Chester in a Cheshire context). During development and restructuring it is important to preserve and protect the existing GI functionality, and to take opportunities to increase and enhance it. In Ellesmere Port and Neston, important functions (in the context of the North West) to consider include taking opportunities to increase or enhance carbon storage, reduce the need to travel by car, moderate the urban heat island (for both vulnerable people and settlements), increase or enhance food production, and reduce flood risk. Other important functions (in the context of Cheshire) include protecting and enhancing biodiversity, and protecting the highest quality agricultural land. In Warrington, the storyline is fairly similar to in Ellesmere Port and Neston, however protecting the highest quality agricultural land for food production is also important in a North West context. In the context of Cheshire, Warrington also has carbon stores to protect. In Vale Royal, important functions (in the context of the North West) to consider include taking opportunities to increase or enhance carbon storage, increase biodiversity, increase or enhance and protect the highest quality agricultural land for food production, and moderate the urban heat island (for vulnerable people). Other important functions (in the context of Cheshire) include reducing the need to travel by car and protecting carbon stores.

Tourism in Cheshire does not come out as especially important in the context of the North West, however, it is most important in a Cheshire context in Vale Royal, followed by Crewe and Nantwich. In Vale Royal, there are opportunities to use areas with the highest landscape capacity for tourism, which could potentially reduce visitor pressure on more vulnerable landscapes in the North West. Reducing flood risk is also important in the context of Cheshire. In Crewe and Nantwich (within a Cheshire context) the most important functions are to take opportunities to use high capacity areas for tourism, and to reduce the urban heat island (in settlements). Chester appears to be less important for tourism, yet the city of Chester is clearly important with its attack brand status. Here, reducing the urban heat island (in settlements) is important in the context of Cheshire.

High quality agricultural land in Cheshire is important in the context of the North West. The most important functions are to increase carbon storage and biodiversity. In particular, important districts are Warrington, Congleton, Crewe and Nantwich, and Chester. In Warrington, increasing carbon storage, protecting food production, increasing and protecting biodiversity, and reducing flood risk and soil erosion are important functions in the context of the North West, and preserving the carbon store is important in the context of Cheshire. The story in Congleton is similar, but reducing flooding and soil erosion are less of an issue, as is protecting the carbon store. In Crewe and Nantwich, increasing the carbon store and increasing biodiversity are the most important functions, whist in Chester it is to increase the carbon store.

Regardless of regional economic priorities, in Cheshire, important GI climate change functions to ‘preserve or protect’ are reducing the need to travel by car, moderating the urban heat island (vulnerable people), food production, and allowing species movement. Important GI climate change functions to ‘increase or enhance’ are carbon sequestration and storage, food production, reducing the need to travel by car, and reducing visitor pressure on vulnerable landscapes. In terms of both the ‘preserve or protect’ and ‘increase or enhance’ functions, carbon sequestration and storage, reducing the need to travel by car, moderating the urban heat island (vulnerable people), reducing soil erosion, allowing species movement, and

reducing visitor pressure on vulnerable landscapes are most important in Macclesfield; moderating the urban heat island (settlements) and reducing flood risk are most important in Warrington. It is most important to 'preserve or protect' food production in Warrington and 'increase or enhance' it in Chester. Parts of Macclesfield and Warrington have the highest multifunctionality to 'preserve or protect', whereas Macclesfield and Vale Royal have the highest multifunctionality to 'increase or enhance'.

Table 8. Percentage of Cheshire districts which are important for GI climate change functions in (a) development and restructuring areas, (b) areas of tourism significance, (c) areas with high quality agricultural land

(a)		% of district in a development and restructuring area & important for GI climate change function									
District / Sub-region	% Dev & Rest	Carbon – preserve/ protect	Carbon – increase/ enhance	Travel	Food - preserve/ protect	Food - increase/ enhance	UHI - people	UHI - settlements	Flood	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Chester	61.0%	1.2%	61.0%	38.9%	4.4%	47.6%	18.1%	4.9%	3.0%	2.5%	18.1%
Congleton	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crewe & Nantwich	13.5%	0.0%	13.5%	9.8%	0.7%	7.6%	2.9%	3.5%	0.6%	0.7%	5.1%
Ellesmere Port & Neston	95.1%	0.9%	95.1%	92.1%	5.2%	35.1%	81.3%	19.4%	14.3%	4.3%	29.7%
Macclesfield	2.1%	0.0%	2.1%	2.1%	0.0%	0.3%	1.0%	2.0%	0.1%	0.0%	0.6%
Vale Royal	66.5%	4.6%	66.5%	43.4%	6.8%	51.4%	29.8%	1.3%	3.1%	8.8%	40.1%
Warrington	68.0%	2.2%	68.0%	68.0%	19.4%	24.2%	32.2%	14.3%	13.6%	5.6%	28.6%
Cheshire	**35.5%**	**1.2%**	**35.5%**	**26.4%**	**3.9%**	**22.9%**	**15.2%**	**4.2%**	**2.9%**	**2.7%**	**14.9%**
NW average	**59.6%**	**8.9%**	**59.6%**	**55.0%**	**5.3%**	**13.7%**	**26.8%**	**12.2%**	**5.6%**	**8.7%**	**32.9%**

(b)		% of district in an area of tourism significance & important for GI climate change function			
District / Sub-region	% Tourism significance	UHI - settlements	Flood	Vulnerable landscape - preserve/ protect	Vulnerable landscape - increase/ enhance
Chester	7.0%	4.9%	0.1%	0.0%	6.7%
Congleton	18.2%	0.0%	1.1%	0.0%	10.3%
Crewe & Nantwich	31.9%	3.5%	2.1%	0.1%	24.9%
Ellesmere Port & Neston	15.9%	1.5%	7.1%	0.0%	7.2%
Macclesfield	19.5%	0.0%	0.4%	7.4%	1.6%
Vale Royal	46.4%	1.3%	4.9%	0.1%	41.7%
Warrington	7.0%	0.5%	3.6%	0.0%	6.1%
Cheshire	**22.6%**	**1.9%**	**2.0%**	**1.7%**	**15.2%**
NW average	**44.3%**	**7.6%**	**5.0%**	**11.2%**	**24.9%**

(c) District / Sub-region	% High quality agricultural land	% of district in an area of high quality agricultural land & important for GI climate change function						
		Carbon - preserve/ protect	Carbon - increase/ enhance	Food - preserve/ protect	Flood	Soil erosion	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Chester	11.7%	0.0%	11.7%	6.4%	0.0%	0.3%	0.2%	3.7%
Congleton	16.9%	0.0%	16.9%	16.9%	0.3%	0.1%	0.7%	9.7%
Crewe &Nantwich	13.4%	0.4%	13.4%	9.6%	0.2%	0.2%	0.3%	5.9%
Ellesmere Port & Neston	5.8%	0.0%	5.8%	5.8%	0.2%	0.0%	0.4%	2.6%
Macclesfield	6.7%	0.2%	6.7%	6.7%	0.1%	0.1%	0.5%	4.3%
Vale Royal	10.5%	0.3%	10.5%	10.5%	0.1%	0.3%	0.5%	5.9%
Warrington	29.3%	3.3%	29.3%	29.3%	3.9%	1.1%	2.3%	14.3%
Cheshire	**12.3%**	**0.4%**	**12.3%**	**10.6%**	**0.4%**	**0.3%**	**0.6%**	**6.0%**
NW average	**10.5%**	**3.7%**	**10.0%**	**9.7%**	**1.8%**	**1.0%**	**0.6%**	**4.3%**

6.2 Cumbria

In Cumbria, the main regional economic priority of interest (in terms of area covered) is tourism, which is important in a North West context. Less important are development and restructuring, although Barrow-in-Furness is important in a North West context, and high quality agricultural land.

Tourism in Cumbria is important in a North West context, with the most important functions being to protect vulnerable landscapes and reduce flood risk. The districts which are most important in terms of tourism are Barrow-in-Furness, Copeland, Allerdale, and South Lakeland. In Barrow-in-Furness, opportunities should be taken to use areas with the highest landscape capacity for tourism, which could potentially reduce visitor pressure on more vulnerable landscapes. Protecting the most vulnerable landscapes, reducing the urban heat island (in settlements), and reducing flood risk are also important GI functions. In Copeland, Allerdale, and South Lakeland, the most important functions (in a North West context) are to protect vulnerable landscapes and reduce flood risk. It is also important in Copeland and Allerdale (in a Cumbria context) to take opportunities to use areas with the highest landscape capacity for tourism. Carlisle comes out as less important for tourism, although the city of Carlisle is mentioned as important in the Regional Economic Strategy. Here, taking opportunities to use areas with the highest landscape capacity for tourism and reducing the urban heat island (in settlements) are important in the context of Cumbria.

Development and restructuring is important in Barrow-in-Furness, with Copeland and Carlisle being important in the context of Cumbria. In Barrow-in-Furness, the most important functions (in the context of the North West) are to take opportunities to increase or enhance carbon storage, reduce the need to travel by car, moderate the urban heat island (for vulnerable people), and increase or enhance food production. Other important functions (in the context of Cumbria) are to protect and enhance biodiversity, moderate the urban heat island (in settlements), reduce flood risk, and protect carbon stores.

High quality agricultural land is not important (in the context of the North West) in any district in Cumbria. It is most important, in the context of Cumbria, in Carlisle and Eden.

Regardless of regional economic priorities, in Cumbria, important GI climate change functions to 'preserve or protect' are reducing visitor pressure on vulnerable landscapes, reducing soil erosion, allowing species movement, and carbon sequestration and storage. Important GI climate change functions to 'increase or enhance' are carbon sequestration and storage, allowing species movement, reducing soil erosion and food production. In terms of both the 'preserve or protect' and 'increase or enhance' functions: carbon sequestration and storage, reducing soil erosion, and allowing species movement are most important in Eden; reducing the need to travel by car and moderating the urban heat island (settlements) are most important in Carlisle; and moderating the urban heat island (vulnerable people) and reducing flood risk are most important in South Lakeland. It is most important to 'preserve or protect' food production in Eden and 'increase or enhance' it in Allerdale. It is most important to 'preserve or protect' the function reducing visitor pressure on vulnerable landscapes in Eden and 'increase or enhance' it in Carlisle. Parts of South Lakeland, Allerdale, and Carlisle have the highest multifunctionality to 'preserve or protect', whereas Carlisle, South Lakeland, Eden and Barrow-in-Furness have the highest multifunctionality to 'increase or enhance'.

Table 9. Percentage of Cumbria districts which are important for GI climate change functions in (a) development and restructuring areas, (b) areas of tourism significance, (c) areas with high quality agricultural land

(a) District / Sub-region	% Dev & Rest	% of district in a development and restructuring area & important for GI climate change function									
		Carbon - preserve/ protect	Carbon - increase/ enhance	Travel	Food - preserve/ protect	Food - increase/ enhance	UHI - people	UHI - settlements	Flood	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Allerdale	2.2%	0.0%	2.2%	2.2%	0.0%	0.9%	0.5%	0.0%	0.2%	0.1%	1.2%
Barrow-in-Furness	73.0%	1.1%	73.0%	60.9%	0.0%	36.5%	57.8%	13.4%	4.9%	5.1%	34.2%
Carlisle	3.2%	0.0%	3.2%	3.2%	0.0%	0.9%	2.4%	1.9%	0.7%	0.2%	1.2%
Copeland	4.3%	0.0%	4.3%	4.3%	0.0%	1.4%	1.3%	0.0%	0.2%	0.3%	2.5%
Eden	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
South Lakeland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cumbria	**2.2%**	**0.0%**	**2.2%**	**2.0%**	**0.0%**	**0.8%**	**1.2%**	**0.4%**	**0.2%**	**0.1%**	**1.1%**
NW average	**59.6%**	**8.9%**	**59.6%**	**55.0%**	**5.3%**	**13.7%**	**26.8%**	**12.2%**	**5.6%**	**8.7%**	**32.9%**

(b) District / Sub-region	% Tourism significance	% of district in an area of tourism significance & important for GI climate change function			
		UHI - settlements	Flood	Vulnerable landscape - preserve/ protect	Vulnerable landscape - increase/ enhance
Allerdale	85.2%	0.0%	10.5%	26.4%	4.7%
Barrow-in-Furness	100.0%	13.4%	12.7%	17.6%	60.0%
Carlisle	27.3%	1.9%	5.1%	7.2%	6.2%
Copeland	93.5%	0.0%	7.0%	46.8%	9.6%
Eden	47.9%	0.0%	1.6%	31.2%	0.1%
South Lakeland	76.4%	0.0%	8.3%	35.7%	1.3%
Cumbria	**63.8%**	**0.4%**	**6.0%**	**29.2%**	**3.8%**
NW average	**44.3%**	**7.6%**	**5.0%**	**11.2%**	**24.9%**

(c) District / Sub-region	% High quality agricultural land	% of district in an area of high quality agricultural land & important for GI climate change function						
		Carbon - preserve/ protect	Carbon - increase/ enhance	Food - preserve/ protect	Flood	Soil erosion	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Allerdale	1.0%	0.1%	1.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Barrow-in-Furness	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Carlisle	3.0%	0.0%	3.0%	2.7%	1.6%	0.0%	0.3%	1.9%
Copeland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eden	2.9%	0.0%	2.9%	2.2%	0.4%	0.1%	0.1%	1.3%
South Lakeland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cumbria	**1.6%**	**0.0%**	**1.6%**	**1.1%**	**0.4%**	**0.0%**	**0.1%**	**0.7%**
NW average	**10.5%**	**3.7%**	**10.0%**	**9.7%**	**1.8%**	**1.0%**	**0.6%**	**4.3%**

6.3 Greater Manchester

In Greater Manchester, the regional priorities (in terms of area covered) are development and restructuring, followed by tourism and high quality agricultural land.

In a North West context, important functions in Greater Manchester to take into account in development and restructuring are reducing the need to travel by car, enhancing and protecting biodiversity, and moderating the urban heat island (for both vulnerable people and settlements). Development and restructuring is important in a North West context in Manchester, Oldham, Rochdale, Salford, Bolton and Bury. In all these districts, important functions (in a North West context) are taking opportunities to increase or enhance carbon storage, reduce the need to travel by car, and protecting and enhancing biodiversity. In Manchester, other important functions (in a North West context) are moderating the urban heat island (for both

vulnerable people and settlements), and reducing flood risk. In Oldham, other important functions (in a North West context) are moderating the urban heat island (for both vulnerable people and settlements), and protecting carbon stores. In Rochdale, other important functions in a North West context are moderating the urban heat island (for vulnerable people) and protecting carbon stores, whilst in a Greater Manchester context increasing or enhancing food production is important. In Salford, other important functions in a North West context are protecting carbon stores. In Oldham, other important functions (in a North West context) are moderating the urban heat island (for both vulnerable people and settlements), and increasing or enhancing food production. In Bury, other important functions (in the context of Greater Manchester) are increasing or enhancing food production, and reducing flood risk. Stockport and Tameside are highlighted as important (in a North West context) for moderating the urban heat island (in settlements) and Wigan for increasing or enhancing food production.

In a North West context, an important function in Greater Manchester to take into account in areas of tourism significance is moderating the urban heat island (in settlements). Tourism is especially important in Manchester in a North West context, and in Wigan, Bury and Salford in a Greater Manchester context. In Manchester, important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism (which could potentially reduce visitor pressure on more vulnerable landscapes in the North West), moderating the urban heat island (in settlements), and reducing flood risk. In both Wigan and Bury, taking opportunities to use areas with the highest landscape capacity for tourism is important in a North West context, whilst reducing flood risk is important in a Greater Manchester context. In Salford, taking opportunities to use areas with the highest landscape capacity for tourism and reducing the vulnerability of landscapes, and moderating the urban heat island (in settlements) are important in a North West context, whilst reducing flood risk is important in a Greater Manchester context. Oldham is highlighted as important (in a North West context) for protecting vulnerable landscapes.

High quality agricultural land is the most important (in a North West context) in Trafford and Salford. In both Trafford and Salford, important functions in a North West context are to increase and protect the carbon store, protect high quality agricultural land for food production, increase and protect biodiversity, and reduce soil erosion. Reducing flooding is also important in both districts in the context of Greater Manchester. Wigan is highlighted as important in a North West context for protecting biodiversity, and in a Greater Manchester context for increasing biodiversity and reducing flooding.

Regardless of regional economic priorities, in Greater Manchester, important GI climate change functions to ‘preserve or protect’ are reducing the need to travel by car, moderating the urban heat island (vulnerable people), allowing species movement, and moderating the urban heat island (settlements). Important GI climate change functions to ‘increase or enhance’ are carbon sequestration and storage, reducing the need to travel by car, reducing visitor pressure on vulnerable landscapes, and allowing species movement. In terms of both the ‘preserve or protect’ and ‘increase or enhance’ functions: reducing the need to travel by car is most important in Wigan; moderating the urban heat island (vulnerable people and settlements) is most important in Manchester; reducing flood risk is most important in Manchester and Salford; reducing soil erosion is most important in Rochdale. It is most important to ‘preserve or protect’: carbon sequestration and storage in Oldham and ‘increase or enhance’ it in Wigan; food production in Trafford and ‘increase or enhance’ it in Wigan; allowing species movement in Oldham and ‘increase or enhance’ it in Rochdale; reducing visitor pressure on vulnerable landscapes in Rochdale and ‘increase or enhance’ it in Wigan. Parts of Rochdale, Salford, Tameside and Bolton have the highest multifunctionality to ‘preserve or protect’, whereas Stockport, Wigan and Manchester have the highest multifunctionality to ‘increase or enhance’.

Table 10. Percentage of Greater Manchester districts which are important for GI climate change functions in (a) development and restructuring areas, (b) areas of tourism significance, (c) areas with high quality agricultural land

(a) District / Sub-region	% Dev & Rest	% of district in a development and restructuring area & important for GI climate change function									
		Carbon - preserve/ protect	Carbon - increase/ enhance	Travel	Food - preserve/ protect	Food - increase/ enhance	UHI - people	UHI - settlements	Flood	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Bolton	75.2%	5.0%	75.2%	75.2%	0.0%	15.8%	39.1%	20.5%	2.8%	18.4%	55.3%
Bury	68.2%	0.0%	68.2%	68.2%	0.0%	13.4%	24.5%	11.7%	5.7%	14.5%	51.5%
Manchester	100.0%	2.7%	100.0%	100.0%	0.0%	6.9%	82.0%	65.0%	12.0%	11.2%	47.2%
Oldham	100.0%	28.8%	100.0%	79.8%	0.0%	0.0%	31.2%	19.2%	2.6%	35.8%	75.9%
Rochdale	100.0%	19.0%	100.0%	92.5%	0.0%	11.3%	42.2%	13.3%	4.3%	25.2%	73.5%
Salford	100.0%	43.8%	100.0%	97.9%	0.0%	0.0%	22.0%	0.0%	2.4%	23.9%	89.6%
Stockport	22.7%	0.0%	22.7%	22.7%	0.0%	0.9%	13.4%	21.2%	1.0%	1.0%	5.8%
Tameside	17.5%	0.8%	17.5%	17.5%	0.2%	0.0%	9.6%	16.8%	0.2%	2.0%	8.0%
Trafford	42.9%	3.7%	42.9%	42.9%	1.7%	4.8%	20.7%	8.0%	5.4%	1.2%	11.3%
Wigan	31.8%	0.4%	31.8%	31.8%	0.3%	18.1%	11.5%	8.6%	2.1%	2.1%	13.7%
Greater Manchester	**65.6%**	**8.8%**	**65.6%**	**62.5%**	**1.6%**	**9.2%**	**31.2%**	**19.8%**	**4.4%**	**12.7%**	**39.9%**
NW average	**59.6%**	**8.9%**	**59.6%**	**55.0%**	**5.3%**	**13.7%**	**26.8%**	**12.2%**	**5.6%**	**8.7%**	**32.9%**

(b) District / Sub-region	% Tourism significance	% of district in an area of tourism significance & important for GI climate change function			
		UHI - settlements	Flood	Vulnerable landscape - preserve/protect	Vulnerable landscape - increase/enhance
Bolton	13.4%	2.7%	1.4%	0.5%	12.6%
Bury	28.6%	2.5%	5.1%	0.1%	27.9%
Manchester	67.3%	64.8%	6.7%	0.0%	66.9%
Oldham	20.1%	0.3%	0.6%	16.9%	0.5%
Rochdale	1.6%	1.5%	0.0%	0.0%	1.6%
Salford	21.4%	12.6%	4.9%	0.4%	20.8%
Stockport	0.8%	0.7%	0.0%	0.0%	0.8%
Tameside	7.7%	7.7%	0.1%	0.0%	6.5%
Trafford	3.0%	1.6%	0.0%	0.0%	2.5%
Wigan	29.5%	0.5%	2.8%	0.1%	27.9%
Greater Manchester	**19.2%**	**8.5%**	**2.0%**	**2.0%**	**16.5%**
NW average	**44.3%**	**7.6%**	**5.0%**	**11.2%**	**24.9%**

(c) District / Sub-region	% High quality agricultural land	% of district in an area of high quality agricultural land & important for GI climate change function						
		Carbon - preserve/ protect	Carbon - increase/ enhance	Food - preserve/ protect	Flood	Soil erosion	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Bolton	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bury	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Manchester	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Oldham	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Rochdale	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Salford	18.5%	17.6%	18.5%	18.5%	0.7%	9.7%	2.4%	11.9%
Stockport	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tameside	1.1%	0.7%	1.1%	1.1%	0.0%	0.3%	0.0%	0.1%
Trafford	22.1%	11.4%	22.1%	22.1%	1.1%	1.8%	1.4%	11.9%
Wigan	3.7%	2.7%	3.7%	3.7%	0.5%	1.0%	0.6%	3.0%
Greater Manchester	**3.9%**	**2.8%**	**3.9%**	**3.9%**	**0.2%**	**1.1%**	**0.4%**	**2.4%**
NW average	**10.5%**	**3.7%**	**10.0%**	**9.7%**	**1.8%**	**1.0%**	**0.6%**	**4.3%**

6.4 Lancashire

In Lancashire, the regional economic priorities (in terms of area covered) are tourism, followed by development and restructuring and high quality agricultural land. Both tourism and high quality agricultural land are important in a North West context.

Tourism is important in a North West context, and in particular the functions to reduce the vulnerability of landscapes and reduce flooding. The districts which are most important in a North West context are Blackburn with Darwen, Burnley, Hyndburn, Pendle, Ribble Valley, Rossendale, Blackpool, Lancaster and Wyre. In Blackburn with Darwen and Burnley important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism, reduce the vulnerability of landscapes, and moderate the urban heat island (in settlements). In Hyndburn, Pendle, and Rossendale the important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism, and reduce the vulnerability of landscapes. In Ribble Valley the important function (in a North West context) is to reduce the vulnerability of landscapes. In Blackpool the important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism, moderate the urban heat island (in settlements), and reduce flooding. In Lancaster the important functions (in a North West context) are to reduce the vulnerability of landscapes and reduce flooding. In Wyre the important function (in a North West context) is to reduce flooding. Fylde, West Lancashire and Wyre are highlighted as important in a North West context in terms of reducing flooding.

In a North West context, important functions in Lancashire to take into account in development and restructuring are protecting carbon stores, reducing flooding, and protecting high quality agricultural land for food production. Development and restructuring is important in a North West context in Blackburn with Darwen, Blackpool, Burnley, Hyndburn, Pendle, Rossendale, Fylde, Chorley, and South Ribble. In all these districts, increasing

carbon storage and reducing the need to travel by car are important functions in a North West context. In Blackburn with Darwen and Burnley, other important functions (in a North West context) are increasing and protecting biodiversity, protecting the carbon store, and moderating the urban heat island (in settlements). Moderating the urban heat island (for vulnerable people) is also important (in a Lancashire context) in Blackburn with Darwen. In Blackpool, other important functions (in a North West context) are moderating the urban heat island (for both vulnerable people and settlements), reducing flooding, and increasing food production. In both Hyndburn and Rossendale, other important functions in a North West context are increasing and protecting biodiversity, protecting the carbon store, and, in a Lancashire context, moderating the urban heat island (for vulnerable people). In Pendle, other important functions in a North West context are increasing and protecting biodiversity, moderating the urban heat island (for vulnerable people), and protecting the carbon store. In Fylde, other important functions in a North West context are protecting high quality agricultural land and increasing food production, protecting the carbon store, reducing flooding, and, in a Lancashire context, increasing biodiversity and moderating the urban heat island (for vulnerable people). In Chorley, other important functions in a North West context are increasing and protecting biodiversity, increasing food production and protecting high quality agricultural land, protecting the carbon store, reducing flooding, and, in a Lancashire context, moderating the urban heat island (for vulnerable people). In South Ribble, other important functions in a North West context are increasing food production and protecting high quality agricultural land, increasing biodiversity, reducing flooding, and, in a Lancashire context, moderating the urban heat island (for vulnerable people). West Lancashire is highlighted as important in a North West context in terms of preserving high quality agricultural land for food production, reducing flooding, and protecting the carbon store. Preston is highlighted as important in a North West context in terms of increasing food production, moderating the urban heat island (in settlements), and reducing flooding.

High quality agricultural land is important in a North West context, in particular in West Lancashire, Fylde, and Wyre. In all these districts, important functions (in a North West context) are to increase and protect carbon stores, to protect high quality agricultural land for food production, and to reduce flooding and soil erosion. In West Lancashire and Fylde it is also important (in a North West context) to increase and protect biodiversity. Chorley is also highlighted as important (in a North West context) for reducing flooding and soil erosion. South Ribble is highlighted as important (in a North West context) for protecting high quality agricultural land for food production, and reducing flooding and soil erosion.

Regardless of regional economic priorities, in Lancashire, important GI climate change functions to ‘preserve or protect’ are reducing the need to travel by car, carbon sequestration and storage, reducing visitor pressure on vulnerable landscapes, and reducing soil erosion. Important GI climate change functions to ‘increase or enhance’ are carbon sequestration and storage, allowing species movement, reducing the need to travel by car, reducing visitor pressure on vulnerable landscapes and food production. In terms of both the ‘preserve or protect’ and ‘increase or enhance’ functions: reducing the need to travel by car and reducing flood risk are most important in West Lancashire; moderating the urban heat island (vulnerable people) is most important in Lancaster; moderating the urban heat island (settlements) is most important in Blackpool; reducing soil erosion and allowing species movement are most important in Ribble Valley. It is most important to ‘preserve or protect’: carbon sequestration and storage and food production in West Lancashire and ‘increase or enhance’ them in Lancaster; reducing visitor pressure on vulnerable landscapes in Ribble Valley and ‘increase or enhance’ it in West Lancashire. Parts of West Lancashire, Rossendale, and Blackburn with Darwen have the highest multifunctionality to ‘preserve or protect’, whereas Ribble Valley, Lancaster and Chorley have the highest multifunctionality to ‘increase or enhance’.

Table 11. Percentage of Lancashire districts which are important for GI climate change functions in (a) development and restructuring areas, (b) areas of tourism significance, (c) areas with high quality agricultural land

(a) District / Sub-region	% Dev & Rest	% of district in a development and restructuring area & important for GI climate change function									
		Carbon - preserve/ protect	Carbon - increase/ enhance	Travel	Food - preserve/ protect	Food - increase/ enhance	UHI - people	UHI - settlements	Flood	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Blackburn with Darwen	100.0%	50.3%	100.0%	98.1%	0.0%	9.5%	26.2%	13.5%	4.0%	31.3%	81.9%
Blackpool	100.0%	2.5%	100.0%	100.0%	5.2%	15.4%	92.5%	73.7%	17.2%	2.8%	24.8%
Burnley	100.0%	31.1%	100.0%	98.9%	0.0%	9.5%	10.7%	13.8%	4.2%	31.0%	87.3%
Chorley	97.8%	16.4%	97.8%	85.6%	8.3%	58.9%	16.1%	0.0%	10.2%	16.9%	61.4%
Fylde	99.8%	22.2%	99.8%	71.3%	48.3%	33.8%	23.4%	0.3%	19.1%	4.4%	33.2%
Hyndburn	100.0%	19.6%	100.0%	99.4%	0.0%	2.8%	29.1%	0.6%	3.9%	13.0%	64.3%
Lancaster	4.7%	0.3%	4.7%	4.7%	0.0%	1.6%	2.1%	1.1%	1.3%	0.3%	2.1%
Pendle	100.0%	23.0%	100.0%	75.3%	0.0%	5.1%	41.7%	0.1%	2.7%	22.6%	65.5%
Preston	49.8%	1.9%	49.8%	47.4%	0.8%	30.8%	17.3%	16.7%	8.9%	3.1%	20.6%
Ribble Valley	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%
Rossendale	100.0%	43.8%	100.0%	97.9%	0.0%	0.0%	22.0%	0.0%	2.4%	23.9%	89.6%
South Ribble	88.7%	5.3%	88.7%	83.1%	11.0%	53.7%	19.3%	0.0%	18.2%	5.7%	38.8%
West Lancashire	42.0%	17.8%	42.0%	25.4%	23.7%	8.5%	1.6%	2.7%	19.6%	2.4%	16.4%
Wyre	14.7%	2.1%	14.7%	9.5%	2.8%	5.7%	8.3%	0.6%	5.6%	0.2%	2.1%
Lancashire	**46.0%**	**11.9%**	**46.0%**	**39.4%**	**6.5%**	**12.2%**	**11.8%**	**3.4%**	**6.6%**	**7.2%**	**27.0%**
NW average	**59.6%**	**8.9%**	**59.6%**	**55.0%**	**5.3%**	**13.7%**	**26.8%**	**12.2%**	**5.6%**	**8.7%**	**32.9%**

(b) District / Sub-region	% Tourism significance	% of district in an area of tourism significance & important for GI climate change function			
		UHI - settlements	Flood	Vulnerable landscape - preserve/protect	Vulnerable landscape - increase/enhance
Blackburn with Darwen	100.0%	13.5%	4.0%	30.8%	66.4%
Blackpool	75.7%	73.7%	12.9%	0.0%	75.5%
Burnley	100.0%	13.8%	4.2%	38.2%	60.4%
Chorley	2.2%	0.0%	0.7%	0.2%	1.0%
Fylde	27.3%	0.3%	10.4%	0.6%	23.6%
Hyndburn	100.0%	0.6%	3.9%	15.7%	82.6%
Lancaster	72.9%	1.1%	13.5%	22.3%	13.6%
Pendle	100.0%	0.1%	2.7%	23.5%	52.2%
Preston	17.4%	4.1%	2.6%	0.8%	7.2%
Ribble Valley	100.0%	0.1%	5.2%	25.3%	12.4%
Rossendale	100.0%	0.0%	2.4%	47.7%	51.1%
South Ribble	34.6%	0.0%	13.2%	1.2%	27.0%
West Lancashire	33.0%	0.2%	18.6%	11.7%	10.1%
Wyre	50.6%	0.6%	16.2%	11.0%	15.7%
Lancashire	**66.0%**	**2.5%**	**9.1%**	**18.0%**	**23.3%**
NW average	**44.3%**	**7.6%**	**5.0%**	**11.2%**	**24.9%**

(c) District / Sub-region	% High quality agricultural land	% of district in an area of high quality agricultural land & important for GI climate change function						
		Carbon - preserve/ protect	Carbon - increase/ enhance	Food - preserve/ protect	Flood	Soil erosion	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Blackburn with Darwen	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Blackpool	5.2%	2.2%	5.2%	5.2%	1.7%	0.6%	0.0%	2.4%
Burnley	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Chorley	8.3%	3.3%	8.3%	8.3%	4.2%	1.4%	0.1%	1.6%
Fylde	48.4%	15.6%	48.4%	48.4%	8.3%	4.8%	1.8%	16.3%
Hyndburn	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lancaster	1.1%	0.8%	1.1%	0.8%	0.8%	0.1%	0.0%	0.3%
Pendle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Preston	0.8%	0.4%	0.8%	0.8%	0.4%	0.0%	0.0%	0.0%
Ribble Valley	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Rossendale	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
South Ribble	11.0%	4.1%	11.0%	11.0%	5.3%	1.6%	0.2%	2.6%
West Lancashire	71.4%	55.4%	71.4%	71.4%	21.6%	18.4%	2.7%	24.6%
Wyre	29.4%	16.1%	29.4%	24.5%	13.5%	4.4%	0.2%	4.5%
Lancashire	**14.6%**	**9.1%**	**14.6%**	**14.1%**	**4.8%**	**2.9%**	**0.4%**	**4.3%**
NW average	**10.5%**	**3.7%**	**10.0%**	**9.7%**	**1.8%**	**1.0%**	**0.6%**	**4.3%**

6.5 Merseyside

In Merseyside, the regional economic priorities (in terms of area covered) are development and restructuring, followed by tourism and high quality agricultural land. Both development and restructuring and high quality agricultural land are important in a North West context.

Development and restructuring is important in a North West context, and in particular the functions of increasing carbon storage, reducing the need to travel by car, moderating the urban heat island (for both vulnerable people and settlements), increasing biodiversity, protecting high quality agricultural land for food production, and reducing flooding. Development and restructuring is important (in a North West context) in Liverpool, Sefton, the Wirral, Halton and St Helens. In all these districts important functions (in a North West context) are increasing the carbon store, reducing the need to travel by car, and moderating the urban heat island (for vulnerable people). In Liverpool, moderating the urban heat island (in settlements) is also an important function in a North West context. In Sefton, increasing and protecting biodiversity, protecting high quality agricultural land for food production, protecting the carbon store, reducing flood risk, and moderating the urban heat island (in settlements) are also important functions in a North West context. In the Wirral, increasing and protecting biodiversity, increasing food production and protecting high quality agricultural land for food production, and reducing flood risk) are also an important functions in a North West context. In Halton, increasing biodiversity, moderating the

urban heat island (in settlements), protecting high quality agricultural land for food production, and reducing flood risk are also important functions in a North West context. In St Helens, increasing biodiversity, increasing food production and protecting high quality agricultural land for food production and moderating the urban heat island (in settlements) are also important functions in a North West context. Knowsley is highlighted as important in a North West context for protecting high quality agricultural land.

In a North West context, important functions in Merseyside to take into account in areas of tourism significance are taking opportunities to use areas with the highest landscape capacity for tourism, and moderating the urban heat island (in settlements). Tourism is important in Liverpool in a North West context, but also in Halton and Sefton in the context of Merseyside. In Liverpool, the most important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism, and to moderate the urban heat island (in settlements). In Halton the most important functions (in a North West context) are to take opportunities to use areas with the highest landscape capacity for tourism, and to reduce flooding. In Sefton, the most important functions (in a North West context) are to moderate the urban heat island (in settlements), to reduce the vulnerability of landscapes, and to reduce flooding. Knowsley is highlighted as important (in a North West context) to moderate the urban heat island (in settlements).

High quality agricultural land is important in a North West context, with all of the functions highlighted as important in a North West context (i.e. protecting high quality agricultural land for food production, increasing and preserving carbon stores, increasing and protecting biodiversity, reducing flood risk, and reducing soil erosion. High quality agricultural land is most important (in a North West context) in Knowsley, St Helens, Sefton, and Halton. In all these districts, important functions (in a North West context) are to increase the carbon store, protect high quality agricultural land for food production, and protect and increase biodiversity. In Knowsley and Sefton, other important functions (in a North West context) are to protect the carbon store and reduce flooding. In St Helens, other important functions (in a North West context) are to protect the carbon store and reduce soil erosion. Liverpool is also highlighted as important (in a North West context) for protecting biodiversity.

Regardless of regional economic priorities, in Merseyside, important GI climate change functions to ‘preserve or protect’ are reducing the need to travel by car, moderating the urban heat island (vulnerable people and settlements), and food production. Important GI climate change functions to ‘increase or enhance’ are carbon sequestration and storage, reducing the need to travel by car, and moderating the urban heat island (vulnerable people). In terms of both the ‘preserve or protect’ and ‘increase or enhance’ functions: reducing the need to travel by car, reducing flood risk, and reducing soil erosion are most important in Sefton; moderating the urban heat island (vulnerable people) is most important in the Wirral; moderating the urban heat island (settlements) is most important in Liverpool. It is most important to ‘preserve or protect’: carbon sequestration and storage in Sefton and ‘increase or enhance’ it in the Wirral; food production in St Helens and ‘increase or enhance’ it in the Wirral; allowing species movement in Sefton and ‘increase or enhance’ it in St Helens; reducing visitor pressure on vulnerable landscapes in Sefton and ‘increase or enhance’ it in the Wirral. Parts of Sefton, St Helens, and Knowsley have the highest multifunctionality to ‘preserve or protect’, whereas Wirral, St Helens, and Halton have the highest multifunctionality to ‘increase or enhance’.

Table 12. Percentage of Merseyside districts which are important for GI climate change functions in (a) development and restructuring areas, (b) areas of tourism significance, (c) areas with high quality agricultural land

(a)		% of district in a development and restructuring area & important for GI climate change function									
District / Sub-region	% Dev & Rest	Carbon - preserve/ protect	Carbon - increase/ enhance	Travel	Food - preserve/ protect	Food - increase/ enhance	UHI - people	UHI - settlements	Flood	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Halton	88.7%	1.0%	88.7%	88.7%	11.4%	12.2%	68.7%	29.8%	6.9%	6.7%	38.2%
Knowsley	45.9%	2.1%	45.9%	45.9%	17.3%	2.2%	21.2%	9.4%	2.7%	4.8%	22.0%
Liverpool	100.0%	1.2%	100.0%	100.0%	4.4%	0.1%	85.9%	74.6%	3.5%	6.8%	34.0%
Sefton	100.0%	19.0%	100.0%	100.0%	28.2%	1.2%	43.2%	16.2%	17.7%	16.0%	40.6%
St. Helens	85.5%	9.8%	85.5%	85.5%	21.0%	30.9%	37.9%	15.2%	5.1%	8.7%	51.1%
Wirral	100.0%	0.0%	100.0%	95.0%	5.9%	28.6%	61.9%	13.0%	8.7%	9.8%	46.5%
Merseyside	**89.5%**	**6.4%**	**89.5%**	**88.5%**	**15.2%**	**14.0%**	**52.9%**	**24.9%**	**8.2%**	**9.5%**	**40.4%**
NW average	**59.6%**	**8.9%**	**59.6%**	**55.0%**	**5.3%**	**13.7%**	**26.8%**	**12.2%**	**5.6%**	**8.7%**	**32.9%**

(b)		% of district in an area of tourism significance & important for GI climate change function			
District / Sub-region	% Tourism significance	UHI - settlements	Flood	Vulnerable landscape - preserve/protect	Vulnerable landscape - increase/enhance
Halton	47.6%	7.1%	6.7%	0.1%	44.2%
Knowsley	20.8%	9.4%	0.3%	0.5%	19.9%
Liverpool	85.4%	74.6%	2.4%	0.1%	84.2%
Sefton	44.7%	16.2%	9.8%	14.5%	25.3%
St. Helens	0.2%	0.1%	0.0%	0.0%	0.2%
Wirral	23.3%	1.7%	2.9%	1.5%	18.2%
Merseyside	**35.3%**	**17.1%**	**3.8%**	**3.4%**	**29.4%**
NW average	**44.3%**	**7.6%**	**5.0%**	**11.2%**	**24.9%**

(c) District / Sub-region	% High quality agricultural land	% of district in an area of high quality agricultural land & important for GI climate change function						
		Carbon - preserve/ protect	Carbon - increase/ enhance	Food - preserve/ protect	Flood	Soil erosion	Biodiversity - preserve/ protect	Biodiversity - increase/ enhance
Halton	19.9%	0.0%	19.9%	19.9%	0.3%	0.2%	1.3%	9.8%
Knowsley	36.2%	8.6%	36.2%	36.2%	2.5%	1.1%	4.6%	22.5%
Liverpool	4.4%	1.0%	4.4%	4.4%	0.4%	0.1%	1.5%	3.5%
Sefton	28.2%	15.9%	28.2%	28.2%	6.6%	1.0%	1.1%	6.8%
St. Helens	33.1%	18.6%	33.1%	33.1%	1.6%	4.2%	3.4%	21.1%
Wirral	5.9%	0.0%	5.9%	5.9%	1.0%	0.2%	0.2%	2.2%
Merseyside	**20.7%**	**8.0%**	**20.7%**	**20.7%**	**2.3%**	**1.2%**	**1.8%**	**10.2%**
NW average	**10.5%**	**3.7%**	**10.0%**	**9.7%**	**1.8%**	**1.0%**	**0.6%**	**4.3%**

7. Potential Green Infrastructure Actions

Table 13 draws together the actions identified in each of the sub-sections of section 4. Further work is required to flesh this table out into an action plan, including identifying delivery mechanisms. It must be stressed that GI actions will need to reflect distinctive local landscape characters.

Table 13. List of actions

CC function of GI	Action
Mitigation	
Carbon sequestration and storage	Avoid new development in areas with highest carbon densities
	Offset carbon lost through new development by increasing carbon stores and/or maintaining the carbon stored in other areas
	Aim for net removal of CO_2 in the North West from land use, land use change and forestry
	Maintain the carbon storage in high density areas
	Increase carbon stored – e.g. through agricultural practices, woodland creation
	Target areas to maintain and increase carbon stored – e.g. woodland creation in lower quality agricultural areas where it has potential to be multi-functional, management of areas of significant carbon stores
Direct fossil fuel substitution	-
Material substitution	-
Reducing need to travel by car	Protect and create high quality recreation areas and local walking and cycling routes (for recreation and commuting) in and near to urban areas, particularly during development and restructuring
	Protect and create local walking and cycling routes (for recreation and commuting) connecting rural areas, as well as rural to urban areas
	Highlight this as an issue to be addressed in local, city/sub-regional plans
Food production	Protect highest quality agricultural land from development and restructuring
	Enhance quality of grade 3 land, particularly where it is in proximity to markets
	Link high quality agricultural land to local markets, including in development and restructuring areas
	Promote agricultural practices which reduce greenhouse gas emissions (e.g. organic, low tillage, etc)
Adaptation	
Moderating urban heat island	Protect assets such as city / town centre parks, open spaces in built up areas, and areas with vulnerable populations
	Ensure no net loss of green cover and increase it wherever possible
	Undertake creative greening to enhance green cover, with particular attention to town centres, areas with low green cover, and vulnerable populations
	Maintain and increase cover of large canopied trees for shade provision
	Where possible, protect GI assets which encourage air flow into urban areas
	Align new development and restructuring so that it encourages air flow into urban areas
	Ensure a water supply for vegetation
Reducing flood risk	Protect flood zones from new development
	If development and restructuring occurs within flood risk areas it should be designed for flood resilience
	Explore areas upstream of flood risk area where it may be possible to reduce flood risk through GI and woodland creation, and take opportunities where they exist
	Design all development and restructuring so that it does not pass on flood risk, especially where it is upstream of flood risk areas
	Take opportunities through development and restructuring to reduce flood risk

	downstream, through SUDS, GI and woodland creation
	Development should be avoided, where possible, in areas where the soil has a high infiltration rate and should not increase the proportion of impervious surface cover on such soils
Reducing soil erosion	Encourage agricultural practices to reduce soil erosion, particularly where there is a high or very high risk
	In other areas where there is a high or very high risk of soil erosion use land cover change and management techniques to reduce the risk
Allowing species movement	Protect existing ecological networks in new development and restructuring areas
	Maximise opportunities for creating new habitats and filling gaps in ecological networks during new development and restructuring, with particular attention to north-south connectivity
	Manage agricultural land to protect existing ecological networks
	Maximise opportunities for creating new habitats and filling gaps in ecological networks in agricultural landscapes, with particular attention to north-south connectivity
Reducing visitor pressure on vulnerable landscapes	Manage visitor pressure in lower capacity areas – e.g. maintain footpaths, change to less vulnerable land cover such as woodland (where appropriate), etc
	Create tourism resources in high capacity landscapes, particularly near to urban areas, to divert pressure from lower capacity landscapes

8. Suggestions for Future Refinement

(1) The GI planning process advocated in the NW GI Guide has 5 stages. This work should fit into this broad framework. It may be necessary to review the extent to which this work fits into the framework and to complete all or part of the 5 stages:

- Partnerships and priorities
- Data audit and resource mapping
- Functional assessment
- Needs assessment
- Intervention plan

(2) It should be noted that in the work presented here the GI resource across the North West has not been mapped. Rather an analysis has been undertaken of where the climate change functions of GI will be most critical. This would then need to be compared with the existing GI resource, to see where GI components need maintaining, creating and enhancing. The GI resource mapping will also be useful in providing baseline data to monitor and evaluate the impacts of actions undertaken as a result of the implementation plan.

Thus, future work should map the GI resource across the NW. This could be undertaken using a common methodology at a sub-regional or district level, building up into a comprehensive NW GI resource map. Such mapping could be especially important in urban areas, which has a complex pattern of land uses. The NW Green Infrastructure Unit has been developing approaches to GI 'typology' mapping, in particular in the Weaver Valley Regional Park.

The urban tree resource is one important component of the GI resource, which in many cases is not adequately audited. 'Trees in Towns II'[25] found short comings in the surveying of urban trees (which can help to produce strategies and planned management). For example only 19% of English local authorities questioned had an accurate record of the percentage of their district covered by trees and woodlands. The Regional Forestry Framework[26] is encouraging NW local

[25] Britt, C. and Johnston, M. (2008). Trees in Towns II – a new survey of urban trees in England and their condition and management. Communities and Local Government, London.
[26] http://www.iwood.org.uk/

authorities to audit urban tree canopy cover using a similar methodology to 'Trees in Towns II', recording information such as percent of land cover, location, ownership of land). Such data will be highly relevant to GI planning and monitoring, and in particular in relation to climate change functionality.

Also consider the relevance of the recently piloted 'Capital Asset Value for Amenity Trees (CAVAT)' methodology[27] for valuing trees.

(3) Revise high quality agricultural land regional priority to become 'best and most versatile' agricultural land by including grade 3a land as well as grades 1 and 2. Further maps and statistics will need revising accordingly.

(4) Revise mapping of growth points to give more accurate boundaries, also potentially housing market renewal areas.

(5) Refinement of functionality mapping as datasets / information becomes available, for example:

- Take on board pluvial flood risk – e.g. using soils data to show areas with highest infiltration rates, data on drain capacity, data on known flood risk from Catchment Flood management Plans and/or Strategic Flood Risk Assessments.
- Include coastal flooding
- Obtain water catchment boundaries dataset – this can be used to target potential GI creation for flood risk reduction upstream of flood risk and priority areas.
- Understanding air flow and cold air drainage in urban areas. Whilst the Forestry Commission have begun some work on this function in Manchester, there has been little work undertaken on this in the UK to date. There are opportunities to learn from urban areas, such as Berlin, which have more of a tradition of climate-related planning (e.g. see Berlin's Digital Environmental Atlas[28]).
- Review datasets used for 'reducing need to travel by car' – needs to take into account recreation areas and walking/cycling routes near to people, as well as walking/cycling roués for daily commuting / movement.
- Consider using Defra's opportunities and optimum sitings for energy crops maps[29] as a proxy for potential for biofuels production. These give a broad brush indication of where there is some or no potential.
- Consider relevance of including more local datasets for commuting opportunities via green walking and cycling routes, as well as local (formal and informal) recreation opportunities – e.g. local accessible natural greenspace (ANGST) studies, cycle routes other than Sustrans, rights of way, residential and employment sites (including inter-rural and rural-urban linkages) – as well as exploring ways of analysing their density and connectivity (which may have potential relevance at a regional level).
- Update regional carbon emissions graphs with data now available for 2006.

(6) Need to further explore the compatibility of the different functions. For example:

- How far are biomass crops compatible with the concept of multifunctionality underpinning GI? Woodland management for biomass could be compatible with other functions, but what about monocultures? Is it compatible with landscape character?

[27] http://www.ltoa.org.uk/docs/CAVAT-rev-May2008.pdf
[28] http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edua_index.shtml
[29] For miscanthus and short rotation coppice; http://www.defra.gov.uk/farm/crops/industrial/energy/opportunities/nw.htm

- Carbon storage and food production. Peat soils store large amounts of carbon, but low lying areas also provide productive soils that have already been subject to great landscape change. Are agricultural practices (such as pumped drainage) compatible with carbon storage?

(7) Review Strategic Flood Risk Assessments and the Environment Agency's Catchment Flood Management Plans (CFMPs) and incorporate into the work here on flood risk. These will help to identify priority areas where flood risk needs reducing, as well as identifying upland and other areas where reduction of runoff, reconnection of rivers with floodplains, etc, is appropriate. CFMPs, as well as Environmental Stewardship, are supporting flood alleviation objectives. The areas where particular policies apply could be mapped on a regional scale.

(8) Consider alternatives to percentage coverage method for identifying priorities in sub-regions, districts. For example:

- Consideration maps – how to weight? – potential for stakeholder workshops to agree a suitable approach, recognising that there will be no 'correct' way to weight this.
- A risk management model which could incorporate values.
- This work was presented at the North West Green Infrastructure Forum on 23rd October 2008. Attendees were asked to undertake a 'prioritising exercise' (table 14) to score what are the most important short/long term functions for each sub-region. This will be analysed to see if there is any agreement.

Table 14. Example of proposed 'prioritising exercise' to be undertaken at the GI Forum

Most familiar sub-region	Sub-region	GI climate change function							
		Carbon sequestration & storage	Reducing need to travel by car	Food production	Moderating urban heat island	Reducing flood risk	Reducing soil erosion	Allowing species movement	Reducing visitor pressure on vulnerable landscapes
	Cheshire		3	1					2
	Cumbria	1		2					3
X	Greater Manchester		2		1	3			
	Lancashire	1		2				3	
	Merseyside		1		3				2

(9) Develop the action plan – for example to include delivery mechanisms across the region.

(10) Explore using Landscape / Joint / Townscape Character Areas ((including the Countryside Quality Counts 2nd Assessment Results) as a basis for GI recommendations. In particular, the forthcoming regional landscape character framework could be most useful.

(11) Need for a central observatory at the regional level for GI data. One option could be through a well resourced GI Unit.

(12) Expand this work to consider the other 10 economic benefits of GI identified by the Natural Economy Northwest project.

(13) To take into account the European Landscape Convention (ELC) principles – e.g. to review this document to see whether reflects the aims of the ELC.