

**DEVELOPING
ECOSYSTEM ACCOUNTS
FOR PROTECTED
AREAS IN ENGLAND
AND SCOTLAND:
THE BORDERS
SUMMARY REPORT**



OCTOBER 2015

Suggested citation: White, C., Dunscombe, R., Dvarskas, A., Eves, C., Finisdore, J., Kieboom, E., Maclean, I., Obst, C., Rowcroft, P. & Silcock, P. (2015), 'Developing ecosystem accounts for protected areas in England and Scotland: The Borders Summary Report', The Scottish Government.

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INTRODUCTION

The Borders is made up of a mosaic of interconnected ecosystems including farmland, moorland, woodland, the river Tweed, and other wetlands and lochs. These **ecosystem assets** provide a range of important services to people living within and visiting the area, including provision of food and water; regulation of air quality, water quality, and flood risk; and cultural services such as aesthetic value, a sense of heritage, and opportunities for recreation.

The value of these services is significant and the capacity of the environment to continue to provide such services has a direct impact on The Borders' prosperity and well-being. However, the monetary value of these **ecosystem services** is not always fully accounted for in the management of land and natural assets.

Ecosystem accounts provide a framework for measuring the extent and condition of these assets, and monitoring changes in the provision of services. This provides a way to communicate the contribution that the environment plays in supporting economic vitality, social wellbeing, and quality of life, and can also be used to evaluate trade-offs as to how investment can support or risk the capacity of ecosystems to function and provide services.

Developing an ecosystem account for The Borders

In 2014, Defra and the Scottish Government funded a project to scope the potential for developing ecosystem accounts for protected and other land areas in the UK. The project builds on work by Defra and the Office for National Statistics and draws on the UN System of Environmental Economic Accounting guidance.

The aim of the accounts is to quantify the extent and condition of ecosystem assets within six pilot areas, as well as to quantify and value the flow of ecosystem services from these assets. In addition to testing the principles of ecosystem accounting methodologies, a key aim of the project is to help inform resource management decisions within the pilot areas.

As part of this project, The Borders was selected as one of the pilot areas. This report sets out some of the key findings for The Borders from the development of the ecosystem accounts. The report is divided into six sections:

- **Asset account** – provides an overview of the quantity and quality of ecosystems in The Borders to monitor changes in the extent and condition of the stock of ecosystem assets.
- **Physical flows** – provides an overview of the physical quantity of services provided within The Borders in 2013.
- **Monetary flows** – provides an overview of the monetary value of the services provided in The Borders in 2013.
- **Appendix A** – provides full details of the asset account tables for The Borders.
- **Appendix B** – provides a series of maps highlighting the physical flows of ecosystem services at a 1 km² level.
- **Appendix C** – provides an overview of the methodology used to estimate the physical and monetary flows.

Further details on the methods used and the results can be found in the **Main Report** and the **Technical Appendix**.

Experimental nature of the ecosystem account

It is important to note that The Borders ecosystem account has been developed as part of a wider effort to demonstrate the concept of ecosystem accounts in practice. As such, the findings outlined in this report should be read with an appreciation of the experimental nature of this exercise.

The number of ecosystem services covered by the account and the accuracy of its findings could be increased through methodological advances and the availability of improved data. This could include steps to further refine The Borders ecosystem accounts for local use, with a greater emphasis on local circumstances and the use of local data sources.

Accompanying reports

There are two separate reports which accompany The Borders summary report. One report is the **Technical Appendix**, which describes in detail:

- The indicators considered for measuring the ecosystem services.
- The methodology and limitations of the different approaches.
- The reasons why certain ecosystem services are difficult to measure in quantitative and monetary terms.

The other report is the **Main Report** which discusses:

- The approach to the project.

- The findings from across the six pilot areas.
- Recommendations and conclusions including an overview of the key lessons learned, potential uses and benefits of the accounts, challenges of developing the accounts, and recommendations for developing the accounts further.

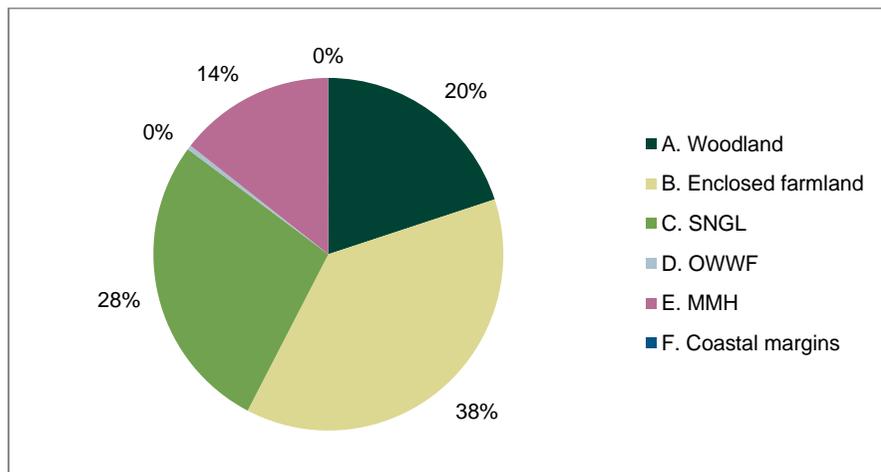
ASSET ACCOUNT

The asset account was developed for six broad ecosystem types:

- A. Woodland
- B. Enclosed farmland
- C. Semi-natural grassland (SNGL)
- D. Open waters, wetlands, and floodplains (OWWF)
- E. Mountains, moorlands, and heaths (MMH)
- F. Coastal margins

Of these six broad ecosystem types, the east of The Borders is dominated by enclosed farmland while the western area is predominantly made up of large expanses of woodland, SNGL, and MMH. An overview of ecosystem coverage is set out in Figure 1 and a map is provided in Figure 3 overleaf.

Figure 1. Ecosystem types in The Borders



A set of indicators was developed to quantify the extent and condition of each of the six ecosystem types. The indicators are grouped into five categories and can be used to track changes in each ecosystem's capacity to provide services over time. This section provides an example of some of the indicators used to monitor ecosystem condition across the five categories.

1) Biomass/carbon

Good data was available from the Countryside Survey on the concentration of carbon in the topsoil layer for four of the six ecosystem types. The results indicate that MMH ecosystems in The Borders have higher topsoil carbon concentrations than other ecosystems, suggesting that they are able to provide significant carbon stores, while enclosed farmlands have much lower soil carbon density. See Figure 2 below.

Figure 2. Topsoil carbon concentration (tonnes per ha)

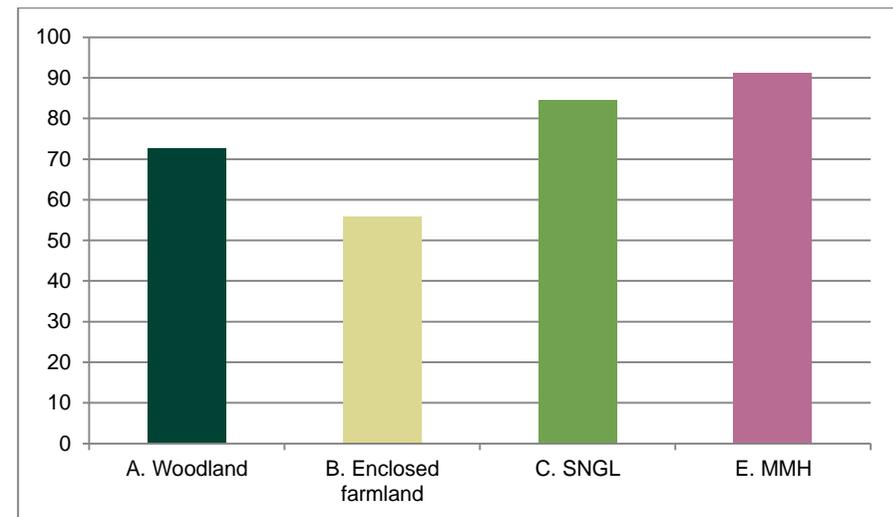
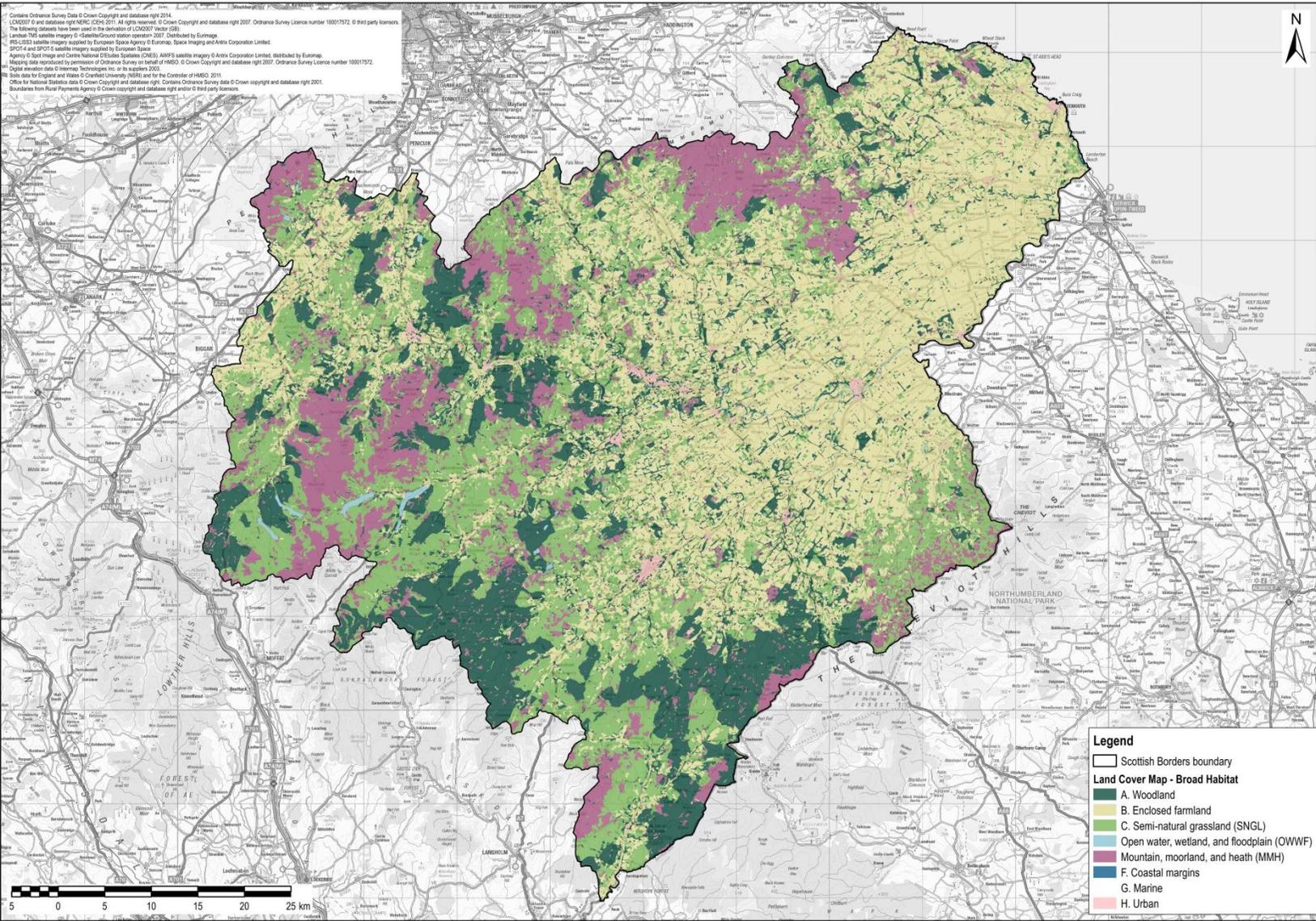


Figure 3. Map of broad ecosystem types in The Borders. Source: Land Cover Map 2007

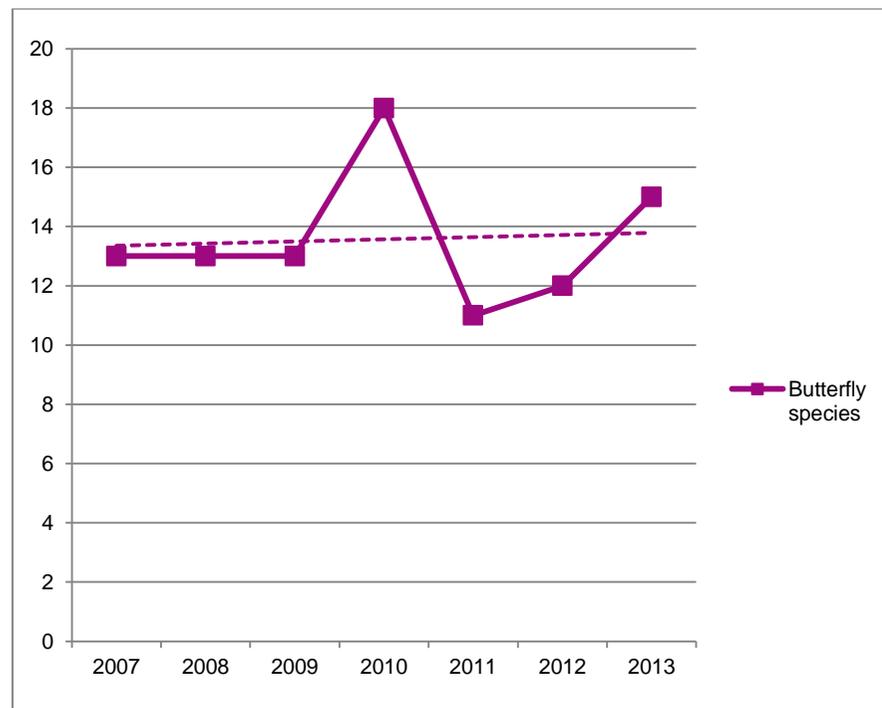


2) Biodiversity

Time series data on the trends in abundance and diversity of butterfly species was available from the Butterfly Conservation Monitoring Scheme. Butterfly data was chosen as an indicator of the condition of SNGL ecosystems (although it should be noted that other factors such as climate can also affect butterfly populations).

As set out in Figure 4 below, the diversity of butterfly species appears to be relatively stable over time.

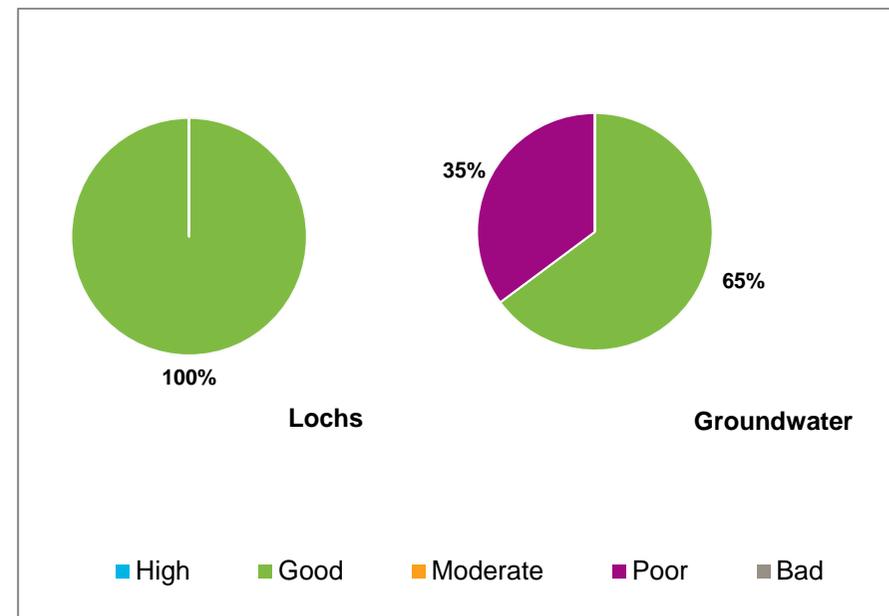
Figure 4. Number of butterfly species recorded in The Borders (2007 to 2013)



3) Soil/water quality

As an indicator of the condition of OWWF ecosystems, data was available on the Water Framework Directive ecological classification for lochs and groundwater. As set out in Figure 5, 100% of lochs in The Borders were in 'High' or 'Good' status in 2013, and 65% of groundwater.

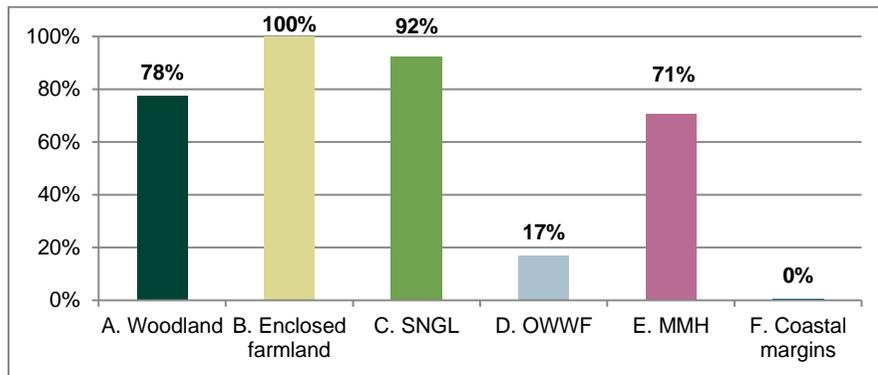
Figure 5. Ecological classification in The Borders 2013



4) Accessibility

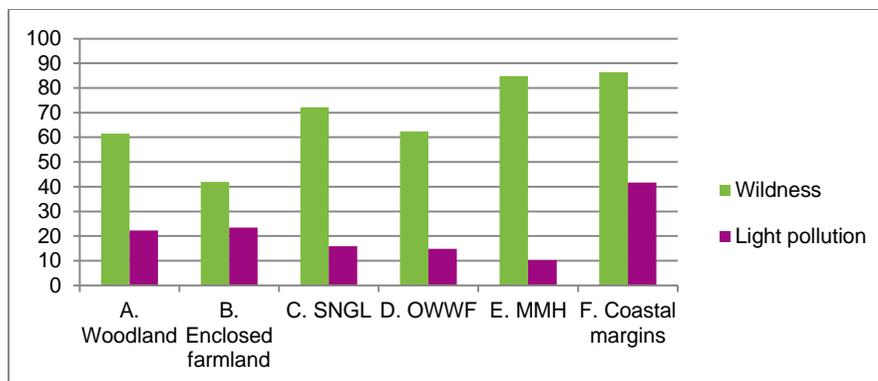
The level of accessibility was measured in terms of the percentage of people living within a travelable distance of each ecosystem. As set out in Figure 6, accessibility is highest for enclosed farmland and lowest for coastal margins.

Figure 6. Population living within travelable distance (%)



While not strictly a measure of accessibility, the level of tranquility and the extent of dark skies provides an indication of the access to 'wilder' ecosystems. Good data on dark skies was available from a CPRE study undertaken in 2000 while data on wildness was available from SNH. The data suggests that MMH and coastal margins are the wildest and MMH have the darkest skies. Maps are set out in Figure 7 below.

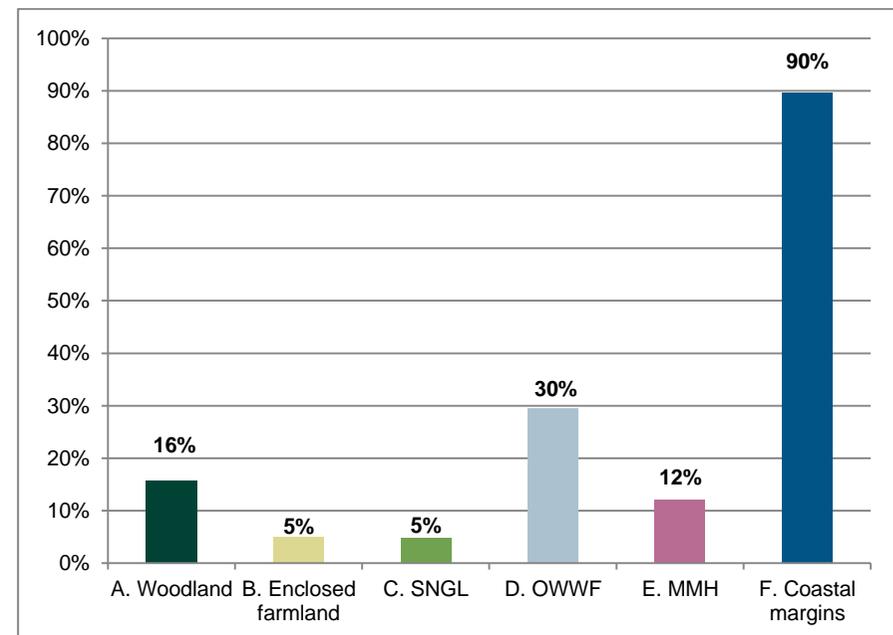
Figure 7. Wildness and light pollution within The Borders



5) Conservation status

Information on the area and condition of SSSIs within The Borders was available through the SNH data sets. Of the six ecosystem types, coverage was highest for coastal margins (100%) and lowest for enclosed farmland (1%). The proportion of designated SSSIs in entirely favourable condition was highest for coastal margin ecosystems and lowest for enclosed farmlands and SNGL. See Figure 8.

Figure 8. Area of SSSIs in entirely favourable condition (%)



The full set of asset account tables developed for each of the six broad ecosystem types in The Borders is available in Appendix A of this report.

PHYSICAL FLOWS

Ecosystems in The Borders provide a range of important services including crops, livestock, timber, wild foods, air and climate regulation, and existence values. Flood protection, recreation, education, and cultural heritage are also important, although it was not possible to quantify the physical flows of these services.

With regards to particular ecosystems:

- **Woodlands** are important for timber and woodfuel production, regulation of air quality and climate, as well as aesthetic values.
- **Enclosed farmlands** are important for crops, livestock grazing, wild foods, and their aesthetic value.
- **SNGLs** are important for livestock grazing, climate regulation, and aesthetic value.
- **OWWFs** are important for the provision of water for drinking and other uses, wild foods, and for supporting charismatic species such as otters.
- **MMHs** are important for wild foods, climate regulation, and supporting charismatic such as hen harriers.

A summary is provided in Table 1 opposite and the full account is set out in Table 2 overleaf.

Table 1. Physical flows of ecosystem services in 2013

Ecosystem service	Measurement unit	Physical flows
Crops	tonnes crops harvested	592,923
Livestock	livestock units on land	150,358
Wild foods	kg meat harvested	67,586
Drinking water	m ³ water abstracted	-
Timber	tonnes timber harvested	459,667
Other water uses	m ³ water abstracted	-
Energy	tonnes woodfuel harvested	66,123
Air quality	tonnes PM ₁₀ absorbed	17,298
Flood protection	-	-
Climate regulation	tonnes carbon absorbed	316,443
Recreation	no. visitors	-
Education	-	-
Heritage	-	-
Aesthetic	no. photos of landscapes	74
Existence		
- <i>Hen harriers</i>	<i>minimum no. young fledged</i>	6
- <i>Otters</i>	<i>no. sites present</i>	90

Table 2. Physical flows account for The Borders in 2013

Ecosystem service	Measurement unit	Woodland	Enclosed farmland	SNGL	OWWF	MMH	Coastal margins	Total
Crops	tonnes crops	-	592,923	-	-	-	-	592,923
Livestock	livestock units	-	99,986	41,438	0	8,933	1	150,358
Wild foods (game birds)	kg meat	-	21,228	-	-	5,066	-	26,294
Wild foods (venison)	kg meat	1,620	-	-	-	-	-	1,620
Wild foods (fish)	kg meat	-	-	-	39,672	-	-	39,672
Drinking water	m ³ water	-	-	-	-	-	-	-
Timber	tonnes timber	459,667	-	-	-	-	-	459,667
Other water uses	m ³ water	-	-	-	-	-	-	-
Energy	tonnes woodfuel	66,123	-	-	-	-	-	66,123
Air quality	tonnes PM ₁₀	15,373	1,009	607	-	308	0	17,298
Flood protection	-	-	-	-	-	-	-	-
Climate regulation	tonnes carbon	288,669	5,171	14,020	18	8,557	8	316,443
Recreation	no. visitors	-	-	-	-	-	-	-
Education	-	-	-	-	-	-	-	-
Heritage	-	-	-	-	-	-	-	-
Aesthetic	no. photos	18	27	16	7	5	1	74
Existence (hen harriers)	min. young fledged	-	-	-	-	6	-	6
Existence (otters)	no. sites present	-	-	-	90	-	-	90

MONETARY FLOWS

The total monetary value of the seven ecosystem services which could be quantified in The Borders was estimated to be around £370 million in 2013. This is predominantly made up from air quality benefits and climate regulation.

However, it is important to note that due to the challenges of monetising the services provided by ecosystem assets, it was not possible to quantify the monetary flows for all of the services included in the accounting framework. As such, these estimates do not capture all of the value of The Borders.

With regards to the **total value** of specific ecosystems, woodlands (£327 million) were found to have the highest values. Woodland ecosystems were also found to be the most valuable in terms of **average value per ha** (see Figure 9).

Figure 9. Value of service flows per ecosystem in 2013 (£/ha)

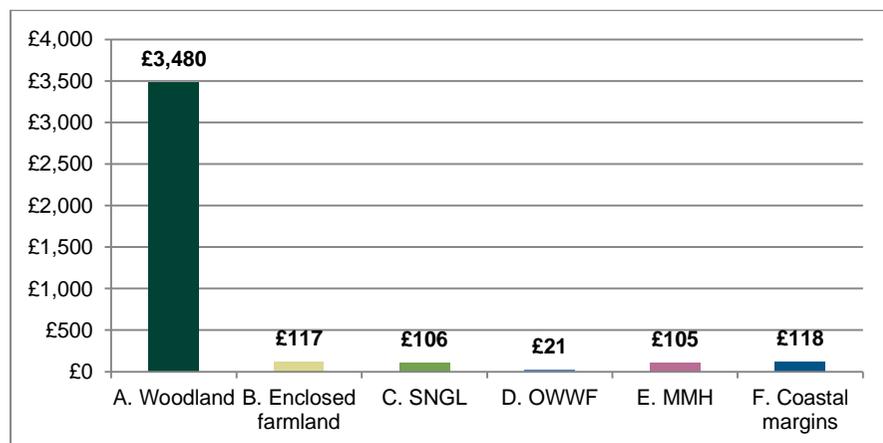


Table 3. Monetary flows of ecosystem services in 2013

Ecosystem service	Valuation basis	Monetary flows
Crops	Resource rent from crops	£1,442,288
Livestock	Resource rent from livestock	£1,741,315
Wild foods	Market value of meat	£102,298
Drinking water	Resource rent from water	-
Timber	Stumpage price of timber	£5,153,762
Other water uses	-	-
Energy	Resource rent from woodfuel	£440,897
Air quality	Avoided damage costs	£291,446,007
Flood protection	-	-
Climate regulation	Avoided abatement costs	£68,252,453
Recreation	Willingness-to-pay	-
Education	-	-
Heritage	-	-
Aesthetic	-	-
Existence	-	-
Total		£368,579,021

Table 4. Monetary flows account for The Borders in 2013 (all figures are presented in 2013 prices)

Ecosystem service	Woodland	Enclosed farmland	SNGL	OWWF	MMH	Coastal margins	Total
Crops	-	£1,442,288	-	-	-	-	£1,442,288
Livestock	-	£1,248,330	£430,043	£0	£62,934	£8	£1,741,315
Wild foods (game birds)	-	£11,276	-	-	£53,554	-	£64,831
Wild foods (venison)	£2,403	-	-	-	-	-	£2,403
Wild foods (fish)	-	-	-	£35,064	-	-	£35,064
Drinking water	-	-	-	-	-	-	-
Timber	£5,153,762	-	-	-	-	-	£5,153,762
Other water uses	-	-	-	-	-	-	-
Energy	£440,897	-	-	-	-	-	£440,897
Air quality	£259,026,653	£16,996,493	£10,233,649	-	£5,181,749	£7,464	£291,446,007
Flood protection	-	-	-	-	-	-	-
Climate regulation	£62,262,038	£1,115,217	£3,024,027	£3,882	£1,845,665	£1,623	£68,252,453
Recreation	-	-	-	-	-	-	-
Education	-	-	-	-	-	-	-
Heritage	-	-	-	-	-	-	-
Aesthetic	-	-	-	-	-	-	-
Existence (hen harriers)	-	-	-	-	-	-	-
Existence (otters)	-	-	-	-	-	-	-
Total value	£326,885,754	£20,813,605	£13,687,719	£38,947	£7,143,902	£9,095	£368,579,021
Total area (ha)	93,943	177,184	129,492	1,889	67,865	77	470,451
Value per ha	£3,480	£117	£106	£21	£105	£118	£783

APPENDIX A. ASSET ACCOUNT TABLES

For each of the six broad ecosystem types within The Borders an asset account was populated using the methodology described in the **Main Report** and accompanying **Technical Appendix**. Complete versions of the populated asset account tables are provided in the following section.

Table 5. Woodland asset account results for The Borders in 2013

Ecosystem extent											
Total area											
Woodland		Broadleaved woodland		Coniferous woodland		Ancient woodland		Managed woodland			
(ha) ¹		(ha) ¹		(ha) ¹		(ha) ²		(ha) ³			
93,943		17,017		76,926		33,075		-			
Ecosystem condition											
Biomass/carbon				Biodiversity	Soil/water quality	Accessibility				Conservation status	
Standing timber volume	Mean annual increment	Topsoil carbon stock	Vegetation carbon stock	Woodland bird index	-	Length core paths	Population with access	Light pollution	Wildness	SSSI cover	SSSI favourable
(m ³) ^{4,5}	(m ³) ^{6,7}	(tonnes carbon in 15 cm) ⁸	(tonnes carbon) ⁹	- ¹⁰	-	(km) ¹¹	(%) ¹²	(0 to 255) ¹³	(1 to 256) ¹⁴	(%) ¹¹	(%) ¹¹
22,308,000	4,912,567	5,648,889	6,576,010	-	-	217	78%	22	61	2%	16%

¹ CEH (2007) Land Cover Map

² Scottish Natural Heritage – Natural Spaces: Ancient Woodland Inventory

³ Data available from Forestry Commission although was not possible to access for this project

⁴ Forestry Commission (2011) Standing timber volume for coniferous trees in Britain

⁵ Forestry Commission (2013) NFI preliminary estimates of quantities of broadleaved species in British woodlands, with special focus on ash

⁶ Forestry Commission (2012) GB 25-year forecast of standing coniferous volume and increment

⁷ Forestry Commission (2014) 50-year forecast of hardwood timber availability

⁸ CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

⁹ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

¹⁰ Data is available from the BTO on bird populations associated with different ecosystems over time although the actual estimates were not available for this project.

¹¹ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snh-information-service/>

¹² ONS – 2011 Census for Scotland

¹³ CPRE (2000) Dark skies mapping

¹⁴ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

Table 6. Enclosed farmland asset account results for The Borders in 2013

Ecosystem extent					
Total area					
Enclosed farmland	Arable and horticulture	Improved grassland	Length hedgerows		
(ha) ¹	(ha) ¹	(ha) ¹	(km) ²		
177,184	106,988	70,196	1,484		
Ecosystem condition (part 1)					
Biomass/carbon		Biodiversity	Soil/water quality	Accessibility	
Topsoil carbon stock	Vegetation carbon stock	Farmland bird index	Prime agricultural land	Length core paths	Population with access
(tonnes carbon in 15 cm) ³	(tonnes carbon) ⁴	- ⁵	(%) ⁶	(km) ⁷	(%) ⁸
11,445,016	177,184	-	31%	450	100%
Ecosystem condition (part 2)					
Accessibility		Conservation status			
Light pollution	Wildness	SSSI cover	SSSI favourable	Agrienvironment schemes	Organic agrienvironment schemes
(0 to 255) ⁹	(1 to 256) ¹⁰	(%) ⁷	(%) ⁷	ha ¹¹	ha ¹¹
23	42	1%	5%	46,945	10,028

¹ CEH (2007) Land Cover Map

² CEH (2014) Mapped estimates of linear feature lengths in Great Britain – 2007

³ CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

⁴ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

⁵ Data is available from the BTO on bird populations associated with different ecosystems over time although the actual estimates were not available for this project.

⁶ Scottish Government - Land Capability for Agriculture [online] available at: <http://www.soils-scotland.gov.uk/data/lca250k#notes>

⁷ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snh-information-service/>

⁸ ONS – 2011 Census for Scotland

⁹ CPRE (2000) Dark skies mapping

¹⁰ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

¹¹ Pers. Comm. with Scottish Government Directorate for Agriculture, Food & Rural Communities on the area of land managed under rural priority scheme

Table 7. SNGL asset account results for The Borders in 2013

Ecosystem extent										
Total area										
SNGL		Rough grassland		Neutral grassland		Calcareous grassland		Acid grassland		
(ha) ¹		(ha) ¹		(ha) ¹		(ha) ¹		(ha) ¹		
129,492		21,940		65		0		107,487		
Ecosystem condition										
Biomass/carbon		Biodiversity		Soil/water quality	Accessibility				Conservation status	
Topsoil carbon stock	Vegetation carbon stock	Butterfly abundance	Butterfly richness	-	Length core paths	Population with access	Wildness	Light pollution	SSSI cover	SSSI favourable
(tonnes carbon in 15 cm) ²	(tonnes carbon) ³	(no. butterflies) ⁴	(no. species) ⁴	-	(km) ⁵	(%) ⁶	(1 to 256) ⁷	(0 to 255) ⁸	(%) ⁵	(%) ⁵
11,545,606	129,492	1,867	15	-	222	92%	72	16	6%	5%

¹ CEH (2007) Land Cover Map

² CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

³ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

⁴ Butterfly Conservation (2013) UK butterfly monitoring scheme

⁵ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snhi-information-service/>

⁶ ONS – 2011 Census for Scotland

⁷ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

⁸ CPRE (2000) Dark skies mapping

Table 8. OWWF asset account results for The Borders in 2013

Ecosystem extent							
Total area							
OWWF	Fen, marsh, and swamp	(Lowland) bog	Freshwater	Length rivers	Lochs	Groundwater bodies	Average precipitation
(ha) ¹	(ha) ¹	(ha) ¹	(ha) ¹	(km) ²	(no.) ³	(no.) ³	(mm/year/km ²) ⁴
1,889	3	-	1,892	3,071	5	37	1,022
Ecosystem condition (part 1)							
Biomass/carbon		Biodiversity		Soil/water quality			
Topsoil carbon stock	Vegetation carbon stock	Wetland bird index		Lochs with high / good status	Groundwater in high / good status	Lowland peatland favourable	
(tonnes carbon in 15 cm) ⁵	(tonnes carbon) ⁶	-		(%) ³	(%) ³	(%) ⁸	
0	6	-		100%	65%	-	
Ecosystem condition (part 2)							
Soil/water quality	Accessibility				Conservation status		
-	Length core paths	Population with access	Light pollution	Wildness	SSSI cover	SSSI favourable	Area NVZs
-	(km) ⁸	(%) ⁹	(0 to 255) ¹⁰	(1 to 256) ¹¹	(%) ⁸	(%) ⁸	(ha) ¹²
-	5	17%	15	62	66%	30%	168,082

¹ CEH (2007) Land Cover Map

² Ordnance Survey – OS Open Rivers [online] available at: <https://www.ordnancesurvey.co.uk/business-and-government/products/os-open-rivers.html>

³ Available via SEPA data request, see: <http://www.sepa.org.uk/about-us/access-to-information/>

⁴ MET Office (2015), 'UKCP09: Gridded data sets of quantities derived from daily precipitation grids'

⁵ CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

⁶ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

⁷ Data is available from the BTO on bird populations associated with different ecosystems over time although the actual estimates were not available for this project.

⁸ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snhi-information-service/>

⁹ ONS – 2011 Census for Scotland

¹⁰ CPRE (2000) Dark skies mapping

¹¹ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

¹² Scottish Government (2011) Nitrate Vulnerable Zones [online] available at: <http://data.gov.uk/dataset/nitrate-vulnerable-zones1>

Table 9. MMH asset account results for The Borders in 2013

Ecosystem extent										
Total area										
MMH	Heather	Heather grassland	Montane habitats	Inland rock	(Upland) bog	Grouse moor area				
(ha) ¹	(ha) ¹	(ha) ¹	(ha) ¹	(ha) ¹	(ha) ¹	(ha) ²				
67,865	22,003	30,129	6,139	2,383	7,211	19,747				
Biomass/carbon		Biodiversity		Soil/water quality	Accessibility				Conservation status	
Topsoil carbon stock	Vegetation carbon stock	Upland bird index	Abundance of deer	Upland peat favourable	Length core paths	Population with access	Light pollution	Wildness	SSSI cover	SSSI favourable
(tonnes carbon in 15 cm) ³	(tonnes carbon) ⁴	- ⁵	(no.) ⁶	(%) ⁶	(km) ⁶	(%) ⁷	(0 to 255) ⁸	(1 to 256) ⁹	(%) ⁶	(%) ⁶
4,059,220	130,964	-	-	23%	88	71%	10	85	23%	12%

¹ CEH (2007) Land Cover Map

² Scottish Border Council Aerial Imagery

³ CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

⁴ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

⁵ Data is available from the BTO on bird populations associated with different ecosystems over time although the actual estimates were not available for this project.

⁶ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snhi-information-service/>

⁷ ONS – 2011 Census for Scotland

⁸ CPRE (2000) Dark skies mapping

⁹ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

Table 10. Coastal margins asset account results for The Borders in 2013

Ecosystem extent						
Total area						
Coastal margins	Supra-littoral rock	Supra-littoral sediment	Saltmarsh	Coastal waterbodies	Transitional waterbodies	
(ha) ¹	(ha) ¹	(ha) ¹	(ha) ¹	(no.) ²	(no.) ²	
77	69	5	3	2	1	
Ecosystem condition (part 1)						
Biomass/carbon		Biodiversity	Soil/water quality			
Topsoil carbon stock	Vegetation carbon stock	Seabird index	Bathing water compliance	Blue flag and seaside award beaches	Coastal waterbodies in high/good status	Transitional waterbodies in high/good status
(tonnes carbon in 15 cm) ³	(tonnes carbon) ⁴	- ⁵	(% beaches) ⁶	(no.) ⁷	(%) ²	(%) ²
0	3	-	-	1	0%	-
Ecosystem condition (part 2)						
Soil/water quality	Accessibility				Conservation status	
-	Length core paths	Population with access	Light pollution	Wildness	SSSI cover	SSSI favourable
-	(km) ⁸	(%) ⁹	(0 to 255) ¹⁰	(1 to 256) ¹¹	(%) ⁸	(%) ⁸
-	2	0%	42	86	100%	90%

¹ CEH (2007) Land Cover Map

² SEPA - Access to Information [online] available at: <http://www.sepa.org.uk/about-us/access-to-information/#our-information>

³ CEH (2007) Countryside Survey 2007: Model estimates of topsoil carbon

⁴ Natural England (2012) Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

⁵ Data is available from the BTO on bird populations associated with different ecosystems over time although the actual estimates were not available for this project.

⁶ SEPA - Bathing Waters [online] available at: <http://apps.sepa.org.uk/bathingwaters/Index.aspx>

⁷ Keep Scotland Tidy (2015) *Personal communication*

⁸ Available via the SNH information service – <http://www.snh.gov.uk/publications-data-and-research/snh-information-service/>

⁹ ONS – 2011 Census for Scotland

¹⁰ CPRE (2000) Dark skies mapping

¹¹ Available via the SNH data gateway, see: <https://gateway.snh.gov.uk/natural-spaces/index.jsp>

APPENDIX B. ECOSYSTEM SERVICE MAPS

GIS maps were developed for each of the ecosystem services where data was available on physical flows. The quantities of each service are divided up spatially into 1 km² grid squares. All maps are based on data from 2013.

Colour bars were developed to highlight hotspots of ecosystem service provision. In each of the maps, red indicates low or absence of provision while blue indicates significant provision. For each of the services, the same scale is used across the two Scottish pilot areas in order to allow comparison of the provision of services in different areas.

The maps have been developed based on estimates of the services provided by ecosystems within The Borders boundaries. As such, squares which overlap the boundaries only represent the value of ecosystem services provided within the boundaries, not the whole value of the 1 km square.

Due to the data limitations, it was not possible to develop maps for the following services: drinking & other water uses, flood protection, recreation, education, heritage, and existence values.

Figure 10. Crop production in The Borders (tonnes of crops in 2013)

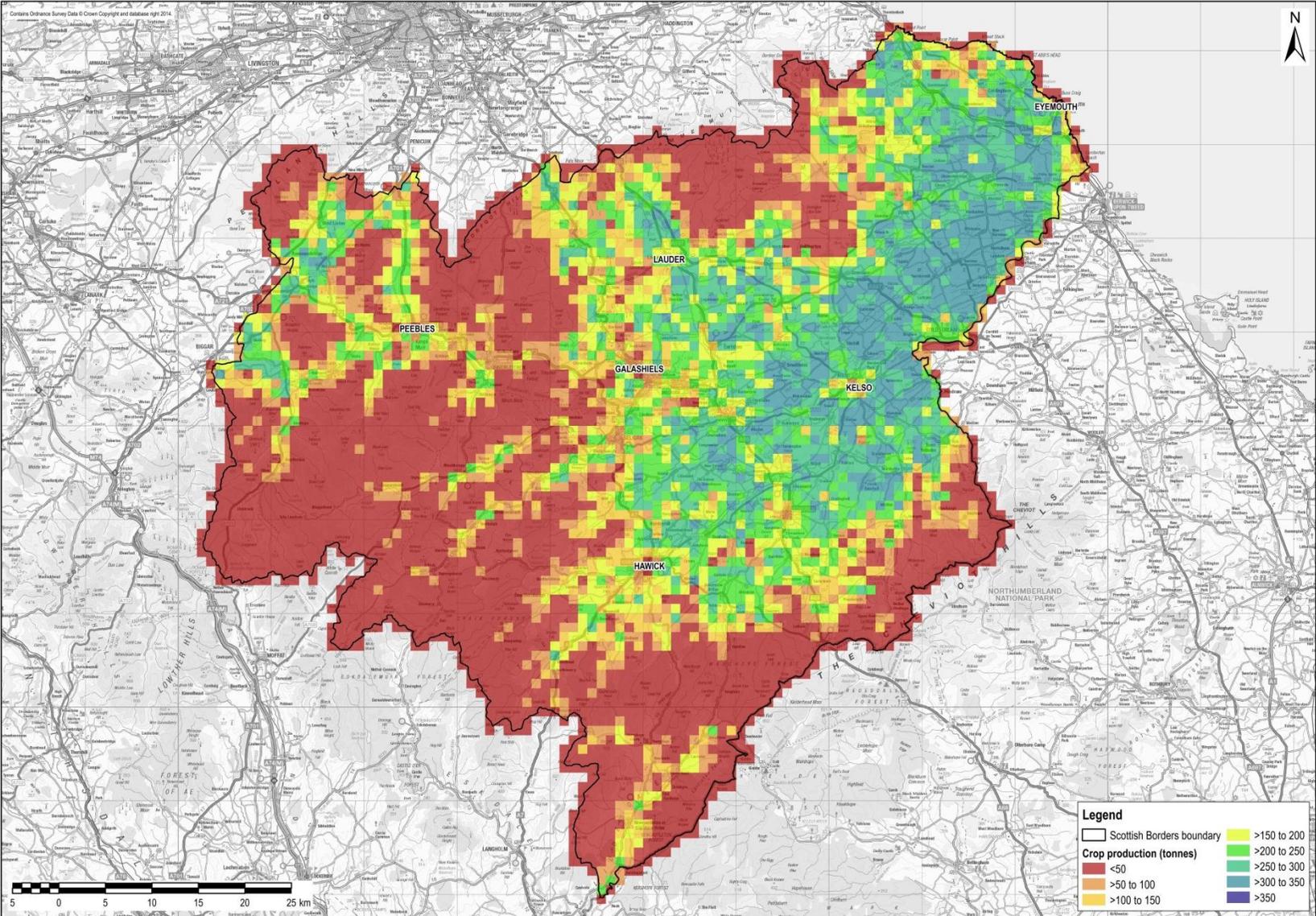


Figure 11. Livestock density in The Borders (Livestock Units in 2013)

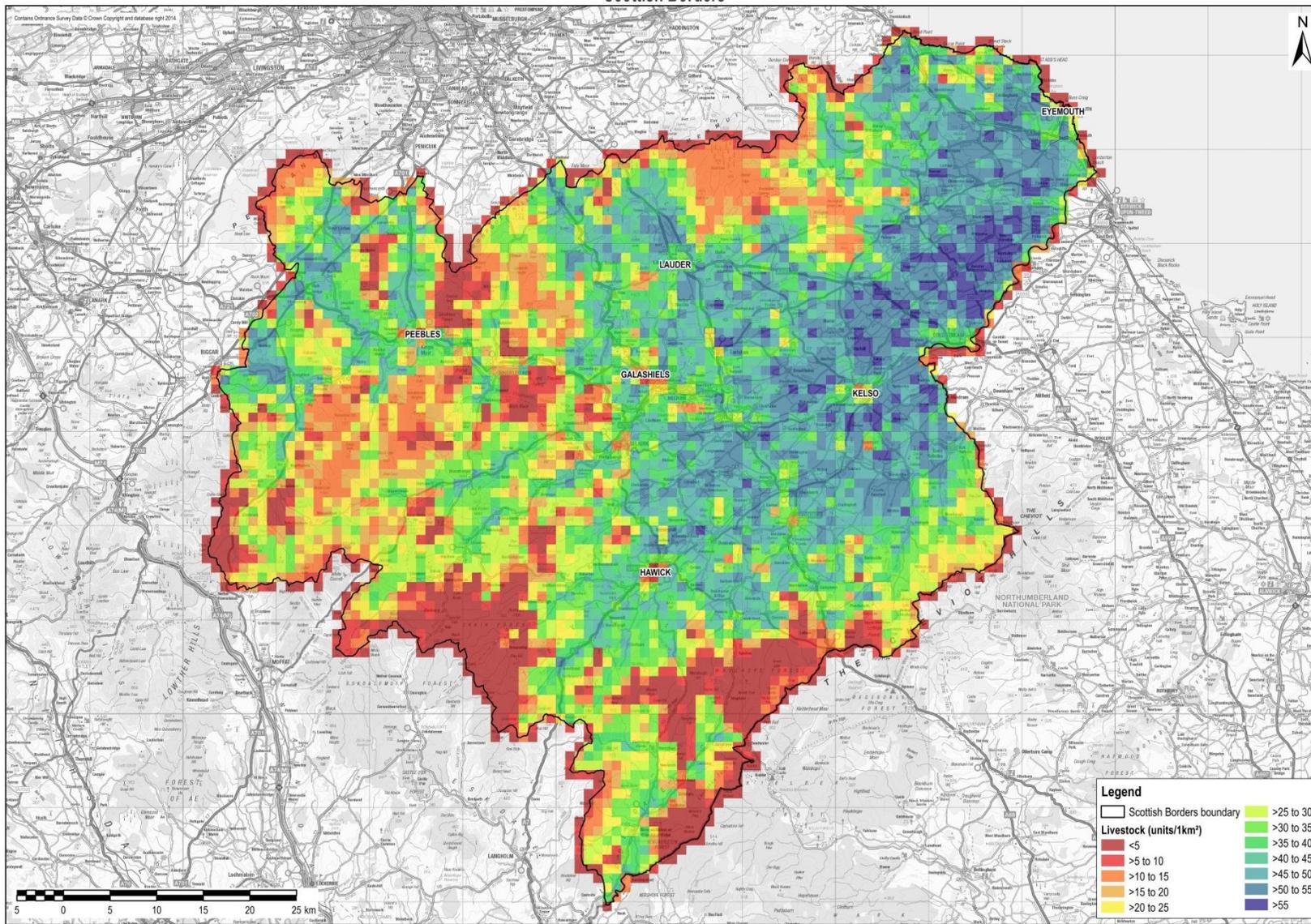


Figure 12. Timber production in The Borders (tonnes of timber in 2013)

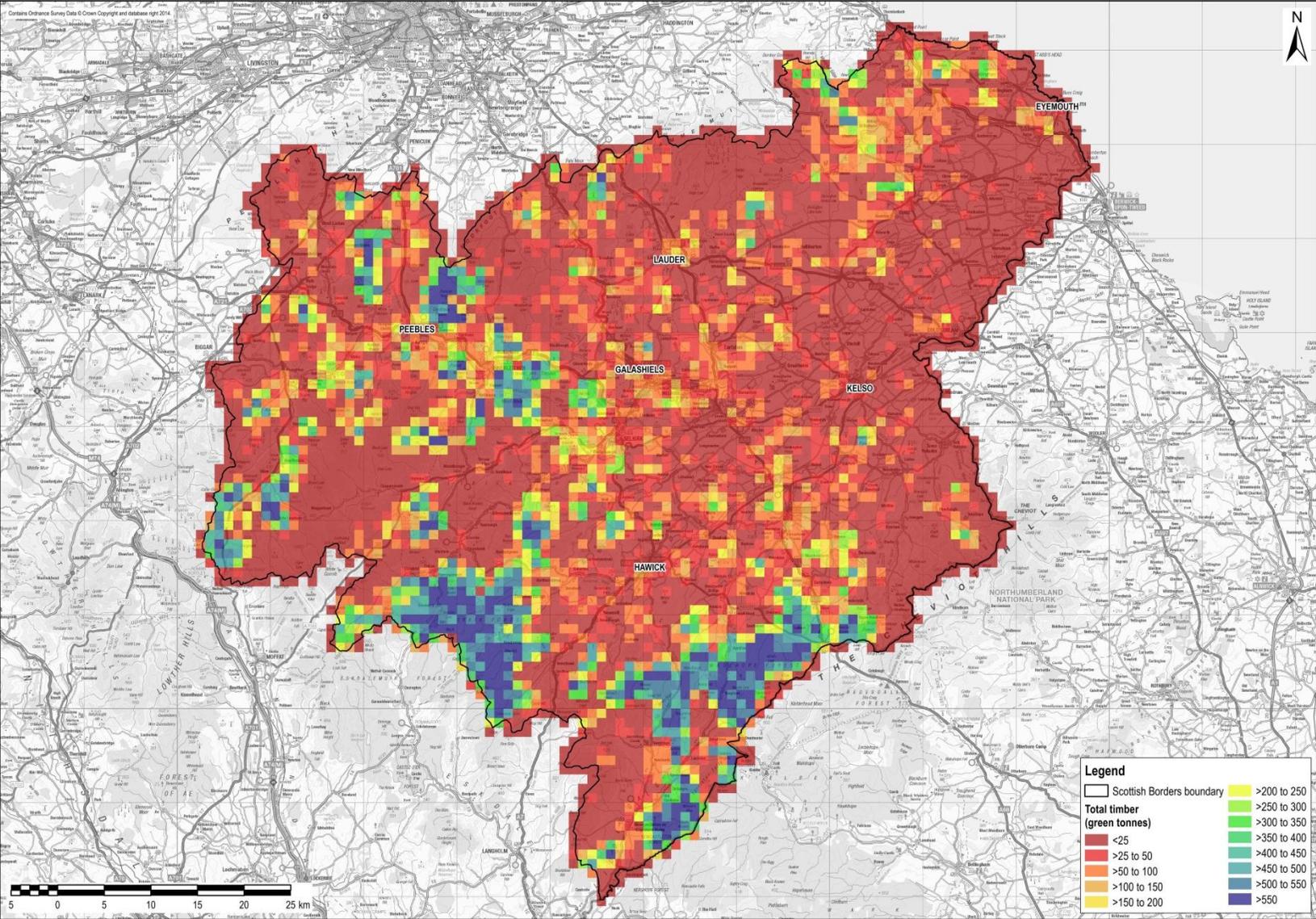


Figure 13. Woodfuel production in The Borders (tonnes of woodfuel in 2013)

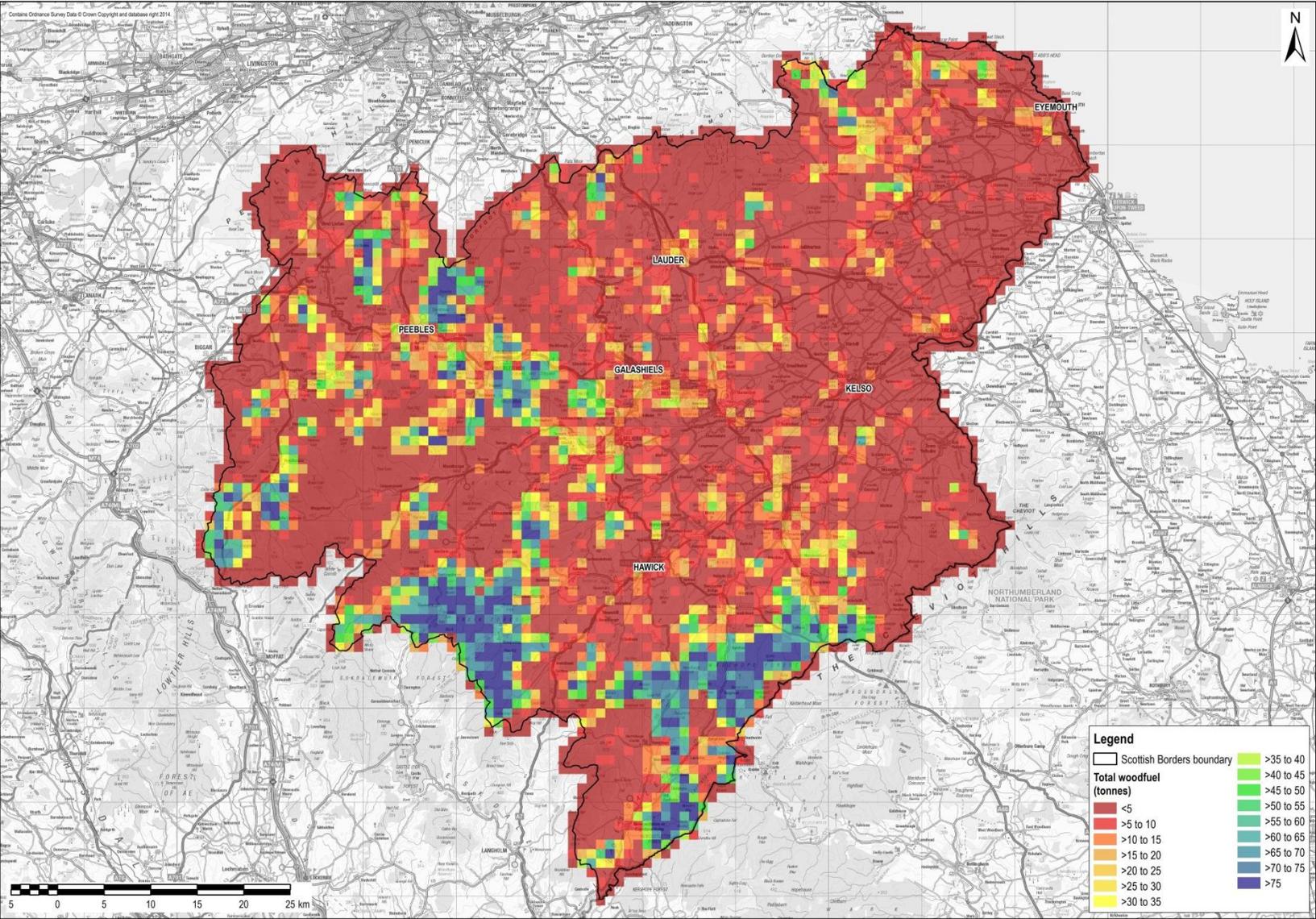


Figure 14. Regulation of air quality in The Borders (kg of PM₁₀ absorbed in 2013)

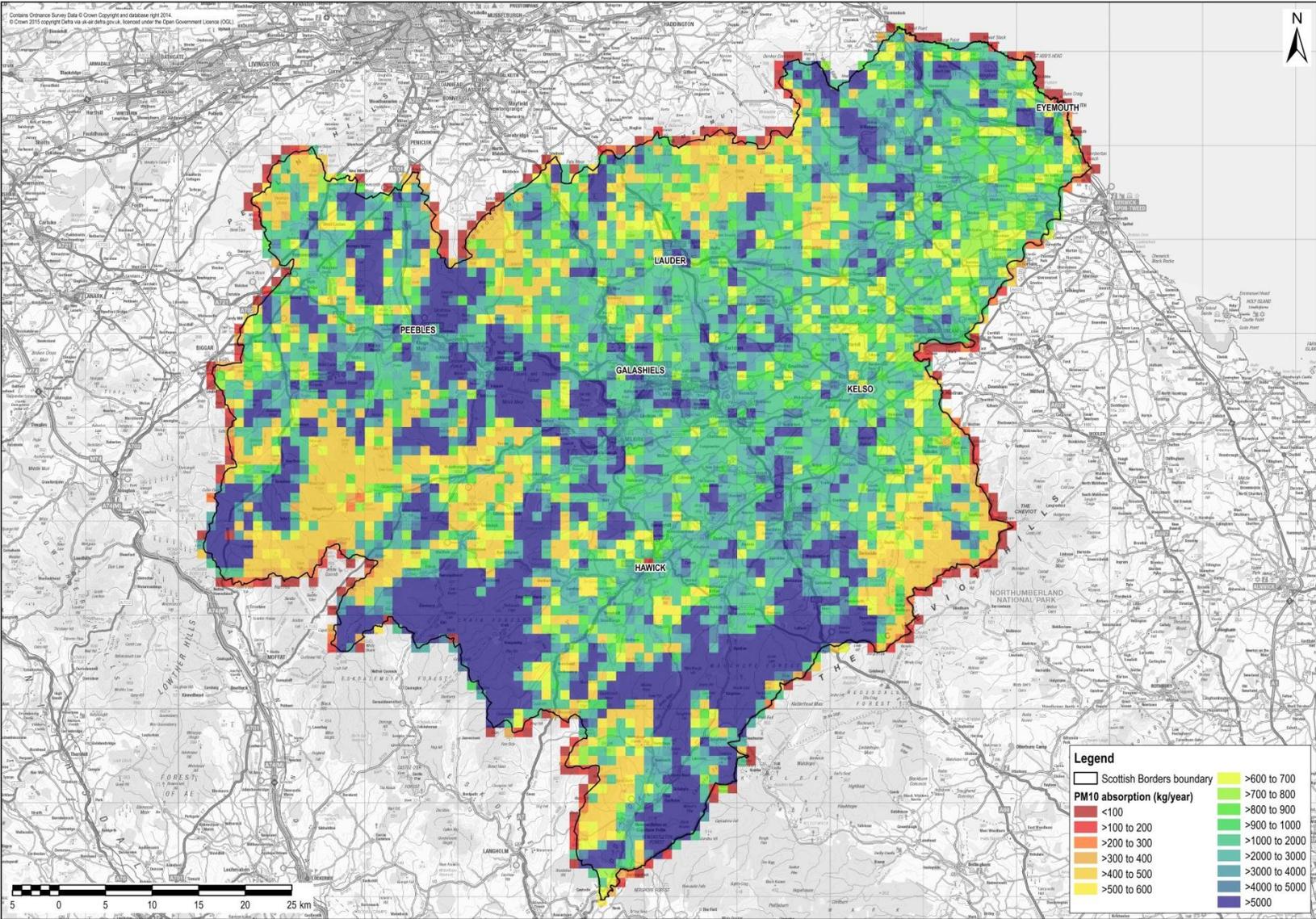


Figure 15. Regulation of climate in The Borders (tonnes of carbon sequestered in 2013)

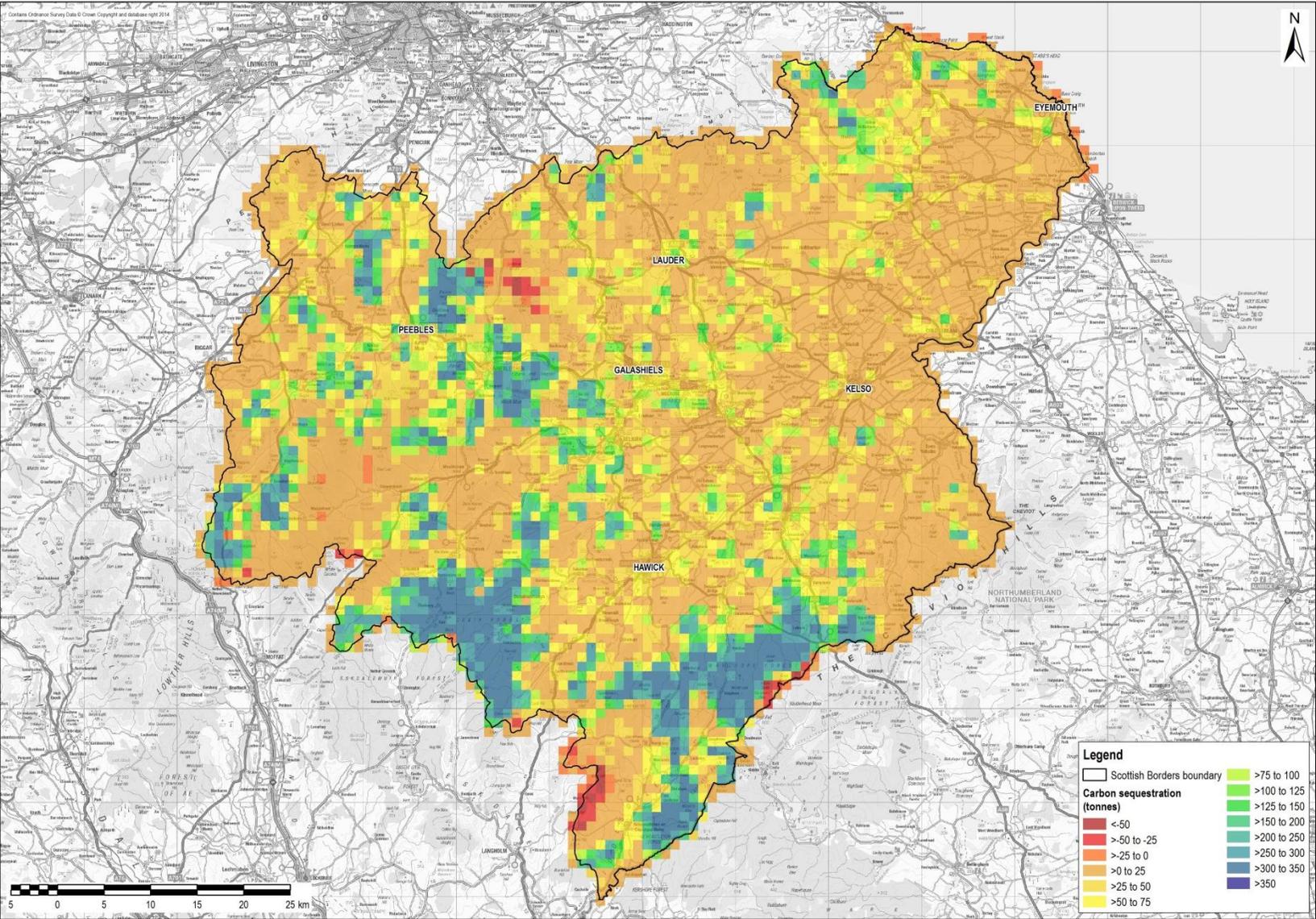
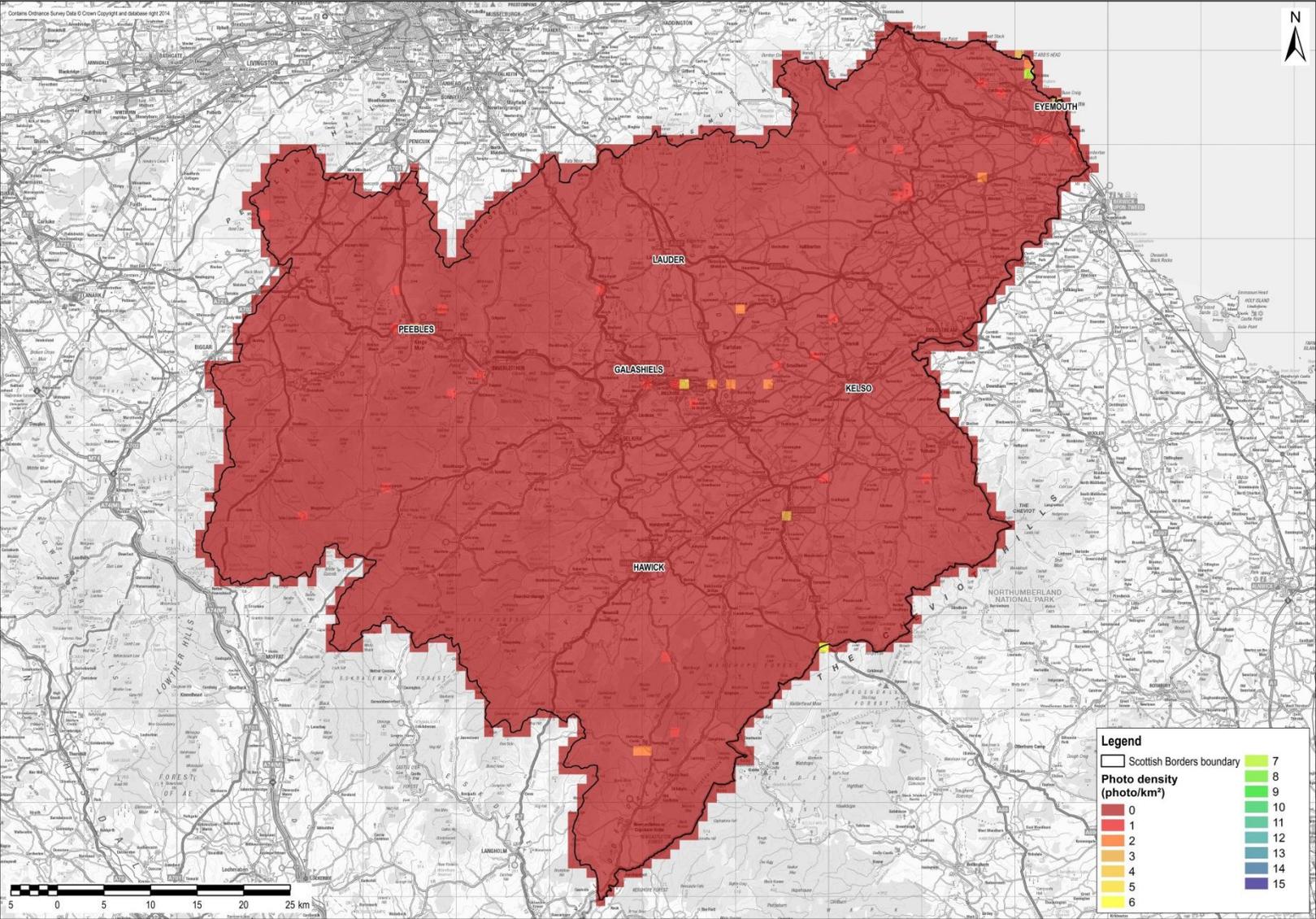


Figure 16. Aesthetically valued landscapes in The Borders (number of photographs from 2005 to 2015)



APPENDIX C. METHODOLOGY

The following table sets out the methodology used to develop the estimates of physical and monetary flows for each of the fifteen ecosystem services. Further details on the methods used can be found in the accompanying **Main Report** and **Technical Appendix**.

Ecosystem service	Physical flows	Monetary flows
Crops	The volume of crops harvested each year was estimated by multiplying the area of thirteen crop types within the pilot areas by the yield per crop. A breakdown of crop areas was obtained from the Defra June Survey and Scottish Government RESAS Statistics (Agriculture). National and, where available, regional crop yields were obtained from Defra datasets, supplemented by industry publications where necessary.	Market prices were obtained from Defra datasets although these values include the returns to human inputs such as machinery, fertilisers, and labour which therefore leads to an over estimation of the ecosystem service value (the bundle of inputs such as pollination, pest control, nutrient cycling etc.). As such, the market values were converted to resource rents i.e. the value of crop production after all human-related inputs have been subtracted.
Livestock	Livestock numbers were estimated using data from the Defra June Survey and RESAS Statistics. These were then converted to Livestock Units and allocated to different ecosystems based on the carrying capacity of each ecosystem, which was calculated by multiplying the area of each ecosystem with a stocking rate for each ecosystem type.	Yields for different livestock were obtained from Defra datasets. These were differentiated for lowland and upland livestock enterprises. Livestock production was estimated by multiplying livestock numbers (by type) by the appropriate yields. As for crops, market prices were obtained from Defra datasets and were converted to resource rents.
Wild foods	Data on the number of deer and game birds killed within the pilot areas was provided by the Game and Conservation Wildlife Trust. Data on the number and weight of salmon and sea trout caught from rivers flowing through the pilot areas was extracted from EA and Scottish Government data.	Market prices were used to estimate the value of the meat harvested from wild foods. It was assumed that the resource rent was similar to the market price due to the limited human inputs required to support provision of wild foods.
Drinking water & Other water uses	Annual volumes of water abstracted from surface and ground water resources within the pilot areas was provided by the EA and SEPA. Agricultural water use was excluded from the analysis in order to avoid double counting of water as an input to agricultural production. It was assumed that all water abstracted for the public water supply is classed as drinking water, while all other water uses are classed as other water uses. No data was available for the Scottish pilots.	The resource rent approach was used to quantify the monetary flows of water abstractions for drinking water. The resource rent was calculated using Annual Business Survey (ABS) data on the revenues and costs for 'water collection, treatment and supply' businesses. Due to a lack of data, it was only possible to develop a resource rent estimate for water abstracted for the public water supply.
Timber & Energy	The average productivity of timber on public and private woodlands was estimated by dividing the total UK production of softwood and hardwood by the area of coniferous and broadleaved woodland in private and public ownership. These average productivity values were combined with data from the Land Cover Map to estimate the total annual hardwood and softwood production within the pilot area boundaries. Forestry Commission data was then used to estimate the share of this wood production that was allocated for timber versus that allocated for woodfuel.	For softwood timber, annual data on the standing price per cubic metre of overbark (or 'stumpage' price) was used, assuming that the stumpage price is broadly equivalent to the unit resource rent for a tonne of timber. For hardwood timber, a constant market price of £35 per cubic metre of overbark was used due to data limitations. The value of woodfuel was estimated using an approximate resource rent based on the market price of woodfuel minus the harvesting, extraction, processing, and transportation costs.
Air quality	Defra data on annual background concentrations of PM ₁₀ for 1 km grid squares across the UK was combined with ecosystem coverage for each 1 km grid square from the Land Cover Map dataset. The quantity of PM ₁₀ absorbed each year was then estimated using the formula: ABSORPTION = FLUX x SURFACE x PERIOD FLUX = deposition velocity for ecosystem x pollutant concentration SURFACE = area of ecosystem x surface area index of ecosystem PERIOD = period of analysis x % dry days x % in-leaf days	Defra air quality guidance was used to calculate the avoided damage cost for absorption of PM ₁₀ . In particular, the central estimate of IGCB air quality damage costs per tonne for emissions of PM ₁₀ in rural areas was used to estimate monetary benefit of the avoided damage due to storage of PM ₁₀ in vegetation within the pilot area boundaries.

Ecosystem service	Physical flows	Monetary flows
Flood protection	The UK NEA identifies woodland, OWWF, MMH, and coastal margin ecosystems as playing an important role in storing and slowing the flow of surface water runoff. However, there is a lack of scientific understanding in terms of quantifying the role such ecosystems play in reducing flood risk.	Due to the lack of a physical indicator for this service it was not possible to develop estimates of the monetary value although this could potentially be done in future through estimates of the avoided damage costs of a reduction in flood risk.
Climate regulation	Average carbon sequestration rates for each ecosystem were combined with data from the Land Cover Map to estimate the annual tonnes of carbon sequestered. In order to account for emissions from degraded peatlands, SSSI data was extracted from Natural England and SNH datasets and was combined with the Land Cover Map data to identify the area of peatland in favourable and unfavourable condition.	The monetary value of this service was estimated using the non-traded DECC carbon values for the period 2008-2015 which are calculated based on the abatement cost per tonne of carbon. As such, this approach focuses on the financial benefits of carbon sequestration, rather than the avoided impacts on ecosystem functioning.
Recreation	The number of recreational visits was estimated using local data on visitor numbers, typically based on the STEAM model. From the total visitor numbers, the number visiting the natural environment was calculated based on visitor feedback surveys. The proportion of visitors to each ecosystem type was then estimated using MENE survey data which asks respondents the types of ecosystem they have visited. No data was available for either of the Scottish pilot areas.	The value of visits to each of the ecosystems was estimated by multiplying the number of visits allocated to each ecosystem with a monetary value per visit. This value was based on a meta-analysis of around 300 previous estimates of values for recreational visits to broad ecosystems in the UK.
Education	It was difficult to develop a comprehensive picture of the number of educational visits to the pilot areas, as there are many different organisations that organise field trips for educational purposes and a lack of data collected on the different types of educational visits.	Due to the lack of a physical indicator for this service it was not possible to develop estimates of the monetary value, although this could potentially be done in future through using estimates of the cost of travel for school visits.
Heritage	A number of approaches were looked at for quantifying the physical flows of this service although it was not possible to identify a clear, measurable indicator which could be included in the accounts.	Due to the lack of a physical indicator for this service it was not possible to develop estimates of the monetary value, although this could potentially be done (at least in part) through hedonic analysis of the impact of proximity to different ecosystems on house prices in terms of amenity value.
Aesthetic	The website www.panoramio.com hosts photographs of aesthetically beautiful natural landscapes. A program was developed to extract data on the photos uploaded to the site, such as the date a photo was uploaded, the latitude and longitude of where the photo was taken, and the unique user ID of the account that uploaded the photo. This data was extracted to identify the number of photographs taken of each ecosystem type.	Due to the lack of available approaches for monetising flows of this service, it was not possible to develop estimates of the monetary value. This could potentially be explored in future through the use of willingness-to-pay surveys.
Existence	Interviews were held with representatives from each of the pilot areas in order to identify which species are considered to be 'charismatic' or to have important existence value to that area. Local data sources were then collected to monitor changes in the populations of these species over time.	Due to the lack of available approaches for monetising flows of this service, it was not possible to develop estimates of the monetary value. This could potentially be explored in future through the use of willingness-to-pay surveys.