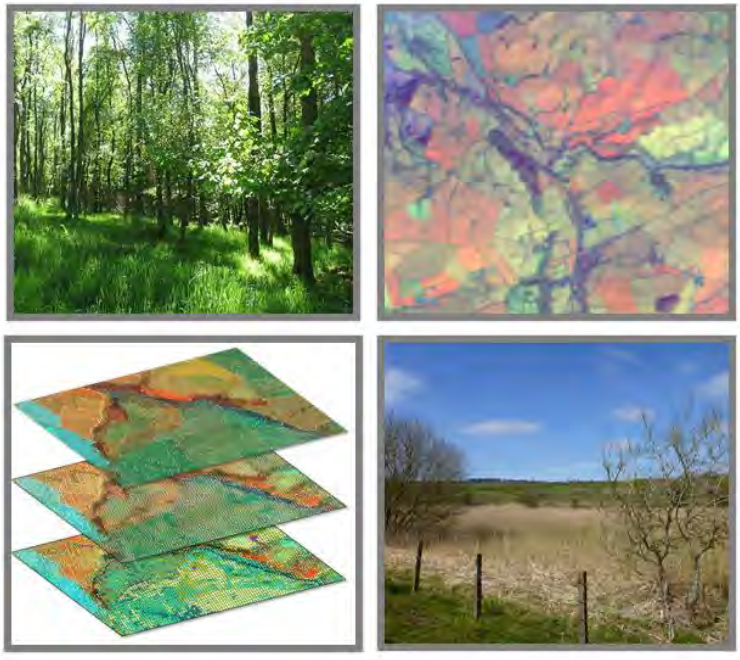
Pilot Regional Land Use Framework: Baseline mapping, constraints & opportunity mapping and final framework

Stage 1 Report: Baseline spatial mapping



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Environment SYSTEMS

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Stage 1 Report: Baseline spatial mapping

1 Introduction

1.1 The Scottish Borders and the regional land use framework

The land resource of the Scottish Borders provides a range of important ecosystem services. However it is a fixed and finite resource, with demands on it continually growing and changing. Scotland's first Land Use Strategy (LUS), published in 2011, set out a vision for future land use in the country to 2050, with a focus on three objectives relating to the economy, environment and communities - the three pillars of sustainability. Key elements of the strategy are partnership working, developing a shared vision for the land using innovative approaches and solutions.

To contribute to the wider strategy, the Scottish Government developed two LUS pilot projects in Scottish Borders and Aberdeenshire, to develop pilot regional land use framework, to consider a wide range of land uses in an area, with a broad range of objectives. Each pilot is local authority led and will help to facilitate the delivery of policies, strategies and objectives in relation to integrated land use by providing a framework to guide decisions about land use.

The pilot framework is to be a tool to guide decisions about land use and management, based on an ecosystems approach, that operates locally (with local support and at a local scale) but takes into account regional and national needs and requirements and statutory planning processes.

Both the LUS and the Scottish Biodiversity Strategy, the 2020 Challenge, are focused around ecosystems approaches. Much work is on-going developing these approaches around the UK and abroad.

1.2 The ecosystem approach

The Convention on Biological Diversity (CBD) defines the ecosystem approach as:

'A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, and which recognises that people, with their cultural and varied social needs, are an integral part of ecosystems'.

The ecosystems approach focuses on the integrated management of the land, water and living resources to promote conservation and sustainable use. It can be used to look at ecosystems as a whole during the decision making process, and for valuing the ecosystem services (ES) they provide. By evaluating the system holistically and highlighting areas of trade-off, where there are pressures on the land and where management can provide multi-benefits, this can help the maintenance of a healthy and resilient natural environment for current and future generations.

The 2020 Challenge sets out three key steps to guide the approach to any ecosystems evaluation, these are;

- **Take account of how ecosystems work**; Nature connects across landscapes, so we need to consider the broad and local scales. The capacity of ecosystems to respond to impacts and provide resources is not infinite. Ecosystems are dynamic so we must recognise that change will happen. By using up-to-date information, embracing adaptive management principles, and trying to sustain nature's multiple benefits, we can ensure that nature continues to contribute to Scotland's growth.

- **Take account of services that ecosystems provide to people**, such as regulating floods and climate, breaking down waste, providing food, fuel and water, and contributing to quality of life, culture and wellbeing.
- **Involve people in decision making,** especially those who benefit from ecosystem services and those who manage them. This means valuing people's knowledge, helping people to participate, and giving people greater ownership and responsibility.

These three steps will be considered throughout and broadly guide the work of developing and preparing the frameworks.

1.3 The Scottish Borders and the ecosystem services it provides

The Scottish Borders is a diverse county with a number of internationally significant and nationally and locally important habitat types including, woodland, wetland, species rich native grasslands and heathland. It also contains high quality agricultural land as well as internationally significant waterbodies. The Scottish Borders covers the majority of the Tweed Catchment which makes it ideal for an ecosystem approach as management at this scale can incorporate full water flow effects.

Each area of land in the Scottish Borders contributes to a range of ecosystem services. The natural habitats of the Borders, including the River Tweed are valued by local people for how they add to the sense of place, provide recreation potential and create scenic quality of the area. They are also important for their less obvious benefits to people such as their effects on natural systems including the regulation of water flow through the landscape which prevents flooding; and carbon sequestration which aids mitigation of climate change. The hidden value of these ecosystems in terms of soil processes and landscape features as well as the management imposed upon them all affects the ecosystem services they provide.

1.4 Project aims

The aim of the pilot project is to use an ecosystems approach;

- to consider existing and land uses future in a collective and integrated way,
- to establish a means to prioritise or guide decisions so as to optimise the use of the land,
- to identify competition or conflicts relating to land use change and seek solutions to resolve them.

The maps produced as part of this pilot aim to contribute to the delivery of the Land Use Strategy (LUS) and on-going. By presenting information about the hidden ecosystem services of the land they aim to assist in the delivery of the Scottish Biodiversity Strategy, the 2020 Challenge, by helping to articulate the aspirations for the preservation of our natural habitats and the development of an ecosystem approach at a more local level. By looking at the opportunities to enhance ecosystem services and the best place for action, they may also help to contribute to CAP Reform in terms of assisting with targeting and prioritisation for Scottish Rural Development Programme (SRDP) and assist in meeting the objectives of the Water Framework Directive as described in the River Basin Management Plans (RBMP) and flood management plans.

The aim of these maps and the ecosystem information is to provide a mechanism which considers existing and future land uses in a collective and integrated way with a view to optimising the use of the land. This information could potentially be used to establish a mechanism to prioritise or guide decisions about possible competing or conflicting uses.

The spatial mapping project is overseen by a project steering group chaired by Scottish Borders Council, with members from SBC, Tweed Forum, University of Dundee and Scottish Government. Further expert stakeholder input has been provided by the Tweed Forum Technical Group.

2 Method

The project methodology aims to develop a spatially based framework which has the potential to be rolled out over the whole of Scotland. The method draws on the SENCE (Spatial Evidence for Natural Capital Evaluation) approach developed by Environment Systems. The framework comprises a series of datasets, maps, rule-bases and an accompanying matrix that can be used to assess, evaluate and map the implications and impacts of land use decisions on the local and wider regional and national environment.

There are three main stages for this framework development project in the Scottish Borders, we are nearing the end of Stage 1, the resources and asset mapping exercise.

Stage 1: Baseline mapping of policy and natural resources/assets 1.1 Identify and collate data 1.2 Produce Maps 1.3 Stakeholder Consultation
Stage 2: Identification and mapping of Constraints and Opportunities 2.1 Agree approach 2.2 Produce mapping 2.3 Stakeholder consultation
Stage 3: Produce framework 3.1 Define basis for framework 3.2 Develop framework 3.3 Stakeholder and public consultation, revise outputs 3.4 Reporting and delivery

The project is based upon the fact that every part of the Scottish Borders provides not just direct benefits to society such as food and timber or a building plot, but also indirect benefits such as the regulation of water flow to prevent flooding and the storage of carbon in the soil which will help mitigate the effects of climate change. The methodology captures, and reflects this as far as possible by using expert rule base system where datasets are evaluated in terms of both the knowledge about the ecosystem service being considered and the knowledge about the data sets used to either map that service or provide a proxy for the service so that it can be mapped.

Even with less than ideal data and a less than exact knowledge about the interactions between a habitat, its location, management and the associated ecosystem service, it is possible to grade the importance into a simple categorisation, of high medium and low effect. The project took a pragmatic approach to the mapping and modelling of ecosystem services, acknowledging that whilst this is a young science with many unknowns, there is a large body of data already available which can be used to inform policy decisions at national, regional and local levels.

This ecosystem services assessment reflects the land cover available within an area. It is based on four factors which interact together in different ways for the services under consideration. These four key factors are:

- The type of habitat or land cover (e.g. woodland or heathland)
- The soil and geology upon which the habitat has established
- The position in the landscape (e.g. on a steep slope or valley bottom next to a river)
- The management imposed upon them (e.g. intensive or extensive or little active management).

Using existing scientific understanding knowledge about how these four factors interacted was used to build ecosystem services layer maps.

Development of the framework will involve sourcing and collating appropriate datasets, putting together necessary rule-bases and understanding relationships between the data, agreeing this with local stakeholders and providing a presentation of the framework that is easy to understand, clear, consistent and widely acceptable across the local land use planning community. The framework will be robust and able to be extended as new theories and tools are developed, such as InVEST and ecosystem health indicators.

2.1 Data acquisition

Data has been sourced from national and regional sources. The data acquisition process is described in Figure 1.

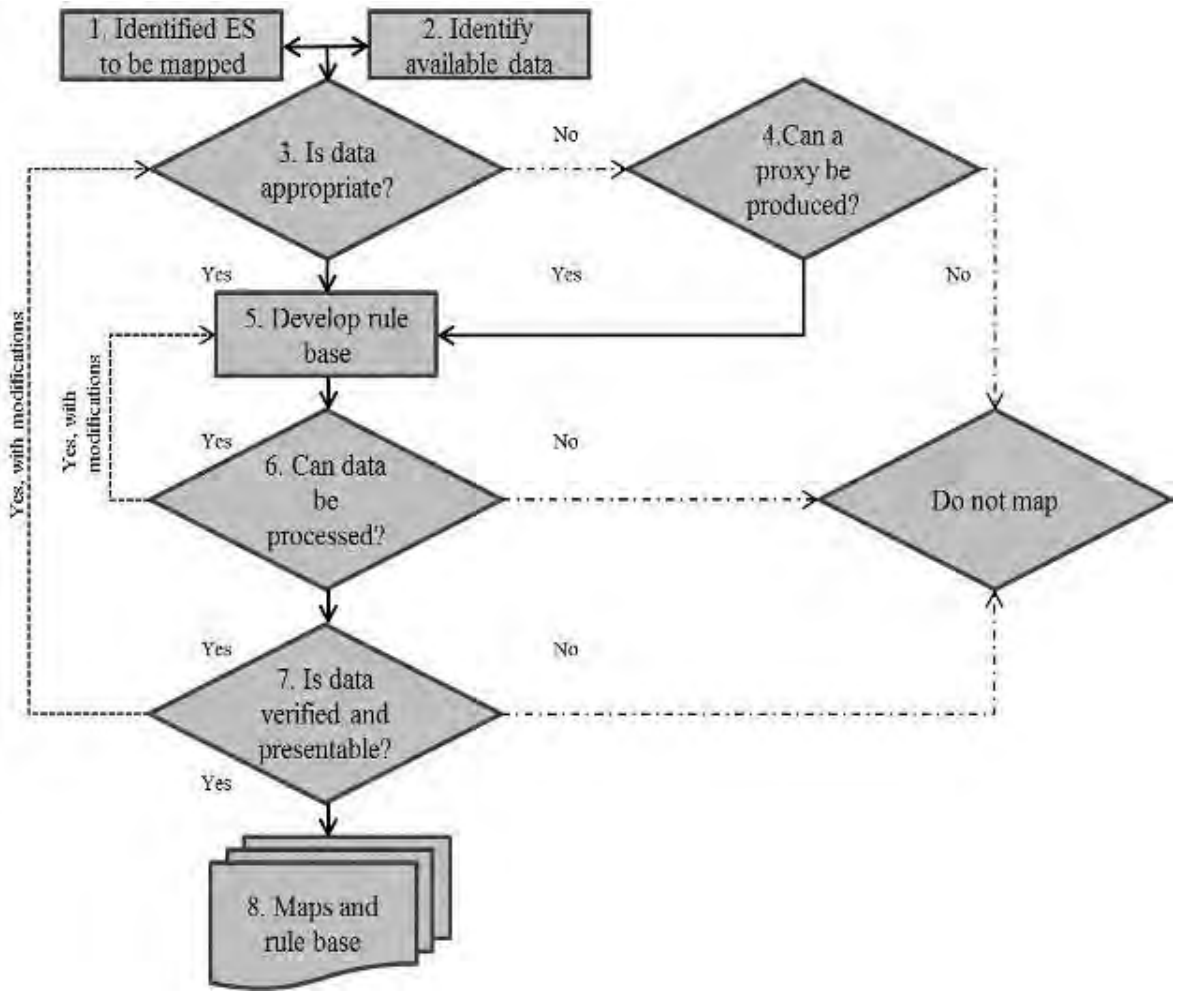


Figure 1: Summary of the method used for data collection and evalutaion

104 100 datasets listed in Appendix 1 were sourced and made available to use within the project. At the end of Stage 1, 74 of these have been used in the creation of the layers.

The project used a range of datasets, underpinned by readily available strategic level datasets such as soils, geology and habitat, as well as local datasets notable species and scheduled ancient monuments. Scale is also an important factor to consider and whether the data is fit-for-purpose. Very broad scale data is only suitable for use at a national strategic level informing national policy and planning issues. For regional and local assessments, meaningful data at this scale is required. Broad scale data has the potential to over simplify the situation on the ground and may not include

sufficient detail. More detailed data about environmental and social assets can be incorporated in the data stack to adequately describe the situation.

Following the data collection all data was subject to a suitability and appropriateness assessment. The key factors considered were:

Quality	Spatial coverage, topology and data projections
Suitability	Appropriateness of the information contained within the layer and how it can inform on one of the services
Availability and licensing	Data restrictions and licencing issues can prevent the data from being used
Metadata quality	Presence of metadata allows us to evaluate how the data was captured, any limitations and allows us to assess the information provided. Datasets which were not provided with sufficient accompanying information could not be assessed and were not considered for further analysis.
The age and frequency of update	How old the dataset is affects whether it is still relevant to the service it is to be used for. Frequency of update also affects whether the data is suitable for use or if there is more recent data available.

Each ecosystem service requires a number of datasets to adequately describe it. There tends not to be one single dataset that is readily available, appropriate to use, simple to map and fully representative of that service. The models combine varying spatial datasets, including both point and polygon vector data and raster data, collected at a variety of different scales, at different dates and with a variety of accuracies and resolutions.

2.2 Confirmation of the ecosystem service terminology to be used

Ecosystem service evaluation is a young science and there are several different typologies which are commonly used to describe the different services. An evaluation of the most commonly used typologies was undertaken. It was decided to use the UK National Ecosystem Assessment (UK NEA) nomenclature as a starting point as this was created for the UK situation to reflect the ecosystem services considerations at the national scale, while many of the others consider the global scale. The terminology could not be followed exactly as it was not feasible to map all the services, and present all the aspects of the resources. For example there is insufficient data to split timber production between fibre provision and fuel provision. Often one timber crop is used for both, with the trunks trees used for timber and the brashings used for fuel. Market value at the time of crop maturity can also impact on the harvest destination, and this information is not available. We have therefore just concentrated on the timber production itself.

During consultation exercises nomenclature has also been raised as a factor which can engage or alienate stakeholders depending on their background. Sufficient description and clarification of any keys on maps is required to prevent these issues.

2.3 Confirmation of the ecosystem service to be included

After consultation with members of the Steering Group, the services listed in Table 1 were included for mapping in Phase 1 of the pilot, focusing on the existing resource of the service. They were chosen as they represent important services for the Borders and sufficient data could be sourced to allow them to be mapped at the catchment scale.

Table 1: services considered in Phase 1 of the LUF pilot

UK NEA service type	Services mapped
Provisioning	Food: Agricultural crops Food: Agricultural livestock Energy Trees: Timber resource
Regulating	Climate regulation: Soil carbon storage Climate regulation: Vegetation carbon storage Detox and purification: Sediment risk for water courses Detox and purification: Water quality Hazard regulation: Flood risk Pollination Soil quality: Land erosion risk Water regulation: Water quantity
Supporting	Wild species diversity: Areas important for biodiversity and nature conservation Wild species diversity: Biodiversity resilience and networks
Cultural	Landscapes Local Places Historic and archaeological significance Recreation (non-motorised access) Sporting Recreation

2.4 Development of the rule-bases

The project utilised a rule-base approach to map and combine individual elements which contribute to each ecosystem services. This approach provides allows combination of multiple different spatial layers with different weightings to represent the whole or part of a complex ecosystem interactions.

The rule base assessment is based on consideration of four factors which interact together in different ways for each parcel of land for each service under consideration. These four key factors are:

- land cover (e.g., grassland, woodland or heathland)
- soil and geology substrate beneath the site
- location of the land parcel in the landscape (e.g., valley bottom, steep slope, proximity to water or urban areas)
- management of a site (e.g., intensive or extensive agriculture or management under a designation as an SSSI or Scenic Area).

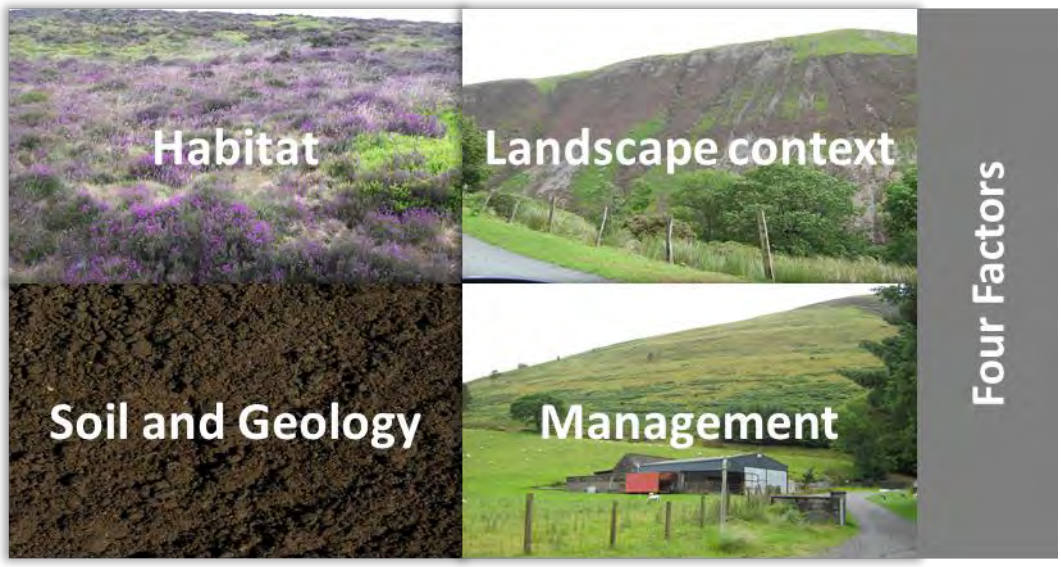


Figure 2: pictorial representation of the four key factors to be considered when mapping ecosystems

The rule-bases use scientific knowledge and expert interpretation to weight different aspects of the landscape representing their contribution to that service. The rule-based approach is an expert system building in information from scientific literature and local knowledge. To create robust locally appropriate outputs, an iterative process occurs with updates to the rule-base if aspects are over or under represented.

The rule-base for each ecosystem service was populated with:

- The specific attribute information of each dataset considered important for mapping the service;
- The relative value to be assigned to each element to enable mapping;
- The relative importance of different datasets to the service as weightings for when they are combined.

With existing scientific knowledge, most data can be categorised by its contribution to the ecosystem service as high, medium and low significance. The rule-bases, used this categorisation of 'high', 'medium', and 'low' to show the level of contribution to the service of aspects of the service. Each service is considered in tern in section 3.1 where the thinking behind the rules for each service is presented. The identified aspects build together to characterise the service are represented by the attributes of the spatial datasets. The example attributes illustrate how the rule-base describes the scoring of the datasets how these data attributes can be used to build up a representation of the ecosystem service being analysed. Expert knowledge was fed into each rule-base.

Each service varies with the level of data input and how well these are able to describe the service. For some proxies have been used while for others specific datasets are able to quantify the areas of highest importance.

Even with less than ideal data and a less than exact knowledge about the interactions between the habitats, the location, management and the service, it is possible to grade the importance into this simple three-step categorisation. As research progresses and new datasets are found it will be possible to become more exacting with these classifications.

In Stage 1 we have been mapping the stock of services as far as can be measured by available datasets, thus providing a state of play at a fixed moment in time. For some services relative values have been assigned, but for others e.g. cultural services such as Local Places and recreation areas important for the resource have been identified and the following consultative stages of the project (2 and 3) will add and amend values. Similarly, further datasets may be added or removed as a result of consultation in developing the pilot regional framework.

3 Results

This section describes the approach to mapping each of the services, while the maps themselves are contained in a separate annex to the report.

3.1 Mapping and iterative rule development

During Stage 1, the 19 services listed in section 2.3 have been mapped. Each of these services is considered below, a brief description of the service is given which is followed by the datasets used and a summary of the types of attributes used to quantify the resource.

During subsequent stages of this project a smaller sub-set of services (approximately seven) will be carried forwards for further development.

3.1.1 Provisioning services

These represent the goods that the land directly provides to humans.

Agricultural goods: Crop resource			NEA service type Provisioning
Food provision is an important ecosystem service that relies on a range of supporting services provided by a range of types and locations of land. Agricultural ecosystems are those that are most directly managed by people to meet human needs. This map covers areas used for crop production, the intensive production of arable crops and intensive small-scale horticultural fruit and vegetable production on allotments.			
Significant effects	Data used	Example attributes	Indicative scoring
Likelihood of land cover to support food production	Land cover Phase 1 habitat layer	Arable Not arable	high low
Current cropping of arable land	Management IACS Permanent Land Data (2012) Allotments	Food crop Part of the intensive agricultural cycle but not currently in crop	high low

Energy			NEA service type Provisioning
The aim of the layer is to help the user visualise the spatial spread of energy provision. This map shows where there is current energy provision in the Borders from wind farms. Hydro-power and fossil fuels are not widely exploited resources in this area and therefore have been excluded.			
Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Presence of wind farm locations	Wind farm consent data from February 2013	Operational On appeal	High low

Agricultural goods: Livestock	NEA service type Provisioning

Food provision is an important ecosystem service that relies on a range of supporting services provided by a range of types and locations of land.

Agricultural ecosystems are those that are most directly managed by people to meet human needs. This map covers areas which support livestock, including arable crops grown for animal feed, intensively grazed areas in lowland arable areas and the extensive permanent grazing regimes on open moorland.

Significant effects	Data used	Example attributes	Indicative scoring
Presence of suitable grazing environments	Land cover Phase 1 habitat layer	Improved grassland Semi-improved grassland Grassland / other habitat mosaics	medium very low
Land managed for supporting livestock	Management IACS Permanent Land Data (2012)	Grazed Crops for stock feed Permanent and temporary grassland	high medium

Timber resource - Forestry	NEA service type Provisioning

The timber resource is a provisioning service, the purpose of this mapping is to highlight features that the land directly provides to us. Plantation woodland has management stages within it, their type and planting regime affect how long it will be until the forest crop is ready. Late stage forestry, mature coniferous plantations have been given the highest score as they are most likely to be timber crop and provide the maximum timber resource. Young and recently felled woodland have been given a lower score as it will many years before timber is available from these sites again. Broadleaved and mixed woodland have been given a very low score as the trees are only felled a few trees at a time for specific site management reasons.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Provision of coniferous plantation	Habitats Forestry Commission NFI Phase 1 habitat layer	Plantations Other woodlands	productive non-productive
Forestry management	Management Forestry Commission sub-compartment data	Confirmation of productive woodland	productive

3.1.2 Regulating services

These services regulate the movement of different features through the environment.

Soil carbon storage	NEA service type Regulating
Soil carbon storage is an important ecosystem service which results from interactions of different ecological processes. The amount of organic matter present within the soil profile is an important component which contributes to the service. Soil organic matter is a heterogeneous mixture of organic compounds that are highly enriched in carbon, ranging in decomposition from fresh plant residues (leaf litter), to highly decomposed material known as humus. Soil organic carbon levels of different soil types are directly related to the amount of organic matter contained in soil from growth and death of plant roots and foliage, as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes. Inorganic carbon is not readily released to the atmosphere or water from the soil so it has not been considered in this analysis.	

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Presence of organic carbon in the soil	Soils National Soil Survey of Scotland 1:250,000 (including SNH soil carbon classification)	 Organic soils Mineral soils	 high Low
Topography suitable for soil carbon accruement	Elevation Slopes derived from DTM	 Shallow slope Steep slopes	 high low
Vegetation cycle accrues / releases soil carbon	Land cover Phase 1 habitat layer	Wetlands and woodlands Heathland Semi-natural grassland Improved grassland High intensity agriculture	high medium low very low negative

Vegetation carbon storage	NEA service type Regulating
Atmospheric carbon is sequestrated by, and stored in, vegetation through the process of osmosis and plant growth. Habitat type is a key determinant of vegetation carbon storage, the more biomass that is present in the vegetation layer the more carbon is stored, with mature woodland at one end of the spectrum and grasslands at the other end. It has been estimated that woodlands and forest vegetation hold up to 80% of the UK total vegetation carbon with those habitats managed for arable and horticultural crops storing the least carbon in their vegetation.	

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Biomass presence	Habitats Phase 1 habitat layer	Woody species Other scrub vegetation Other short vegetation	high medium low
Biomass removal	Management Ancient woodland Inventory Forestry Commission NFI IACS Permanent Land Data (2012)	 Ancient woodland Semi-natural woodland High intensity agriculture	 high high negative

Water quality regulation	NEA service type Regulating

Water quality is a key ecosystem service that effects human health and wellbeing and can have significant economic consequences. Water quality is influenced by both natural processes and human activities.

Soil temporarily stores water that falls as rain and subsequently releases it to rivers and streams, or adds it to the overall groundwater resource. Some soil types effectively filter water as it percolates through it, whilst others add to the suspended particulate matter and mineral burden of the water. Steep slopes shed water more rapidly than shallow slopes. The water has higher energy and is able to carry more particulate matter within it, picked up from the land surface.

Habitat, through its link to vegetation type and soil type, has an important influence on water quality. This is largely linked to the structure of the vegetation present. Some species of plants assist with water purification.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
	Habitat Phase 1 habitat layer	Woodland Hedge Heathland Bog Arable	moderate/high moderate moderate moderate/low low/negative
Filtration effect of the soils	Soils National Soil Inventory Scotland 1:250,000	 Brown earths Peaty soils	 moderate/high low
Quality status of the water bodies	Water body quality Water framework directive Coastal water body 1:50,000 Water framework directive Transitional water body 1:50,000 Water framework directive Loch water body 1:50,000 Water framework directive River water body 1:50,000	 Good Fail Good Fail Good Fail Good Fail	 High Negative High Negative High Negative High Negative
Slope is linked to flow rate	Elevation Slopes derived from DTM	 Steep slopes	 Negative

Sediment risk for water courses (SCIMAP)	NEA service type Regulating services

Sedimentation in rivers is a risk to water quality, blocking light and can affect water flow, changing in-stream areas of erosion and deposition.

The SCIMAP tool developed by Durham University builds in topography, land cover and rainfall to model the water flow effects and the areas at most risk of providing sediment to the water system.

By identifying the areas causing highest risk to water courses, areas vulnerable to land use change can be targeted for mitigation work in the subsequent opportunities mapping exercises.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Slope and flow characteristics	Terrain Nextmap DTM	Ground saturation and down slope water flow effects have been built in to the model to accurately calculate overland flow.	High flow higher risk Low flow lower risk
Vegetation preventing erosion	Land cover Phase 1 habitat layer	Sparsely vegetated areas Arable land – regularly bare Dense vegetation (e.g. woodland, heaths, bogs)	high very low
Average rainfall	Met office 5k	Higher rainfall	higher risk

Flood risk	NEA service type Hazard

Combination of water quantity, land erosion risk and SEPA flood risk layers. This infers the areas most at risk of flooding from already well-established datasets and indicative water quantity models. When considering opportunities in the subsequent mapping exercises can show the areas with greatest potential for flood mitigation work.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Areas which are effective at regulating water flow	Water quantity layer	Low water quantity regulation High water quantity regulation	high low
Areas already identified as at risk of flooding	SEPA flood risk layers Fluvial flood risk Potentially Vulnerable Areas	High risk of flooding No risk of flooding	High low

Land Erosion Risk	NEA service type Regulating services

The susceptibility of land to erosion can be seen as a composite of how easily the substrate can be eroded, and any mitigating effects of the surface vegetation. The higher the risk of erosion the more vulnerable the soil profile and higher the risk of sediment transport to watercourses. By identifying the risk, areas vulnerable to land use change can be targeted for mitigation work in the subsequent opportunities mapping exercises.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Soil and slope characteristics	JHI Inherent risk of erosion by overland flow	Soil texture, runoff and slope characteristics = prone to erosion Soil texture, runoff and slope characteristics = less prone to erosion	high low
Vegetation preventing erosion	Habitats Phase 1 habitat layer IACS Permanent Land Data (2012)	Sparsely vegetated areas Arable land – regularly bare Dense vegetation (e.g. woodland, heaths, bogs)	high low

Pollination resource	NEA service type Regulating service Supporting service

A biotic pollinator is any living thing that moves pollen from the male anthers of a flower to the female stigma of a flower enabling fertilisation. The pollination resource can be seen as the amount of pollen present in an area and is an important supporting service. Areas poor in pollen producing species are unable to produce enough pollen to support pollinator species. Pollinators are an essential component of the natural environment and are essential for the maintenance of many habitat types and production of insect pollinated crops.

Pollination as a service is not often mapped due the relatively small scale of the process. Most common known proxy methods to map pollination involve the use of land cover and land use, pollinator habitat and crop yields to map the pollination service.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Species which affect pollination	Species Borders notable species	Bee species Butterflies & moths Dragonflies (associated with pollinator predation around water)	high medium negative
Species which produce pollen	Species Borders notable species	Flowering plants	high
Indicative pollen presence	Habitat Phase 1 habitat layer	Habitat often contains a high proportion of pollen rich species (e.g. heath, scrub) Habitat often contains some pollen rich species (e.g. Semi-natural grassland) Habitat contains few pollen	medium/high medium low

	Arable crop type IACS Permanent Land Data (2012)	rich species (e.g. woodland, improved grassland) Insect pollinated flowering crop (e.g. Oil seed rape, legumes, potatoes) Non-insect pollinated crop (e.g. Silage, Oats, Wheat)	 medium very low

Water quantity regulation	NEA service type Regulating

Water quantity regulation is a key ecosystem service which affects everyone. Excess water in a natural system can cause flooding events which can lead to severe social and economic consequences. Conversely, too little water over a long period causes drought conditions and water restrictions.

The regulation of water is complex and is affected by obvious factors such as climate (rainfall in particular), but also less obvious ones such as topography, soil, vegetation and land cover type (especially sealed surfaces, such as concrete and tarmac).

At its simplest, soil temporarily stores water that falls as rain as it percolates through the system towards rivers and streams, or into the groundwater resource. The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape.

Habitat, through its link to vegetation type and soil type, has an important influence on water quantity. This is linked largely to the structure of the vegetation present and effect on infiltration.

Steep slopes shed water more rapidly than shallow slopes. Steep slopes are also more likely to be in the upper reaches of catchments and are characterised by small streams with rocky banks, which in times of heavy rainfall can quickly rise.

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Vegetation effect on interception	Habitats Phase 1 habitat layer	 Dense vegetation (e.g., woodland) Variable density vegetation (e.g., heath, bog) Low density vegetation and vegetation often removed (e.g., arable)	 high moderate low
Infiltration and drainage characteristics of the ground	Soil / geology National Soil Inventory Scotland 1:250,000 with HOST classification BGS Superficial 1:50,000 BGS Bedrock 1:50,000	 free drainage poor drainage Permeable substrate Impermeable substrate	 high low high low
Drainage	Drainage and topography DTM	 Gentle slopes Steep slopes	 high low

3.1.3 Supporting services

These services and their effective functioning are important to the health of all the other services which they underpin.

Biodiversity and nature conservation	NEA service type Regulation and Maintenance Provisioning Cultural

Biodiversity is an important supporting ecosystem service that underpins a majority of ecosystem services and provides benefits to most aspects of human wellbeing. Biodiversity describes the range and diversity of species existing and includes genetic diversity within species and between different taxa in any area.

Climax communities of semi-natural habitats that have been present for a long period of time tend to have the highest biodiversity, as over time they can develop specialized niches. The structure of the vegetation both above and below ground has a profound effect on biodiversity. The more complex the structures and the more varied the niches or locations for biodiversity development the greater the diversity of species found in an ecosystem.

The value of a parcel of land for biodiversity and nature conservation can be assessed by considering:

Naturalness – those habitats which have received little modification by humans.

Diversity – The higher the plant community species richness, the higher the diversity within the habitat. This is difficult to accurately compare as some plant communities are intrinsically more species rich than others. Detailed habitat classifications such as Annex I or NVC, which take into account the presence of species and communities, can be added to the broader habitat classifications to model species diversity.

Connectivity – Habitats which are well connected are more likely to support a greater number of organisms that inhabit that particular ecological niche. Fragmented patches (depending on size) can only support smaller populations.

All vegetation types have been scored in this biodiversity layer and then any management and connectivity have been added as modifiers to infer more likelihood of good quality habitat.

Significant effects	Data used	Example attributes	Indicative scoring
Naturalness	Habitats Phase 1 habitat layer	Semi-natural habitats (e.g. heath, bog, woodland) Other habitat (e.g. scrub, parkland, bracken) Intensively managed land (e.g. improved grassland, arable, urban)	high medium low
	Management Designated sites IACS Permanent Land Data (2012)	Internationally protected (e.g. SAC, SPA) Nationally protected (e.g. SSSI, NNR, SWT) Locally protected (LBS) High intensity agriculture	high medium low very low
Diversity	Species Borders Notable Species	Internationally important Nationally important Locally important	high medium low
	Habitats Phase 1 habitat layer	Semi-natural habitats (e.g. heath, bog, woodland)	high

		Other habitat (e.g. scrub, parkland, bracken) Intensively managed land (e.g. improved grassland, arable, urban)	medium low
Location within the landscape	Connectivity Forest Research Integrated habitat networks Woodland, Wetland, Heathland, Acid grassland, Neutral grassland	Well connected habitat Poorly connected habitat	high low

Biodiversity resilience and networks	NEA service type
	Regulation and Maintenance Provisioning Cultural

Biodiversity is an important supporting ecosystem service that underpins a majority of ecosystem services and provides benefits to most aspects of human wellbeing. Biodiversity describes the range and diversity of species existing and includes genetic diversity within species and between different taxa in any area. Maintaining important habitats and species is important

The ecological resilience of a system is the capacity of the ecosystem to respond to disturbance or damage and to recover quickly. Disturbances can include natural change such as flooding, together with activities related to human action such as land use change and pollution. These disturbances can change the composition of biological communities and increase the rates of species invasions and extinctions. Those habitats and ecosystems which can maintain their intrinsic diversity and value during these shifts are considered resilient. In ecological systems, resilience lies in the requisite variety of functional groups and the accumulated capital that provide sources for recovery.

The value of a habitat parcel for biodiversity resilience can be assessed by considering:

Size – The area of a patch of habitat must be sufficient to be resistant to edge effects and invasive species, as well as being resilient to future environmental changes.
Vulnerability – The speed of habitat turn-over and whether they are easily altered. This can be either because they are easy to overlook (e.g. species rich wet grasslands which can be considered 'rough land' by farmers) or because they are very sensitive to external changes in management, (e.g. calcareous grasslands, in the absence of management tend to scrub over).
Connectivity – Habitats which are well connected are less likely to suffer edge effects. Fragmented patches (depending on size) can only support smaller populations and are therefore are less resilient to stochastic event and less resistant to impacts.

For this resilience layer, important habitats have been included scored by their patch size and the type of habitat, with added value given to areas within the networks, as they are likely to be more resilient and the area surrounding the important habitats from the networks, picking up the less important vegetation which is likely to add to the network.

Significant effects	Data used	Example attributes	Indicative scoring
Resilience - patch size	Habitat Phase 1 habitat layer	Size of habitat patches Woodlands >2ha Heathlands >0.5ha Grasslands >0.2ha	 high

		Woodlands <2ha Heathlands <0.5ha Grasslands <0.2ha	low
Resilience - vulnerability	Habitat Phase 1 habitat layer		
Location within the landscape – surrounding vegetation types	Networks Forest Research Integrated habitat network	Semi-natural habitat within the network Semi-natural habitat outside the network Other vegetation within the network	high medium low
Management will prevent or add to pressures on the site	Management Protected sites	Internationally protected site Nationally protected site Locally protected site	high medium

3.1.4 Cultural services

These are less tangible services which concern the way people interact with their environment.

Landscapes	NEA service type Cultural services
Landscapes are an important part of cultural ecosystem services and identify many of the Borders recognised landscapes. Landscape contributes to the culture and identities of the Borders' local communities. This includes the underlying geology and landform which can form prominent local features, waterways also markedly add to the landscape as do areas where the natural or cultural heritage is particularly significant.	

Significant effects	**Data used**	**Example attributes**	**Indicative scoring**
Recognition of the landscape at different levels	Areas which add to the landscape of the Borders Borders Designed Landscapes Historic Gardens and Designed Landscapes Iconic Viewpoints (wind farm study) Landscape Character Areas National Scenic Areas Natural Heritage Zones SNH Wildlands Special Landscape Areas	Nationally identified features Regionally identified features Locally identified features	high low

Local places			NEA service type Cultural services
The local sense of place is derived from the culture and identities of the Borders' local communities. This describes the factors that make the Borders a distinctive place.			
Significant effects	Data used	Example attributes	Indicative scoring
Natural features	Parks LDP Greenspace The Tweed River Rivers and Lochs Important trees (Tree Preservation Orders and Veteran Trees)	Presence of the features	Present
Activities	Visitor attractions Common riding routes	Presence of the activities	Present
Landscape Character	Landscape Character Areas (with important local place attributes)	Boundaries used for context	Present
Features adding to the historic character	Scheduled Monuments Listed buildings Gardens and designed landscape	Presence of the features	Present

Historic and Archaeological significance			NEA service type Cultural
The historic and archaeological significance of areas can shape their current character and the development over time of spread of settlement distribution. Historic and archaeological landmarks add to the sense of the place, provide points of interest and can be culturally important.			
Significant effects	Data used	Example attributes	Indicative scoring
Important historical and archaeological sites	Historic Scotland Scheduled Ancient Monuments SBC Historic Environment Records RCAHMS Historic Land Use Assessment	Presence of sites	high

Recreation (non-motorised)			NEA service type Cultural
Habitats provide opportunities and benefits for recreation, e.g. gardens, parks, woodlands, and the wider countryside. These sites are places of interaction between people and nature and are fluid with no fixed boundaries. The highest levels of recreation are often linked to environmental settings which facilitate many activities (e.g. local parks, woodlands or the coast). The level of use of these sites varies by site access and how accessible different settings are to people. Those sites which are associated with a footpath, cycleway, road network and car park are more likely to be used.			
Significant effects	Data used	Example attributes	Indicative scoring

Areas which contribute to recreational value	LDP Greenspace National Scenic Areas	Presence of the resource	Present
Places associated with recreation	Historic Gardens and Designed Landscapes Properties in care	Presence of the resource	Present
Areas used for outdoor activities	Bathing waters Canoeing - river access points Common Good land Cycle Routes Horse riding routes Foot paths including Scotland's Great Trails Promoted Paths Paths around other key settlements NNR Scotland SWT reserves	Presence of the resource	Present

Recreation sporting		NEA service type Cultural	
Habitats provide opportunities for sporting recreation. In the borders areas of upland moorland is specifically managed by burning to create suitable grouse habitat. Many of the woodlands are used in some way for sporting recreation, either shooting for pest control or for some aspect of sport shooting. Watercourses provide suitable locations for fishing which is a high popularity sport in the Borders for locals and attracting tourists.			
Significant effects	Data used	Example attributes	Indicative scoring
Many woodlands in the Borders are used in some way for shooting	Habitat Phase 1 habitat layer	Semi-natural woodland	low/medium
Distinctive management of heathland indicative of grouse moors	Derived grouse moors	Grouse moor presence	high
Management of fish stocks	Fishing data	Rivers and lochs stocked for fishing	high

4 Further development and proposed next steps

4.1 Consultation exercises

Verifying the datasets used and the weightings given for each layer is an important part of the process. An iterative process of mapping, internal sense checking, external consultation with the steering group and other local experts, and subsequent tweaking of the rules and datasets used has occurred throughout this stage of the project. This consultation with the stakeholders in the Borders has been important not only to check whether they 'believe' the mapping from their own experiences of the area, but also to identify any issues regarding clarity of outputs and ease of understanding of people from different backgrounds and ecosystems experience.

Clarifications of the mapping rules and map presentation have been created of the mapping templates to aid interpretation by both the general public and scientific experts. Where needed the mapping colour ramps were amended to help improve both clarity and ease of understanding. This iterative process is important to engage potential users and ensure transparency and clarity of outputs.

4.2 Agreement on map terminologies and map frame properties and further iteration

Final clarifications of map terminologies and map presentation is underway, with thinking at this stage of development into opportunities future work shown at the sub-catchment level for six case study areas suggested by the project steering group, Ale Water, Gala Water, Ettrick/Yarrow, Leet, Eye and Eddleston to model issues at a finer scale shown in Figure 3.

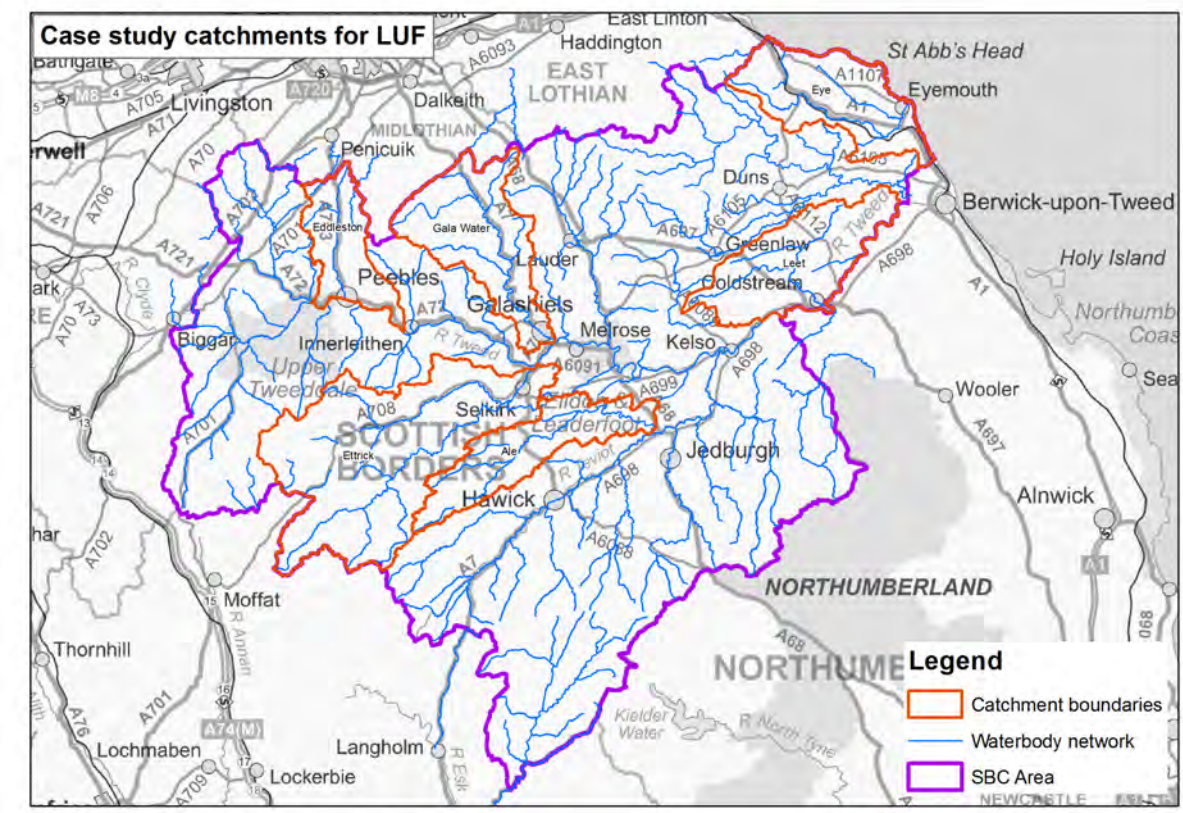


Figure 3: The location of the six case study sub-catchments

4.3 Next steps:

The next stage of the process is further verification of data used through a wider stakeholder consultation. At the end of this process the list of layers will be reduced down to approximately seven for taking forwards.

Through the stakeholder consultation programme feedback will also being gathered to enable values to be added or amended especially for the cultural services where presence of aspects have been recorded rather than rankings.

The baseline mapping will help SBC and Tweed Forum to articulate the concept of the ecosystem approach to stakeholders and enable a consideration of the key issues to begin with stakeholders in Stage 2 : Opportunities & constraints. Through this iterative process the mapping will move forward to map both opportunity areas to deliver ecosystem services and also areas of constraint/potential conflict between ecosystem service provisions. Advances in geo-informatics and ecosystem service theory will be used to develop the existing baseline maps into the opportunity mapping exercise.

The stock maps will inform the baseline of the Strategic Environmental Assessment to be carried out by SBC. SBC, Tweed Forum and ES will consider the baseline mapping alongside the policy mapping to consider whether there are other datasets that can be included to improve the spatial description of the services.

5 Appendix 1 – Datasets sourced

	Summary title	Full title	Used?	Source	Access
Agriculture	Council owned allotments SBC	Council owned Allotments	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	IACS permanent land 2012	Integrated Administration and Control System (IACS) and Single Application Form (SAF) data	Yes	Scottish Government	Restricted licence through Scottish Government.
	Land capability for agriculture 250k	Land capability for agriculture 250k	No	James Hutton Institute	Licence through Scottish Government.
	Land capability for agriculture 50k	Land capability for agriculture 50k	No	James Hutton Institute	Licence through Scottish Government.
Basemaps	Aerial photography	All Tweed ECW	Yes	Scottish Borders	PSMA licence through Scottish Borders council
	Bare ground classification	Bare ground classification of the Scottish Borders 2013	Yes	NASA	Freely available from USGS.
	Bedrock geology 1:50,000	DiGMapGB-50 Series: Bedrock	Yes	British Geological Survey	Licence through British Geological Survey.
	JHI Inherent Erosion Risk	Inherent geomorphological risk of soil erosion by overland flow in Scotland	Yes	James Hutton Institute	Licence through Scottish Government
	Landsat 8 imagery	Landsat 8 imagery 4th June 2013 Landsat 8 imagery 6th July 2013 Landsat 8 imagery 20th July 2013	Yes	NASA	Freely available from USGS.
	Met Office Long term average rainfall	UKCP09 Series: Rainfall 1961-1990 Monthly Averages	Yes	Met Office	Licence through the Met Office
	National land use definitions	National Land Use Definitions of Land Use (Version 3.2) 2009	No	The Geoinformation Group	Licence through Scottish Borders Council
	National land use definitions - settlements	National Land Use Definitions of Land Use (Version 3.2) 2009	No	The Geoinformation Group	Licence through Scottish Borders Council
	Nextmap DTM	NEXTMAP DTM 10m	Yes	NEXTMAP	Licence through Scottish Borders Council.
	OS basemapping	OS 50k raster OS boundary line	Yes Yes	Ordnance Survey	PSMA and Subcontractor licence through Scottish Borders Council Available through Ordnance Survey Open Data.
	OS MasterMap polygons	OS MasterMap Topography layer	Yes	Ordnance Survey	PSMA and Subcontractor licence through Scottish Borders Council
	Peat depth	Soils 250k Peat depth	Yes	James Hutton Institute	Licence through Scottish

					Government
	SNH Soil carbon layer 250k	Carbon richness of soil 1:250,000 scale map units (Scottish Natural Heritage)	Yes	James Hutton Institute *Method:* Scottish Natural Heritage	Licence through Scottish Government
	Soil Drainage (HOST)	Soil Drainage XLS	Yes	James Hutton Institute	Licence through Scottish Government
	Soils 250k	National soil map 1:250,000	Yes	James Hutton Institute	Licence through Scottish Government
	Superficial geology 1:50,000	DiGMapGB-50 Series: Superficial	Yes	British Geological Survey	Licence through British Geological Survey.
Biodiversity	Borders notable species	Borders Notable Species	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	Hedges	SBC Hedges	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	Phase 1	Phase 1 habitat layer	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Scottish Ornithologist's Club SE Bird Atlas	SOC SE Bird Atlas data	No	Scottish Ornithologist's Club	Licence through Scottish Borders Council
Habitat networks	Forest Research Integrated Habitat Network	IHN Wetland network IHN acid grassland network IHN woodland network IHN heathland network IHN neutral grassland network	Yes	Forest Research	Licence through Forest Research
Management and designated areas	RAMSAR	RAMSAR_Scotland	No	Scottish Natural Heritage	Available using an Open Government Licence
	SPA	SPA_Scotland	Yes	Scottish Natural Heritage	Available using an Open Government Licence
	SSSI	SSSI	Yes	Scottish Natural Heritage	Available using an Open Government Licence
	SWT Reserves	SWT_Reserves	Yes	Scottish Wildlife Trust	Licence through Scottish Wildlife Trust.
	Geology Conservation Review Sites	GCR_Scotland		Scottish Natural Heritage	Available using an Open Government Licence
	Local biodiversity sites	Passed LBS 130416	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	National nature reserves	National Nature Reserves	Yes	Scottish Natural Heritage	Available using an Open Government Licence
	SAC	Special Areas of Conservation	Yes	Scottish Natural Heritage	Available using an Open

					Government Licence
	Greenspace (Local development plan)	LDP_Greenspace	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Scottish Borders Woodland Strategy	Scottish borders woodland strategy	No	Scottish Borders Council	Licence through Scottish Borders Council.
	Strategic green networks	Borders strategic green networks	No	Scottish Borders Council	Licence through Scottish Borders Council.
Economic areas	Local plan employment sites	Local plan employment sites	No	Scottish Borders Council	Licence through Scottish Borders Council.
	Scottish index of multiple deprivation	SBC_SIMD_2012	No	Scottish Government	Licence through Scottish Government
Emergency planning	Emergency planning sandbag locations	Sandbags_120808	No	Scottish Borders Council	Licence through Scottish Borders Council.
Energy	Wind turbines	All turbines Feb13 Windfarms Above 5mw Feb 13 Windfarms Below 5mw Feb 13	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
Flooding	coastal flooding 1 in 100	SEPA indicative flood maps: Coastal 100	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	coastal flooding 1 in 1000	SEPA indicative flood maps: Coastal 1000	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	coastal flooding 1 in 200	SEPA indicative flood maps: Coastal 200	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	fluvial flooding 1 in 100	SEPA indicative flood maps: Fluvial 100	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	fluvial flooding 1 in 1000	SEPA indicative flood maps: Fluvial 1000	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	fluvial flooding 1 in 200	SEPA indicative flood maps: Fluvial 200	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	Potentially Vulnerable Areas	PVA_CATEGORISED	Yes	Scottish Environmental Protection Agency	Licence through SEPA
Pollution	Contaminated land	Conland_sites	No	Scottish Borders Council	Licence through Scottish Borders Council
Forestry	Community woodland	cw_boundaries	No	Scottish Borders Biological Records Centre	Licence through Scottish Borders Council
	Forest estates boundaries	SBC_NFEW_LegalBoundary	No	Forestry Commission	Licence through Scottish Borders Council
	Forest recreation areas	NATIONAL_FOREST_ESTATE_RECREATION_AREAS_SCOTLAND	yes	Forestry Commission	Licence through Scottish Borders Council
	Forest reproductive material sites	SBC_ForestReproductiveMaterialSites	no	Forestry Commission	Licence through Scottish Borders Council

	Forest roads	SBC_NFEW_Roads	Yes	Forestry Commission	Licence through Scottish Borders Council
	Forest sub compartments	FC_SBC_NFEW_Sub Compartments	Yes	Forestry Commission	Licence through Scottish Borders Council
	National forest inventory	National Forest inventory Scotland	Yes	Forestry Commission	Licence through Scottish Borders Council
	Native Woodland Survey	Scottish semi-natural woodland inventory	Yes	Scottish Natural Heritage	Licence through Scottish Natural Heritage.
	Tree preservation orders	Tree preservation orders	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Veteran trees	Veteran trees	Yes	Scottish Borders Council	Licence through Scottish Borders Council
Historic	battlefields inventory	Battlefields Inventory Boundary	No	Historic Scotland	Licence through Historic Scotland
	Conservation areas	Conservation Areas		Historic Scotland	Licence through Historic Scotland
	Historic Environment Record	HER	No	Historic Scotland	Licence through Historic Scotland
	Historic Landuse Assessment	Historic Land use Assessment	Yes	Royal Commission on the Ancient and Historical Monuments of Scotland	Licence through Royal Commission on the Ancient and Historical Monuments of Scotland
	Listed buildings	Listed Buildings	No	Historic Scotland	Licence through Historic Scotland
	Properties in care	Properties in Care	No	Historic Scotland	Licence through Historic Scotland
	Scheduled Monuments	Scheduled Ancient Monuments	Yes	Historic Scotland	Licence through Historic Scotland
Landscape	Areas of Great Landscape Value	aglv	No	Scottish Borders Council	Licence through Scottish Borders Council
	common good land	common_good	yes	Scottish Borders Council	Licence through Scottish Borders Council
	SBC Designed landscapes	SBC Designed landscapes	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Gardens and designed landscapes - Scotland	Gardens and designed landscapes Scotland	Yes	Historic Scotland	Licence through Scottish Natural Heritage
	National scenic areas	National_Scenic_Areas	Yes	Scottish Government	Available using an Open Government Licence
	Natural Heritage Zones	NHZ	No	Scottish Natural Heritage	Licence through Scottish Natural Heritage
	SNH wildlands	Scotland Wildland	Yes	Scottish Natural Heritage	Licence through Scottish Natural Heritage

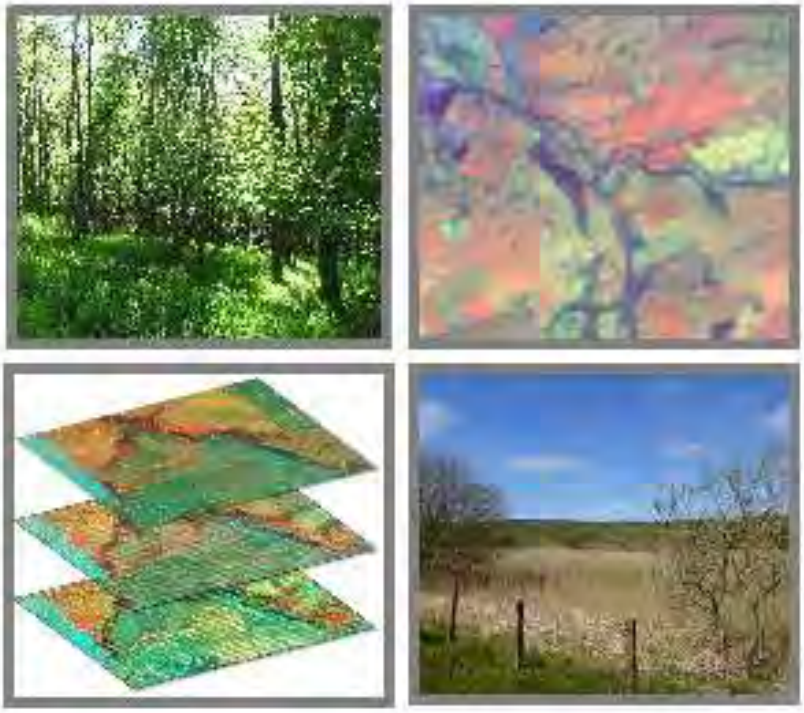
	Special Landscape Areas	Special Landscape Areas	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Local Landscape character assessment	LCA More detailed boundaries	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	National Landscape Character assesment	National Landscape Character Assessment	No	Scottish Natural Heritage	Licence through Scottish Natural Heritage
Recreation	bathing waters	Designated bathing waters	Yes	Scottish Government	Available using an Open Government Licence
	Canoeing river access points	Canoe and Kayak Water Access Points	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Community riding routes	Not received	Not receive d	Not received	Not received
	Cycle routes	Sustrans	Yes	Sustrans	Licence through Scottish Borders.
	fisheries	Not received yet	-	Not received yet	Not received yet
	Grouse moors	PotentialGrouseMoors	Yes	Derived layer from interpretation from Landsat imagery	
	iconic viewpoints	Iconic_vpts	Yes	Scottish Borders Council	Licence through Scottish Borders Council
	Paths around other key settlements	Paths_for_LUS	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	Promoted Paths	Paths_for_LUS	Yes	Scottish Borders Council	Licence through Scottish Borders Council.
	Scotland's Great Trails	Paths_for_LUS	yes	Scottish Borders Council	Licence through Scottish Borders Council.
	Visitor attraction numbers	SBC_visitor_attractions	yes	Derived from Moffat Centre table "Attractions in the Scottish Borders"	
Water quality	Nitrate vulnerable Zones (Scotland)	Nitrate_Vulnerable_Zones	no	Scottish Government	Available using an Open Government Licence
	Private water supplies	AllPWS	No	Scottish Environmental Protection Agency	Licence through SEPA
	SEPA WFD coastal classification data	SEPA Water Framework Directive coastal classification data	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	SEPA WFD lake classification data	SEPA Water Framework Directive lake classification data	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	SEPA WFD lake pressures data	SEPA Water Framework Directive lake pressures data	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	SEPA WFD river	SEPA Water Framework	Yes	Scottish	Licence through

	classification data	Directive river classification data		Environmental Protection Agency	SEPA
	SEPA WFD transitory pressures data	SEPA Water Framework Directive transitory pressures data	Yes	Scottish Environmental Protection Agency	Licence through SEPA
	SEPA WFD transitory water bodies pressures	SEPA Water Framework Directive transitory water bodies pressures	No	Scottish Environmental Protection Agency	Licence through SEPA
	Private Water Supplies	AllPWS	no	Scottish Environmental Protection Agency	Licence through SEPA

Pilot Regional Land Use Framework: Baseline mapping, constraints & opportunity mapping and final framework

Stage 1 Report: Baseline spatial mapping

Appendices

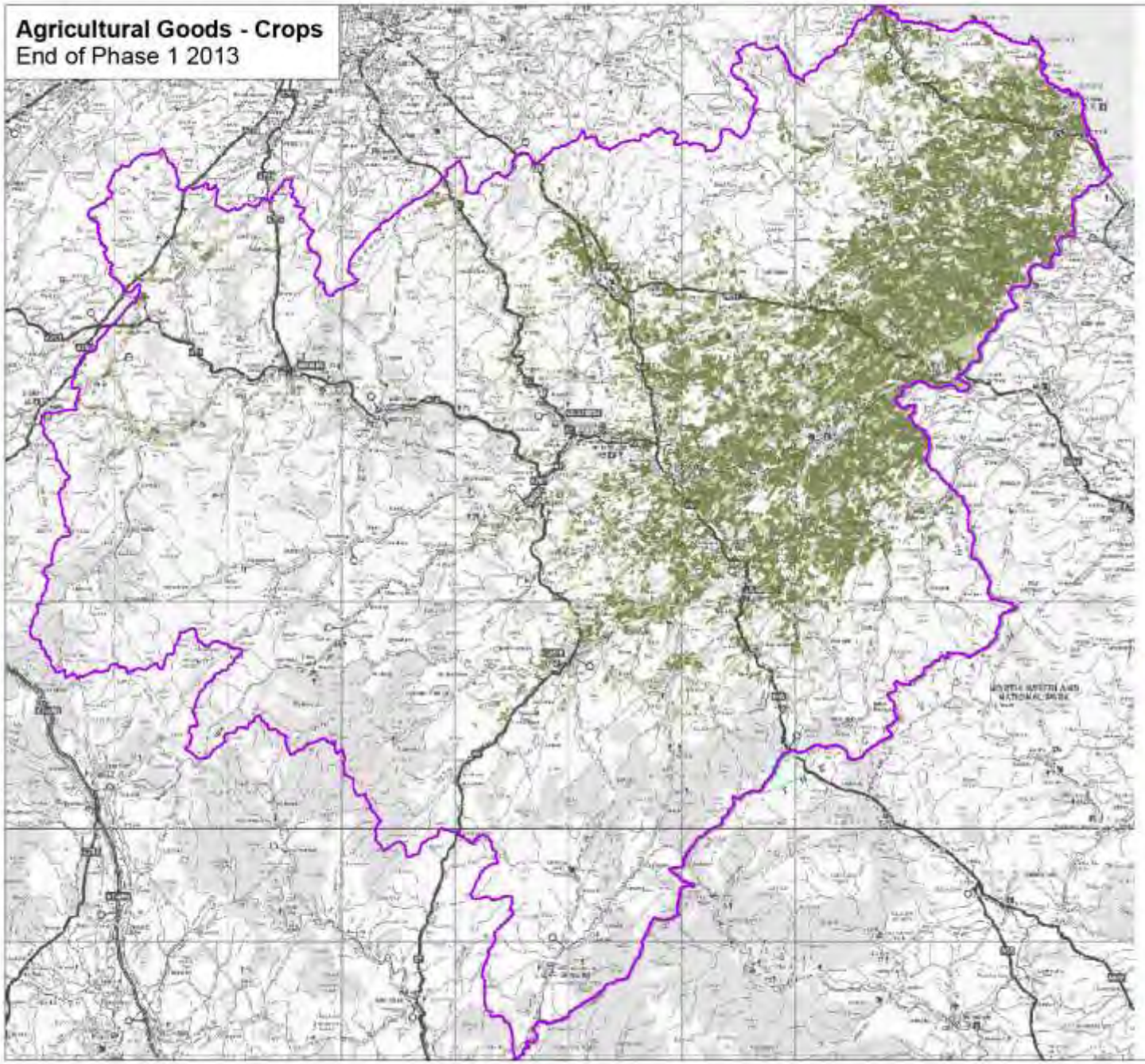


October 2013

A report produced for Scottish Borders Council and Tweed Forum by

Environment SYSTEMS

Agricultural Goods - Crops
End of Phase 1 2013



Legend

SBC Area

Crop provision

High

Low

Food provision is an important provisioning ecosystem service. Agricultural crops are an important industry in the Borders. This map shows the distribution of land currently involved in arable food production. This map includes areas used for crop production, the intensive production of arable crops and intensive small-scale horticultural fruit and vegetable production on allotments. The darker areas on the map are likely to be managed exclusively for human arable food crops while the lighter colours will be cropping from another stage of the arable rotation with occasional aftermath grazing for animal feed.

The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Provisioning Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	indicative scores
Agricultural goods: crop resource	Likelihood of land cover to support food production	Land cover	Arable	high
			Not arable	low
	Current cropping of arable land	Management	Food crop	high
			Part of the intensive agricultural cycle but not currently in crop	low

0 5 10 20

Kilometres

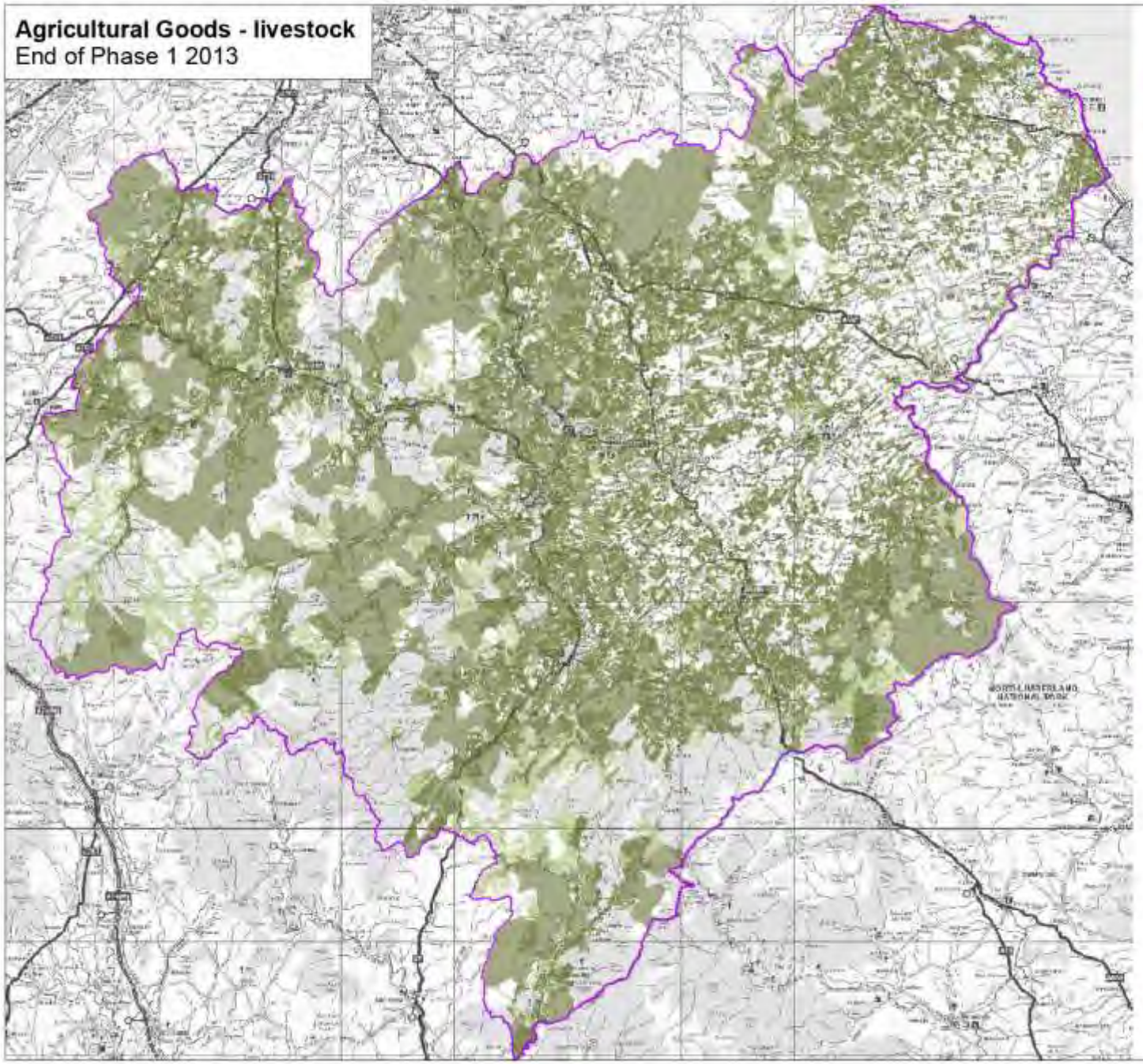
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Agricultural Goods - livestock
End of Phase 1 2013



Legend

SBC Area

Livestock value

High

Low

Food provision is an important provisioning ecosystem service. Livestock farming is an important enterprise in the Borders. This map includes areas of the Scottish Borders that have the greatest contribution to supporting livestock, the darker areas are likely to be managed intensively for livestock agriculture with short term silage leys, fodder crops or intensively grazed areas while the paler areas represent the extensive permanent grazing regimes on open moorland with low stocking rates.

The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Provisioning Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes
Agricultural goods: livestock	Presence of suitable grazing environments	Habitats	Improved grassland Semi-improved grassland Grassland / other habitat mosaics
	Land managed	Management	Grazed Permanent and temporary grassland Crops for stock feed

0 5 10 20

Kilometres

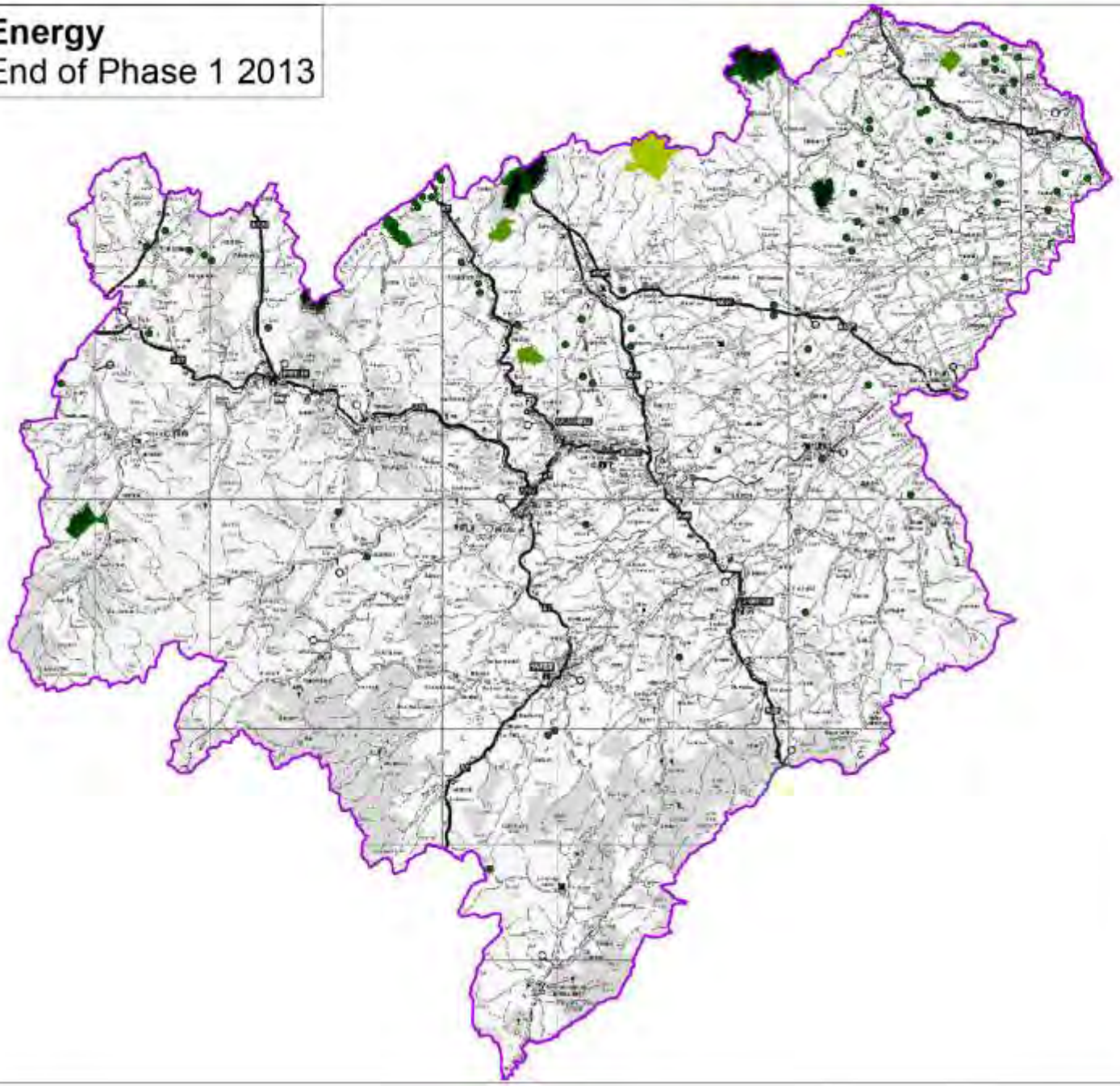
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Energy
End of Phase 1 2013



Legend

- SBC Area
- Windfarms below 5MW (as of Feb 2013)
- Windfarms above 5MW (as of Feb 2013)
- Turbines

Status

- Approved (Operational)
- Approved on Appeal (Operational)
- Approved on Appeal (Under Construction)
- Approved

This map shows where there is current wind energy provision in the Borders. Wind energy generation is an important industry in the Borders. The maps area based on current wind farm locations as of Summer 2013. These are shown in green colours.
The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields

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Kilometres

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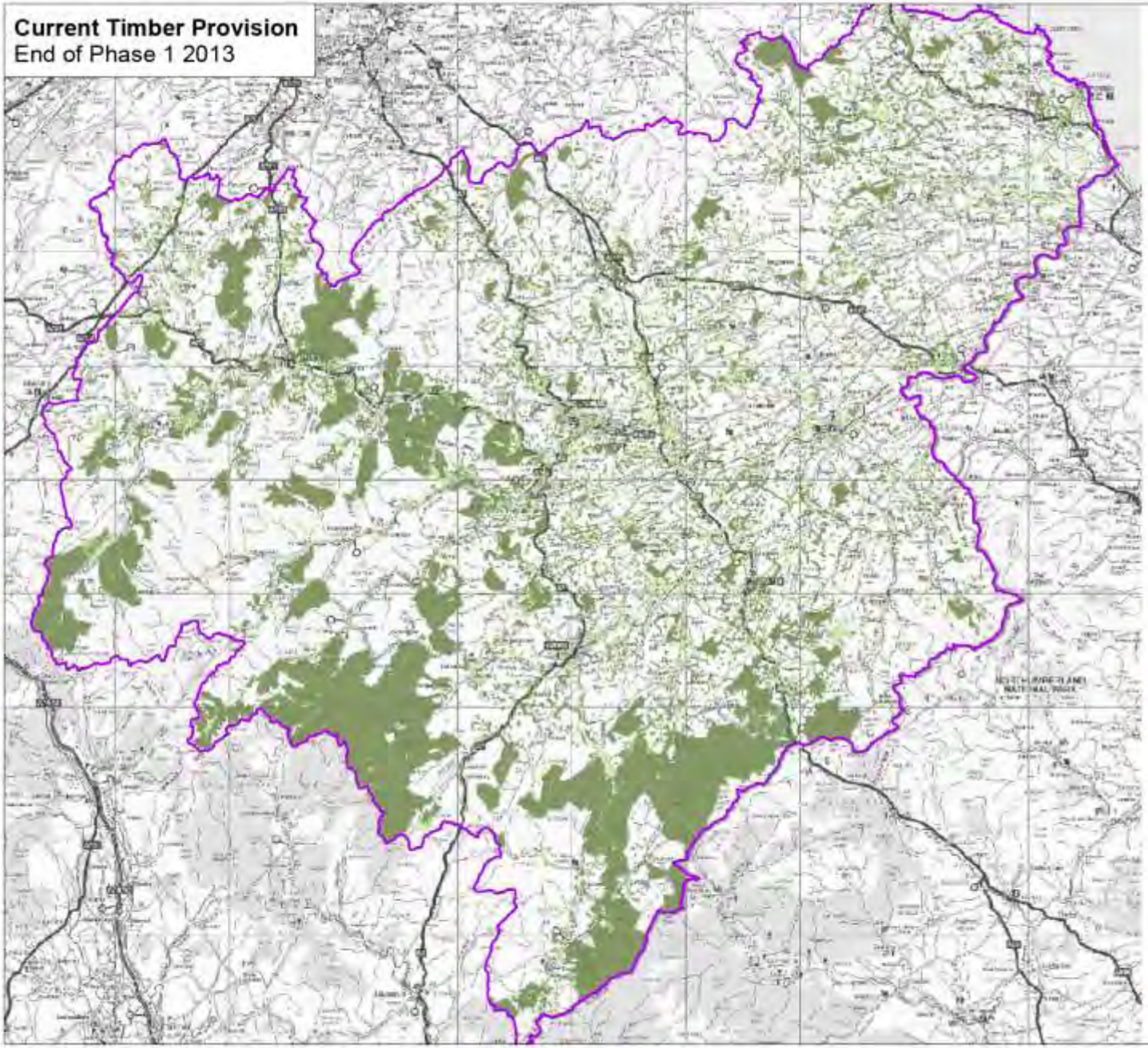
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

Current Timber Provision
End of Phase 1 2013



Legend

SBC Area

Timber resource

Semi-natural woodland

Plantation woodland

This map shows where there is currently the potential to provide timber as a resource. In this map we have shown the woodlands by their relationship to commercial timber production, separating coniferous plantations from other woodland.
The map has been created using existing woodland and habitat data; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Provisioning Services*				
Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Trees and Standing vegetation: Current Timber Resource	Coniferous plantation	Habitats	Conifer plantations	High
			Other woodlands	Low

0 5 10 20
Kilometres

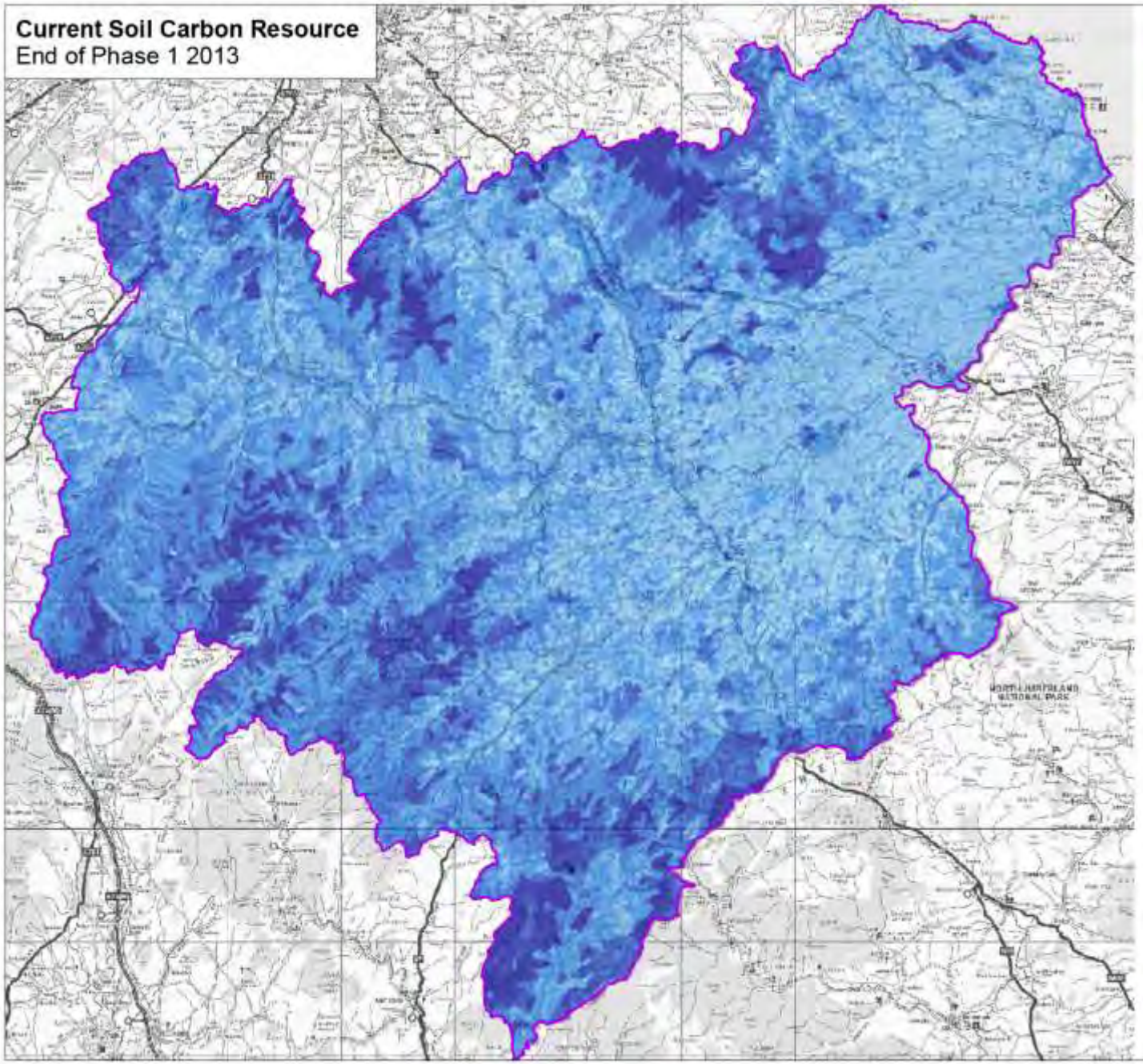
N

TWEED FORUM

Scottish Borders Council

Environment Systems

Current Soil Carbon Resource
End of Phase 1 2013



Legend

SBC Area

Soil Carbon Value

High

Low

Carbon storage in the soil is a major mitigating factor for climate change, the more carbon stored in the soil, the less greenhouse gases are released into the atmosphere. This map shows areas where land has the potential to store carbon in the soil. They are calculated using information about soil type, landform and vegetation together with the management information we have available. The darker colours shows areas with high level of organic soil carbon overlain by vegetation which is actively helping the soil to store carbon. The lightest areas are sandy soils with little organic carbon which are regularly disturbed by ploughing for arable use where carbon is released into the atmosphere.
The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: Regulating Services

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Relative ranking
Soil carbon storage: Organic carbon stored in soils	Presence of organic carbon in the soil	Soils (including SNH soil carbon classification)	Organic soils	high
			Mineral soils	low
	Topography suitable for soil carbon accruement	Slope	Jittle slope	high
			Steep slopes	low
	Vegetation cycle accrues / releases soil carbon	Land cover	Semi-natural wetlands	high
			Semi-natural woodlands	
			High intensity agriculture	low

0 5 10 20

Kilometres

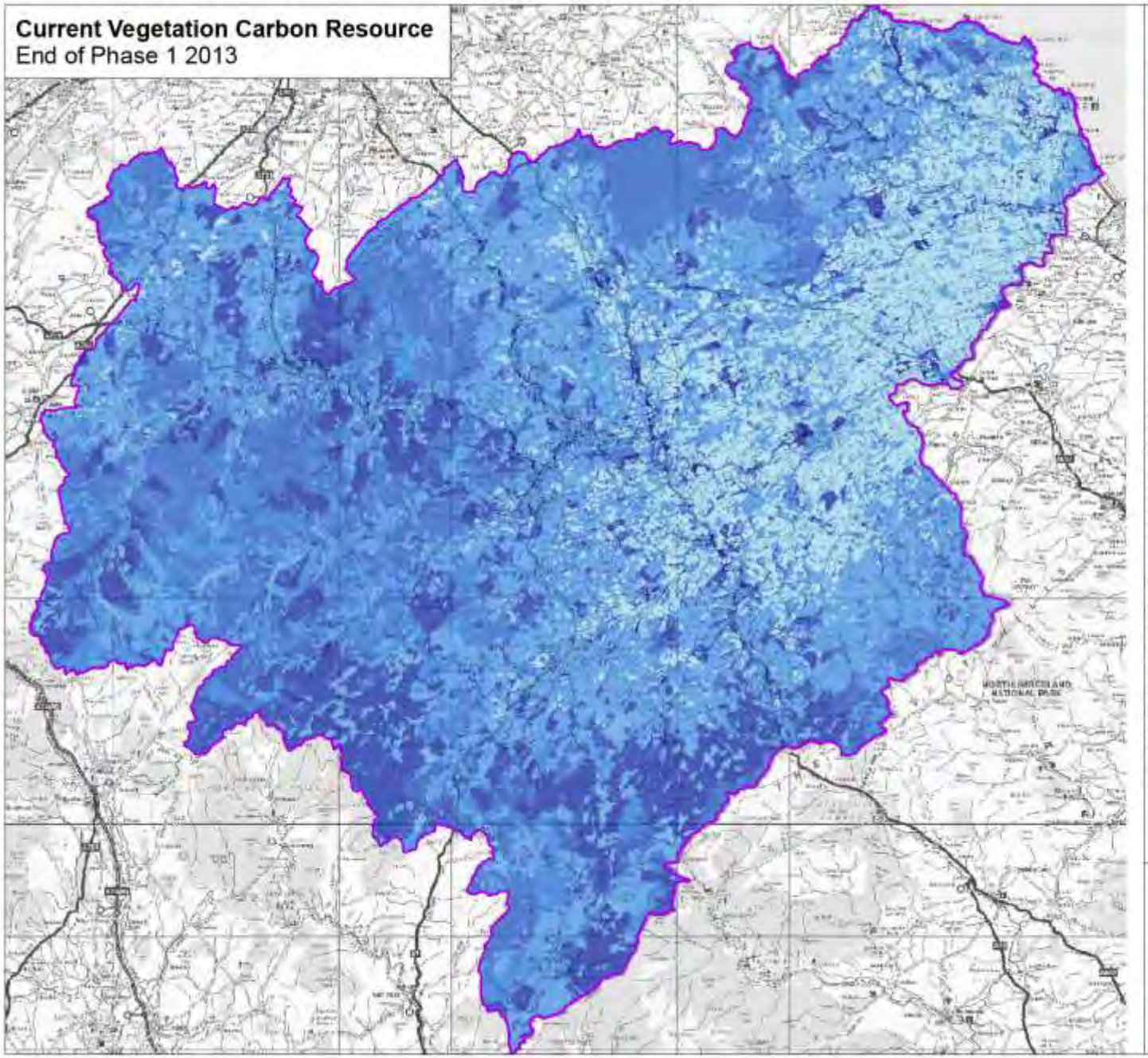
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Current Vegetation Carbon Resource
End of Phase 1 2013



Legend

- SBC Area
- Gala Water
- Tweed Lowlands

Vegetation Carbon Resource

High

Low

Carbon storage in the vegetation can help mitigating climate change by binding up the carbon and preventing its release to the atmosphere. This map shows where there is significant storage of carbon within the vegetation of the Borders. Atmospheric carbon is sequestrated by and stored in vegetation through the process of photosynthesis, resulting in vegetative growth. The more above ground biomass present in the vegetation the more carbon that is stored, with mature woodland at one end of the spectrum and grasslands at the other end. The darker areas of the map show where there is more carbon storage in the vegetation, which include areas of woodland. Conversely the lighter areas are arable cropping where vegetation carbon is removed from the land each year. The maps have been calculated using information on vegetation type, woodland type and management of land.

The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Regulating Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Vegetation carbon resource: how much carbon is stored in the vegetation	Biomass present	Habitats	Woody species	high
			Bare ground	low
	Biomass removal	Management	Ancient woodland	high
			High intensity agriculture	low

0 5 10 20

Kilometres

N

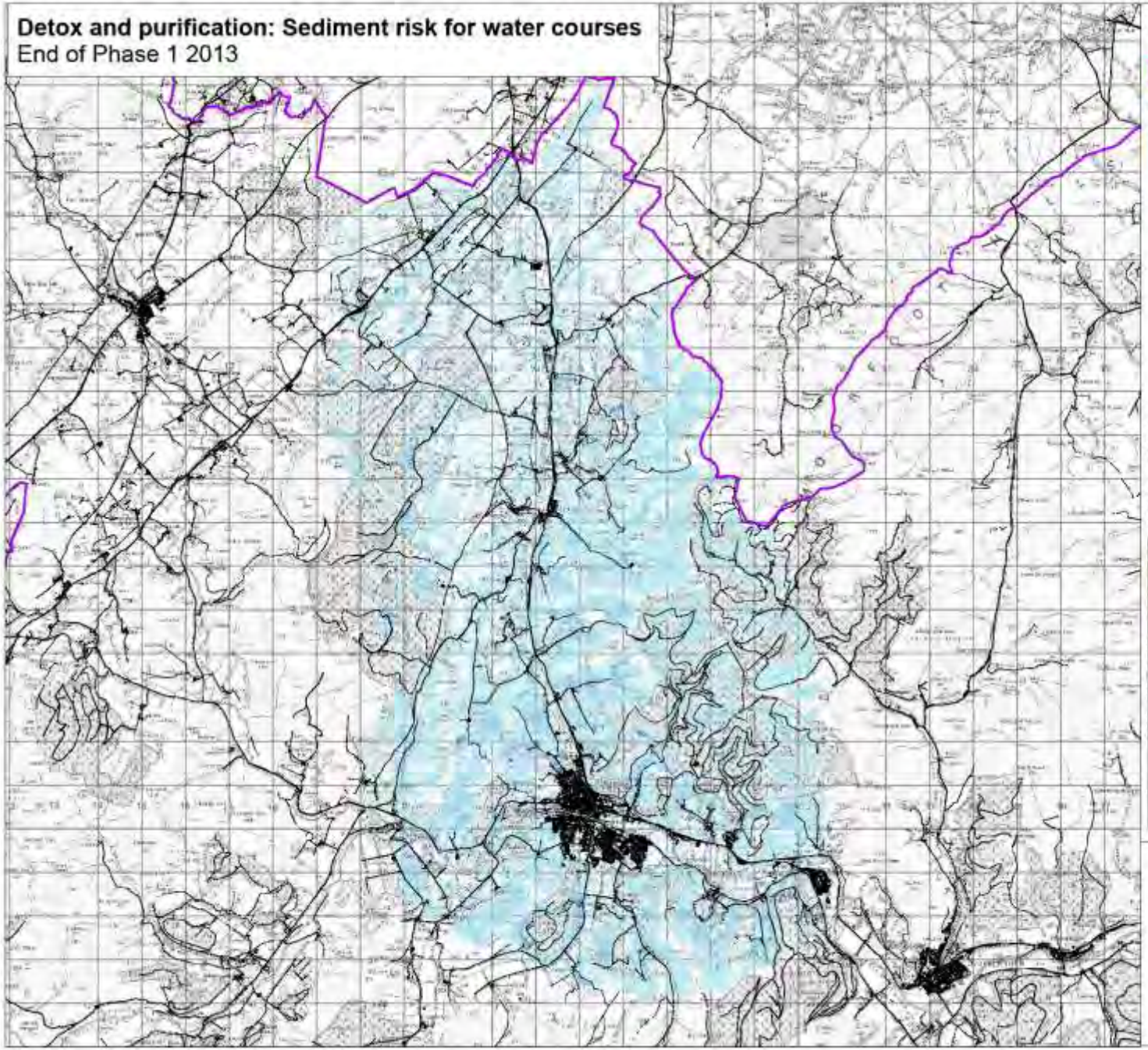
TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Detox and purification: Sediment risk for water courses

End of Phase 1 2013



Legend

SBC Area

Eddleston Scimap erosion risk

High : 1

Low : 0

Pure clean water is essential for human health and the proper functioning of the whole environment. Where excessive sediments reach the water it causes problems with pollution, changing channel structure and loss of spawning grounds for salmon. This map shows how each parcel of land in the Borders contributes to the purification and detoxification of water by preventing sediment entering the river systems. It is based on landform data with additional information on vegetation and soil association. It is run using a model called 'scimap'.
The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Regulating Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	
Detox and purification: Sediment risk for water courses	Slope and flow characteristics	Terrain Modelling (DTM)	Ground saturation and down slope water flow effects have been built in to the model to accurately calculate (overland) flow	High flow: higher risk Low flow: lower risk
	Vegetation preventing erosion	Land cover, Phase 1 habitat data	Scarcely vegetated areas, Arable land – regularly bare Dense vegetation (e.g. woodland, heaths, bogs)	High Very low
	Average rainfall	Met office SL	Higher rainfall	Higher risk

0 1.25 2.5 5

Kilometres

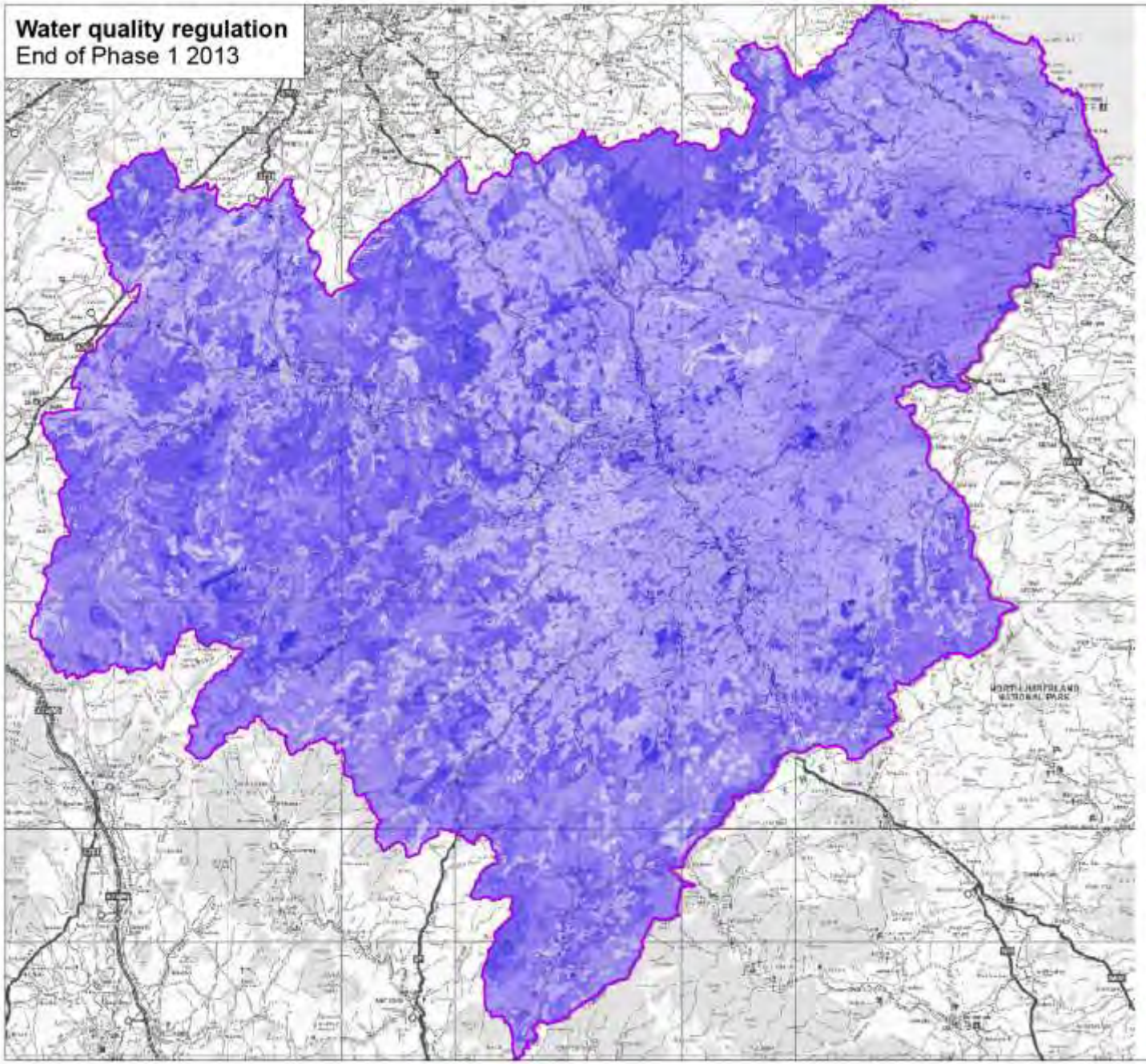
N

TWEED FORUM

Scottish Borders Council

Environment Systems

Water quality regulation
End of Phase 1 2013



Legend

SBC Area

Water quality regulation

High

Very low

Pure clean water is essential for human health and the proper functioning of the whole environment. This map shows those area of land within the Borders that contribute most to the filtration and supply of fresh water. It uses scientific knowledge and existing data sets about soil type, vegetation cover and landform as well as land management to show which areas of land have the greatest potential to help purify and filter the water. The darker the colours the more the land will be contributing to water filtration and therefore good water quality, lighter areas have less role and those areas in the contrasting colour have a negative role and decrease the water quality

The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields

NEA Classification: *Regulating Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Water quality regulation	Land cover effect on	Habitat Phase 1 habitat level	Woodland Hedge Heathland Bog Arable	Med/high med med Med/low low/neg
	Filtration effect of the soils	Soils National Soil Inventory Scotland 1:250,000	Brown earths Peaty soils	Med/high low
	Quality status of the water bodies	Water body quality Water Framework directive data	Good Fail	High Negative
	Slope is linked to flow rate	Elevation Slopes derived from DTM	Steep slopes	Negative

0 5 10 20

Kilometres

N

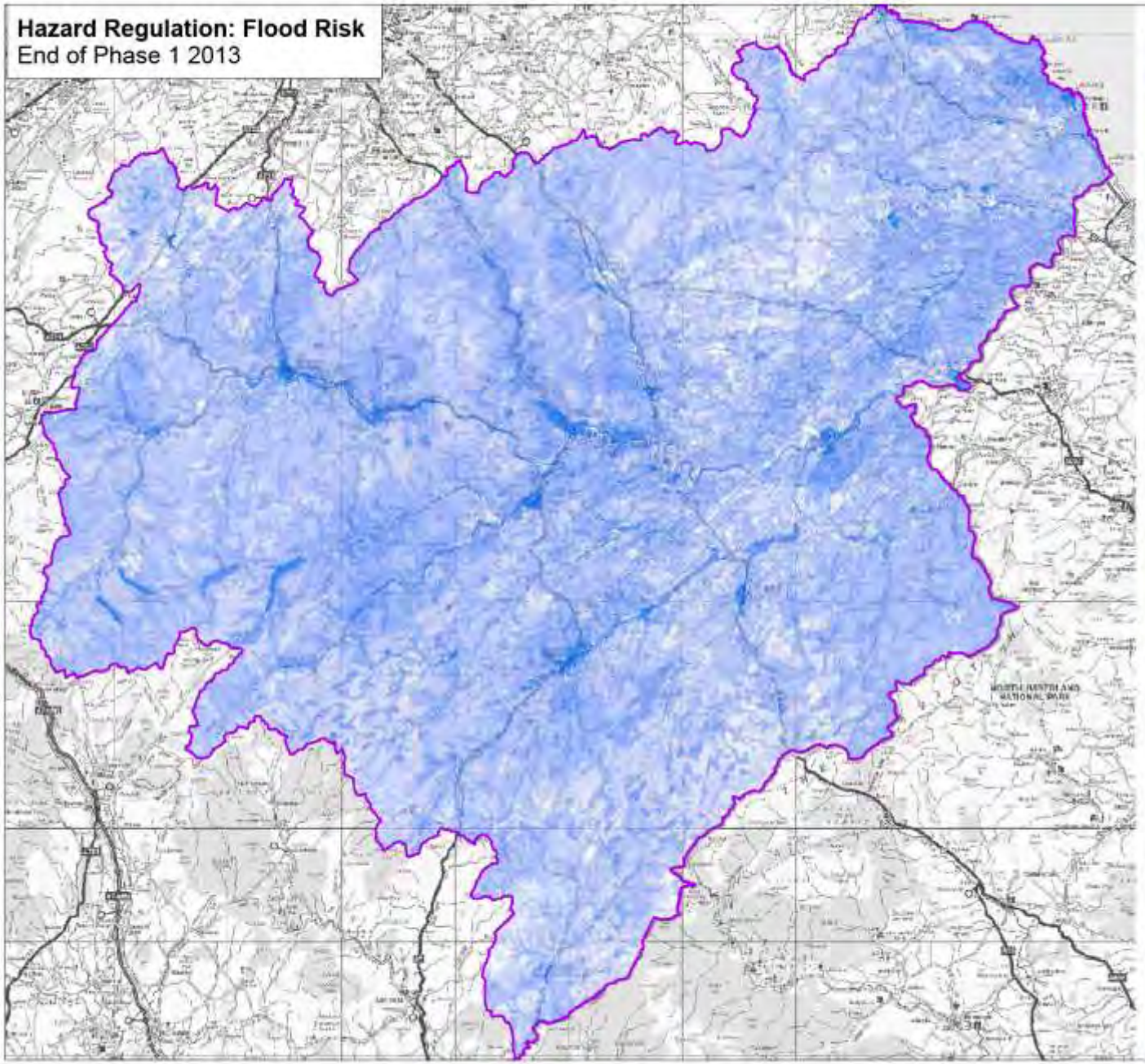
TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Hazard Regulation: Flood Risk

End of Phase 1 2013



Legend

SBC Area

Flood Risk

High

Low

Flooding is a major hazard in the Borders. This map shows where the environment is helping to slow the movement of rainfall through the land into rivers (also known as overland flow), and where is most at risk of flooding. This is an important ecosystem service especially during heavy rainfall events. A number of factors help slow this type of overland water flow, the first is the structure of the vegetation. Habitats such as woodlands have many layers of vegetation which help slow down the rain drops by friction, so that by the time they reach the ground they have, to some extent, been dispersed and are subsequently travelling slowly enough to sink into the soil. The other factors are soil type, landform and land management, data about each of these factors has been built into this model. The darker the colours the higher the risk of flooding and adding to flooding issues, in lighter coloured areas there are more barriers to fast overland flow.
This map was produced using a combination of water quantity, land erosion risk and SEPA flood risk layers. This infers the areas most at risk of flooding from already well-established datasets and indicative water quantity models. When considering opportunities in the subsequent mapping exercises can show the areas with greatest potential for flood mitigation work.
The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Regulating services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative mapping
Hazard / Soil quality: Flood Risk	Areas which are effective at regulating water flow	Water quantity layer	Low water quantity regulation	high
			High water quantity regulation	low
	Areas already identified as at risk of flooding	SEPA flood risk layers Fluvial flood risk Potentially Vulnerable Areas	High risk of flooding	High
			No risk of flooding	low

0 5 10 20

Kilometres

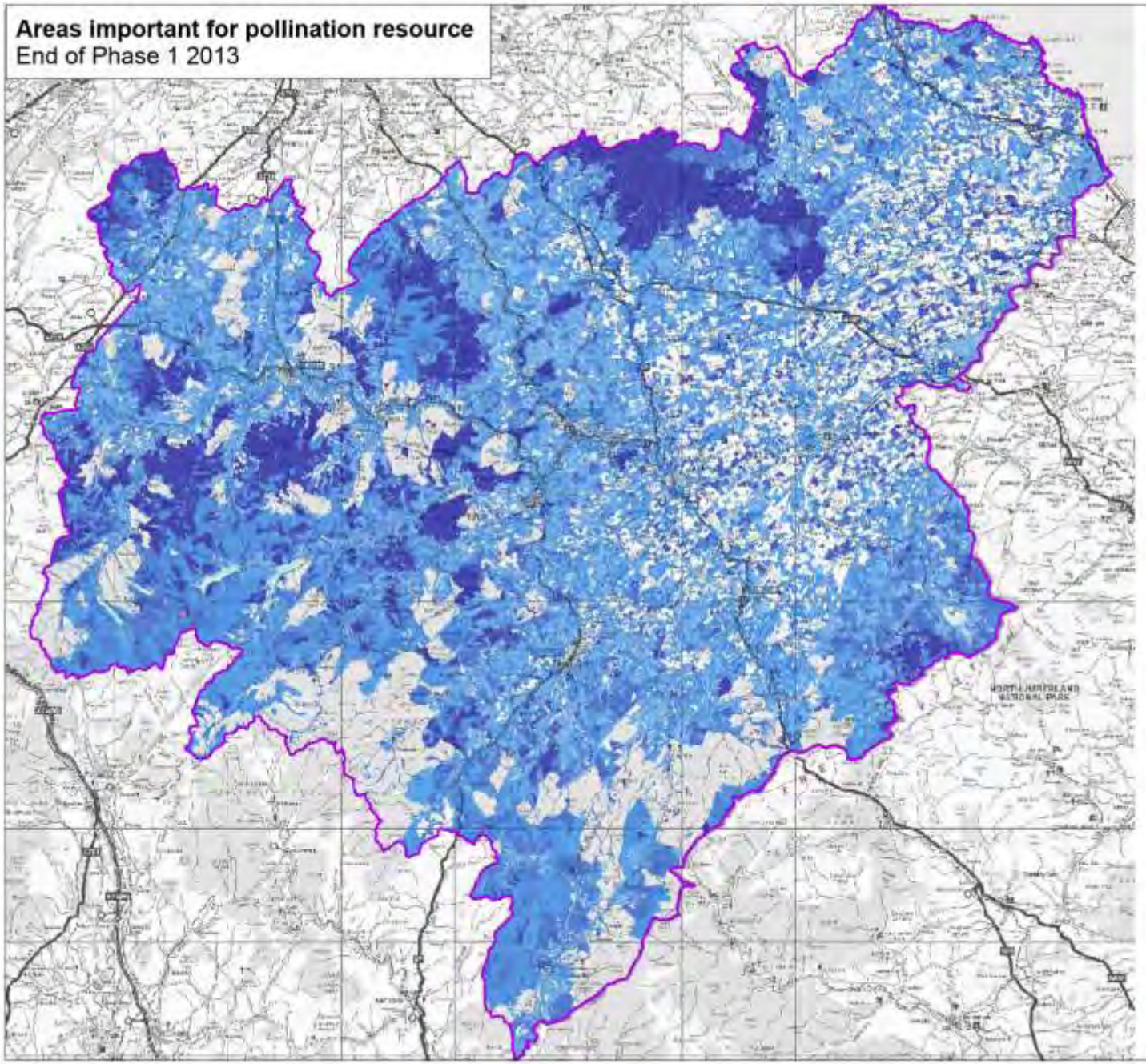
N

TWEED FORUM

Scottish Borders Council

Environment Systems

Areas important for pollination resource
End of Phase 1 2013



Legend

SBC Area

Pollination resource

High

Very low

Insect pollination of our food and flower crops is an extremely important ecosystem service for without it many of our crops would not effectively form. This pollination map uses information about habitat and landform to model where the most flowering plants may be present, providing a pollen resource for insects to flourish. These insects are then able to pollinate crops in fields, gardens and allotments as well as in semi-natural habitats.

The darker areas on the maps show where the habitats most likely to support pollinators, the lighter areas show areas where there are few flowering plants and little support for insect pollinators.

The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Supporting/Regulating Services* *(underpins all services)*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	indicative scarcity
Pollination resource	species which attract pollinators	Species: Borders notable species	bee species Bumblebee Diptera associated with	high medium negative
	species which produce pollen	Species: Borders notable species	Flowering plants	high
	habitats providing pollen resource	Habitat: Phase 1 habitat layer Additional data: HCR Permanent Land Data (2012)	Habitats often containing high proportion of pollen-rich species (e.g. heath, scrub, grassland) Habitats often containing pollen-rich species (e.g. hedgerow, grassland) Habitats essential for pollen-rich species (e.g. woodland, improved grassland) Insect pollinated flowering crops (e.g. Oil seed rape, legumes, peas/bean) Non-insect pollinated crops (e.g. Grass, Oats, Wheat)	medium/high medium medium very low

0 5 10 20

Kilometres

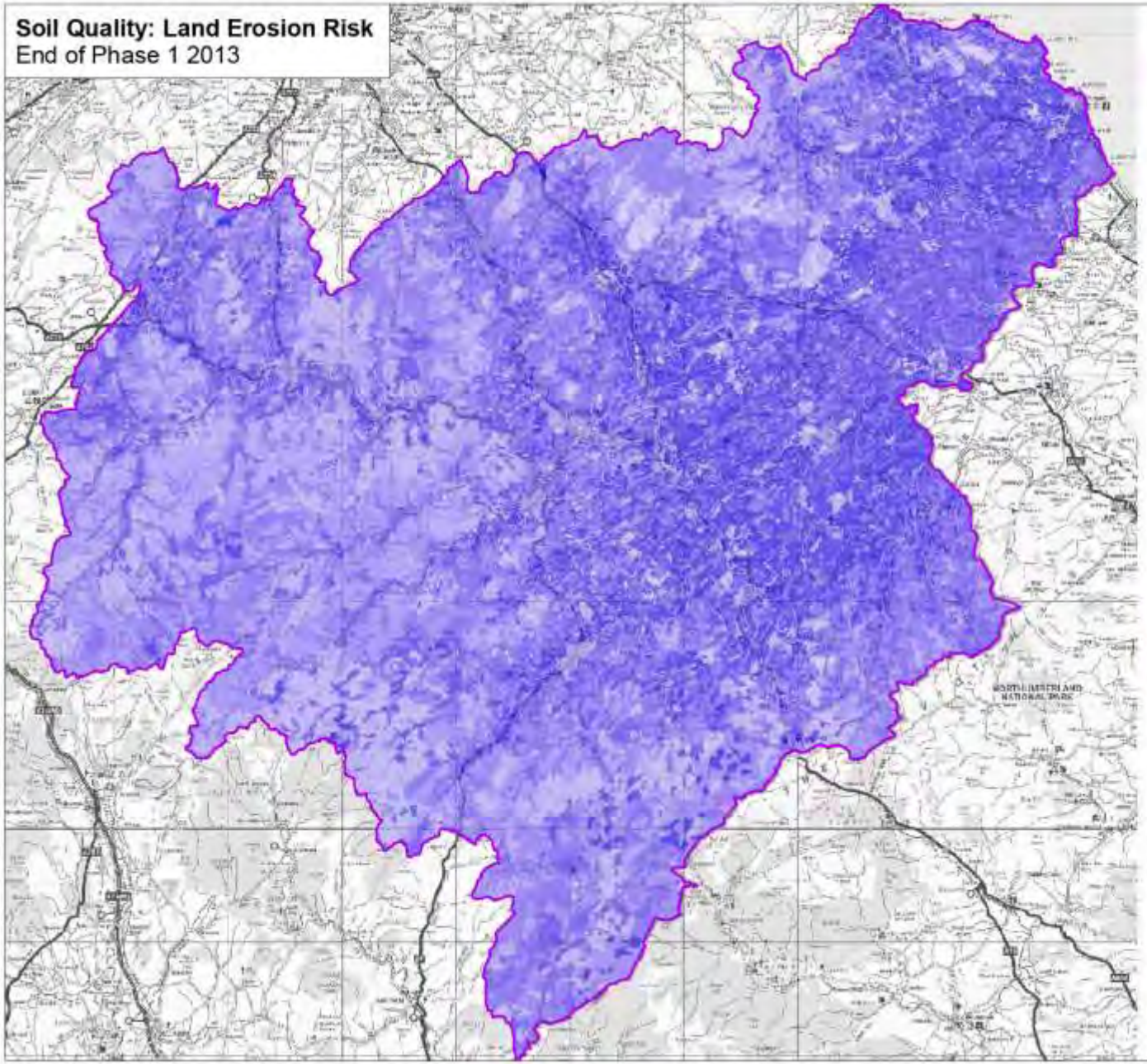
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Soil Quality: Land Erosion Risk
End of Phase 1 2013



Legend

SBC Area

Land Erosion Risk

High

Low

Land erosion risk is a significant factor leading to loss of soil and infrastructure. Land erosion risk is based on the interaction of soil, geology, landform (in particular slope), and vegetation cover. Existing data about these features was modelled together to provide this map. The darker colours have the highest potential for erosion risk, the lighter colours little erosion risk.
The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification *Regulating services*

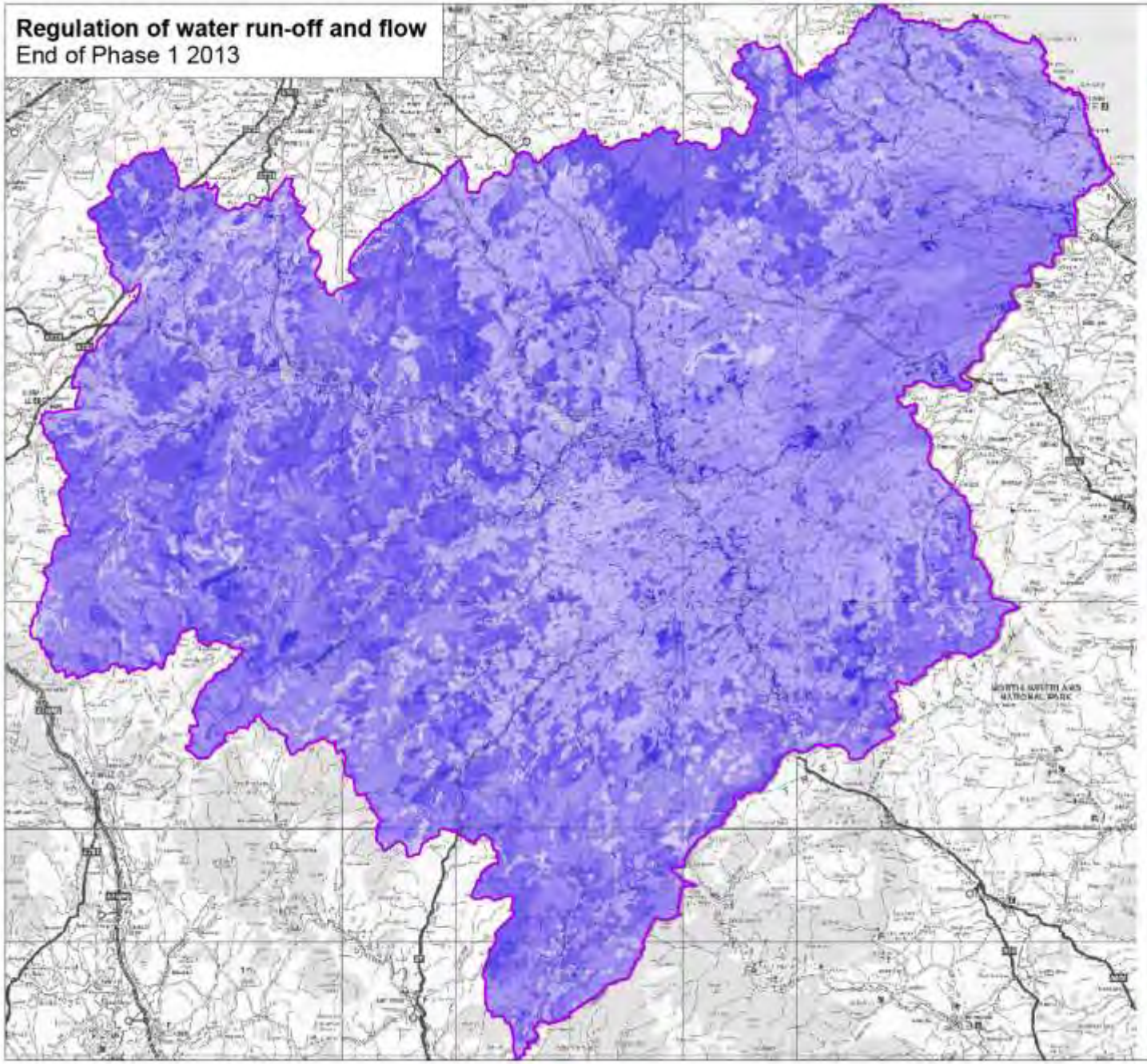
Ecosystem Service Typology	Significant effects	Data used	Example attributes	Erosion risk
Hazard / Soil quality: Land erosion risk	Soil and slope characteristics	Inherent risk of erosion by overland flow	Soil properties and slope prone to erosion	high
			Soil properties and slope less prone to erosion	low
	Vegetation preventing erosion	Habitats	Sparsely vegetated areas	high
			Arable land – regularly bare	

0 5 10 20
Kilometres

N

TWEED FORUM · Scottish Borders Council · Environment Systems

Regulation of water run-off and flow
End of Phase 1 2013



Legend

SBC Area

Water Regulation Capacity

High

Low

The regulation of water through the landscape is an important ecosystem service in the Borders. This map shows where the environment is helping to slow the movement of rainfall through the land into rivers (also known as overland flow) This is an important ecosystem service especially during heavy rainfall events A number of factors help slow this type of overland water flow, the first is the structure of the vegetation. Habitats such as woodlands have many layers of vegetation which help slow down the rain drops by friction, so that by the time they reach the ground they have, to some extent, been dispersed and are subsequently travelling slowly enough to sink into the soil. The other factors are soil type, landform and land management, data about each of these factors has been built into this model. The darker the colours the more important the role that area has in slowing water movement, in lighter coloured areas there is little barriers to fast overland flow.
The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Regulating Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scores
Water quantity regulation	Vegetation effect on interception	Habitats	Dense vegetation	high
			Sparse vegetation	low
	Infiltration and drainage characteristics of the ground	Soil / geology	Soil and geology = free drainage	high
			Soil and geology = poor drainage	low
	Drainage	Topography	Gentle slopes	high
			Steep slopes	low

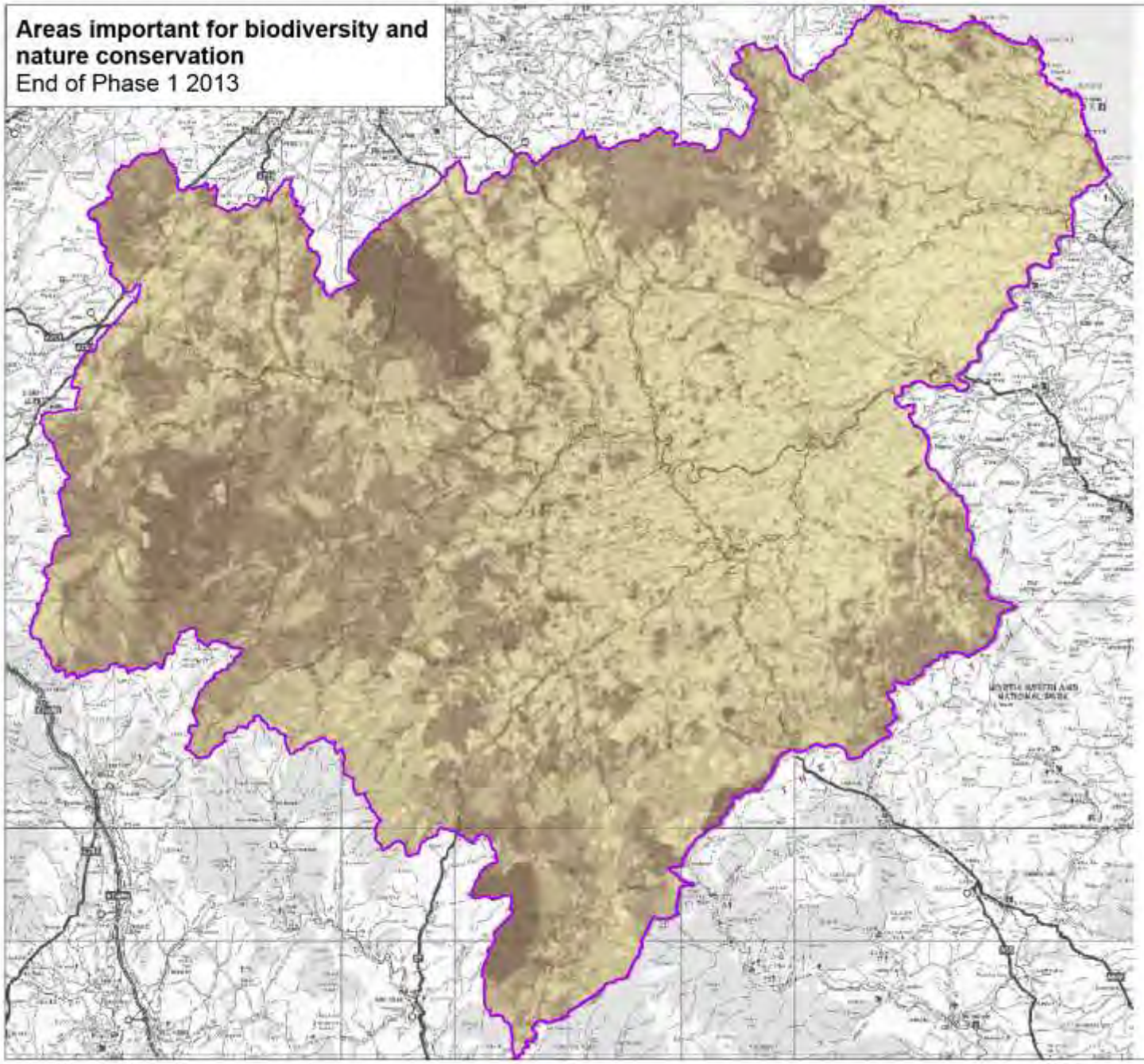
0 5 10 20
Kilometres

N

TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

Areas important for biodiversity and nature conservation

End of Phase 1 2013



Legend

SBC Area

Existing resource

Value

High

Low

Biodiversity is an important supporting ecosystem service that underpins all ecosystem services and provides benefits to most aspects of human wellbeing. There are two aspects to biodiversity mapped in the Borders, one is the amount of biodiversity present and the other is the resilience of the natural systems to withstand change. This map looks at the quantity of biodiversity in the Borders. Biodiversity is the range and diversity of species existing and generally includes genetic diversity as well as the different taxa in any area. Certain habitats have more biodiversity than others based on the number of different 'niches' available. Therefore heterogeneous landscapes have higher biodiversity values than homogenous systems. Biodiversity is found both below ground in the soil and above ground in the habitats and animals which use them. This map uses the standard criteria defined in the nature conservation review to evaluate biodiversity potential in the Borders, using a range of data set to model habitat naturalness, the diversity above and below ground and the connectivity of the habitats. The darkest areas on the map have the highest biodiversity and the lighter colour the lowest.

The map has been created using existing datasets; they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: *Supporting/Regulating Services* *(underpins all services)*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	relative value
Biodiversity and nature conservation resource	Naturalness	Habitats	Semi-natural habitats	high
			Intensively managed land	low
		Management	Protected sites	high
			High intensity agriculture	low
	Diversity	Species	Internationally important	high
			Nationally important Locally important	low
	Location within the landscape	Connectivity	Well connected habitats	high
			Poorly connected habitats	low

0 5 10 20

Kilometres

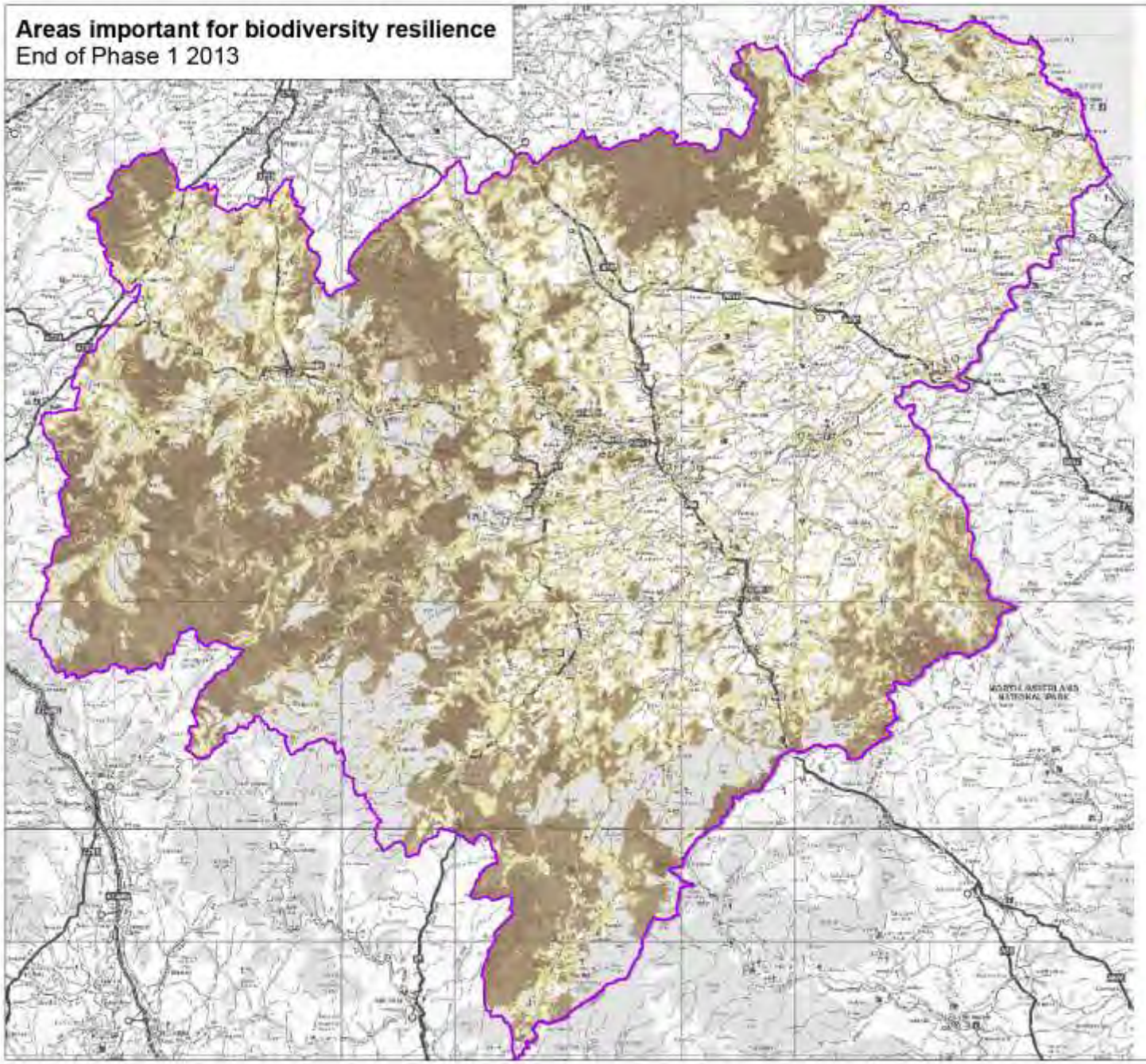
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Areas important for biodiversity resilience
End of Phase 1 2013



Legend

SBC Area

Existing resource

High

Very Low

Biodiversity is an important supporting ecosystem service that underpins all ecosystem services and provides benefits to most aspects of human wellbeing. There are two aspects to biodiversity mapped in the Borders, one is the amount of biodiversity present and the other is the resilience of the natural systems to withstand change. This map looks at the resilience of the habitat in the Borders to recover from adverse events. We have used data about habitat, species, soil, geology and landform in the Borders to calculate how the size of the habitat, the vulnerability of habitats easily changed by management) and Below Ground species resilience can be mapped together to show those areas of the Borders most resilient to change in Biodiversity in dark colours and those which are fragile and easily changed in lighter colours.
The map has been created using existing datasets, they should be interpreted as the best available information at the current time and are strategic scale rather than details of individual fields.

NEA Classification: Regulating Services

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Wild species diversity: Biodiversity resilience and networks	Resilience - patch size	Habitat Phase 1 habitat layer	Size of habitat patches Woodlands >2ha Heathlands >0.5ha Grasslands >0.2ha Woodlands <2ha Heathlands <0.5ha Grasslands <0.2ha	high low
	Resilience - vulnerability	Habitat Phase 1 habitat layer	Least vulnerable habitat (e.g. woodland) More vulnerable habitat (e.g. grassland)	high low
	Location within the landscape – surrounding vegetation types	Networks Forest Research integrated habitat network	Semi-natural habitat within the network Semi-natural habitat outside the network Other vegetation within the network	high medium low
	Management will prevent or limit to pressure on the site	Management Protected sites	Internationally protected site Nationally protected site Locally protected site	high medium

0 5 10 20

Kilometres

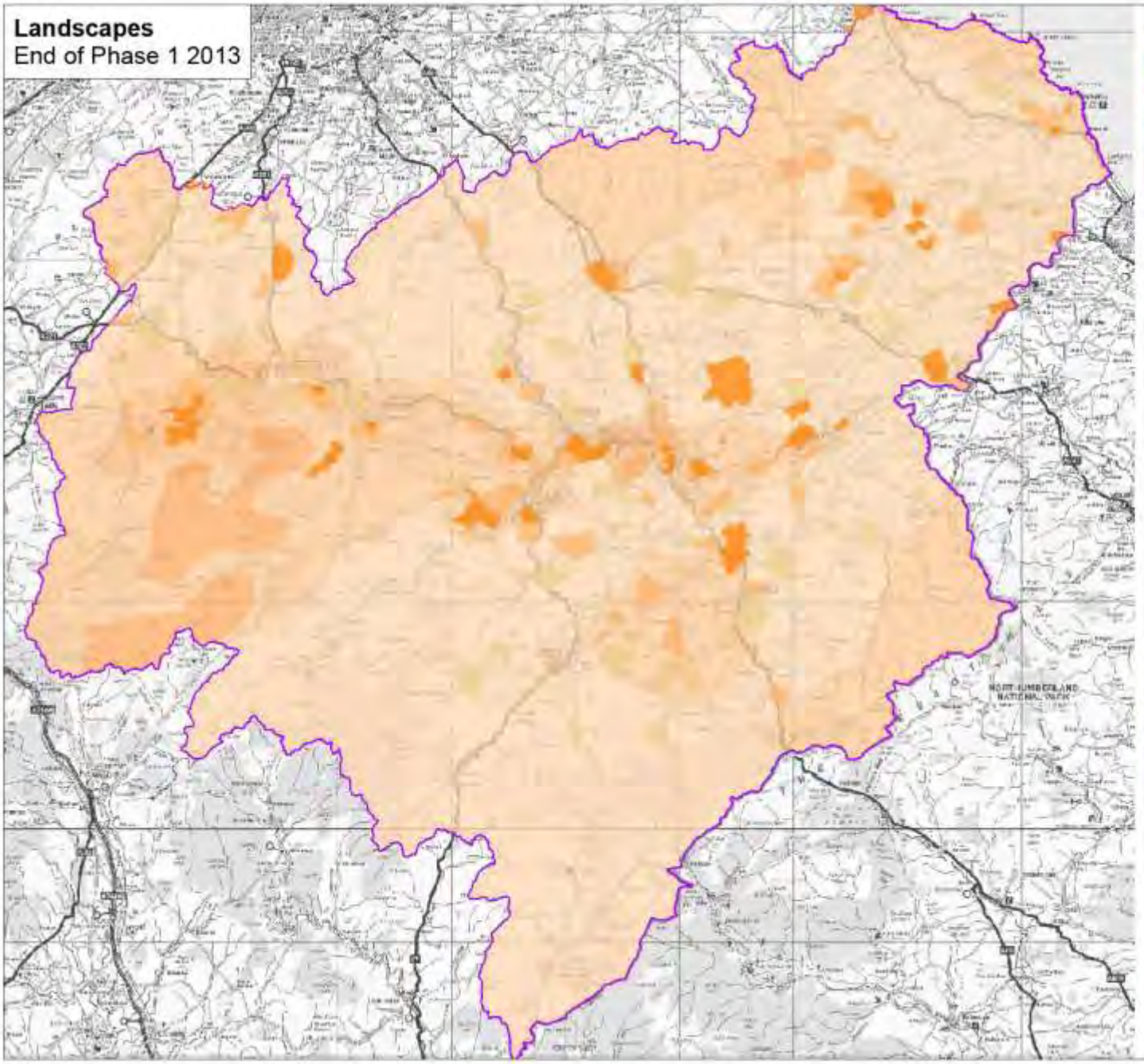
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Landscapes
End of Phase 1 2013



Legend

SBC Area

Landscape designations

High

Low

The Landscape of the Borders is important, not just as scenery but because it links our culture and nature and links the past with the present and as such as a significant ecosystem service. The Borders has a highly valued landscape. These are essential to social well-being and an economically healthy society contributing the strong local identity and distinctiveness. This map shows the areas within the Borders that have landscape designation both in nations (darker colours) and local (lighter colours) they show the areas of the Borders that are recognised to both visitors and locals and give an overall picture of those areas of special significance. This map does not show the landscape valued by local communities.
This map highlights the areas with the highest number of important features relating to sense of place as dark colours, and those with fewest as lighter colours.

NEA Classification: Cultural services				
Ecosystem Service Typology	Significant effects	Data used	Example attributes	relative scoring
Landscape	Recognition of the landscape at different levels	Areas which add to the landscape of the Borders	Nationally identified features Regionally identified features Locally identified features	high low

0 5 10 20

Kilometres

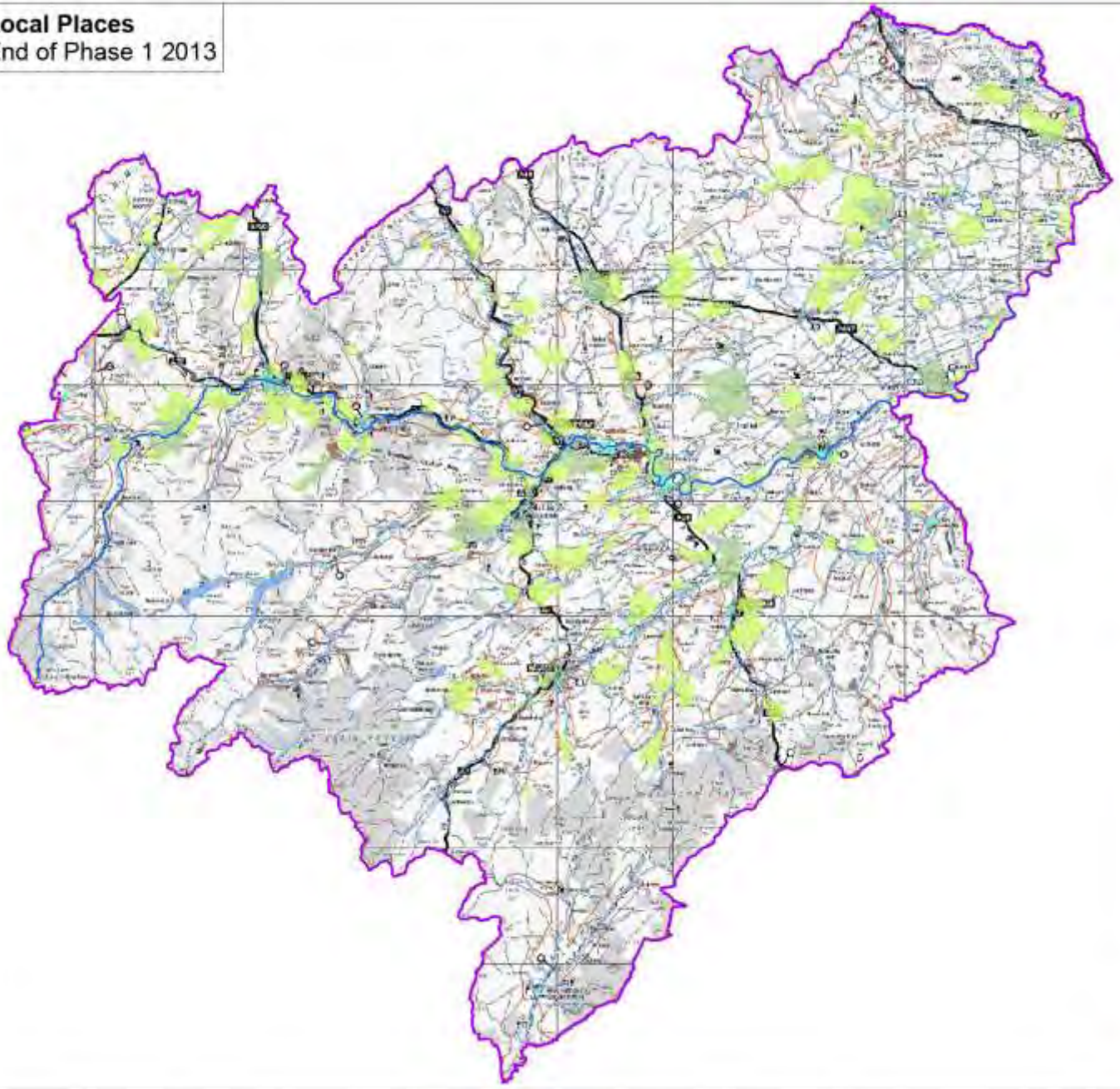
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Local Places
End of Phase 1 2013



Legend

- SBC Area
- River Tweed
- Rivers and Lochs

Listed Building Category

- A
- B
- C

none

- < 15000 visits
- 15000-50000 visits
- > 50000 visits
- Historic Gardens and Designed Landscapes (National dataset)
- SBC Designed Landscapes
- Notable Trees
- Tree Preservation Orders
- LDP Greenspace
- Scheduled Ancient Monuments
- Conservation_Areas

Landscape character area types

- Coastal Types
- Lowland Types
- River Valley Types
- Upland Fringe Types
- Upland Types

This map shows where there is evidence, that areas within the Borders have a cultural significance and add to a sense of place
Sense of place is an important cultural ecosystem service which identifies the Borders and many of its recognised landscapes. Sense of place contributes to the culture and identities of the local communities. The special qualities of the is described by many factors. This includes the underlying geology and landform which can form prominent local features, waterways also markedly add to the sense of place as do areas where the natural or cultural heritage is particularly significant. This map highlights the areas with the highest number of important features relating to sense of place as dark colours, and those with fewest as lighter colours.

NEA Classification: Cultural Services

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Significance
Local places	Natural features	Parks LDP Greenspace The Tweed River Rivers and Lochs Important trees (Tree Preservation Orders and Veteran Trees)	Presence of the features	Present
	Activities	Visitor attractions Common riding routes	Presence of the activities	Present
	Landscape Character	Landscape Character Areas with important local place attributes	Boundaries used: No conflict	Present
	Features adding to the historic character	Scheduled Monuments Listed buildings Gardens and designed landscape	Presence of the features	Present

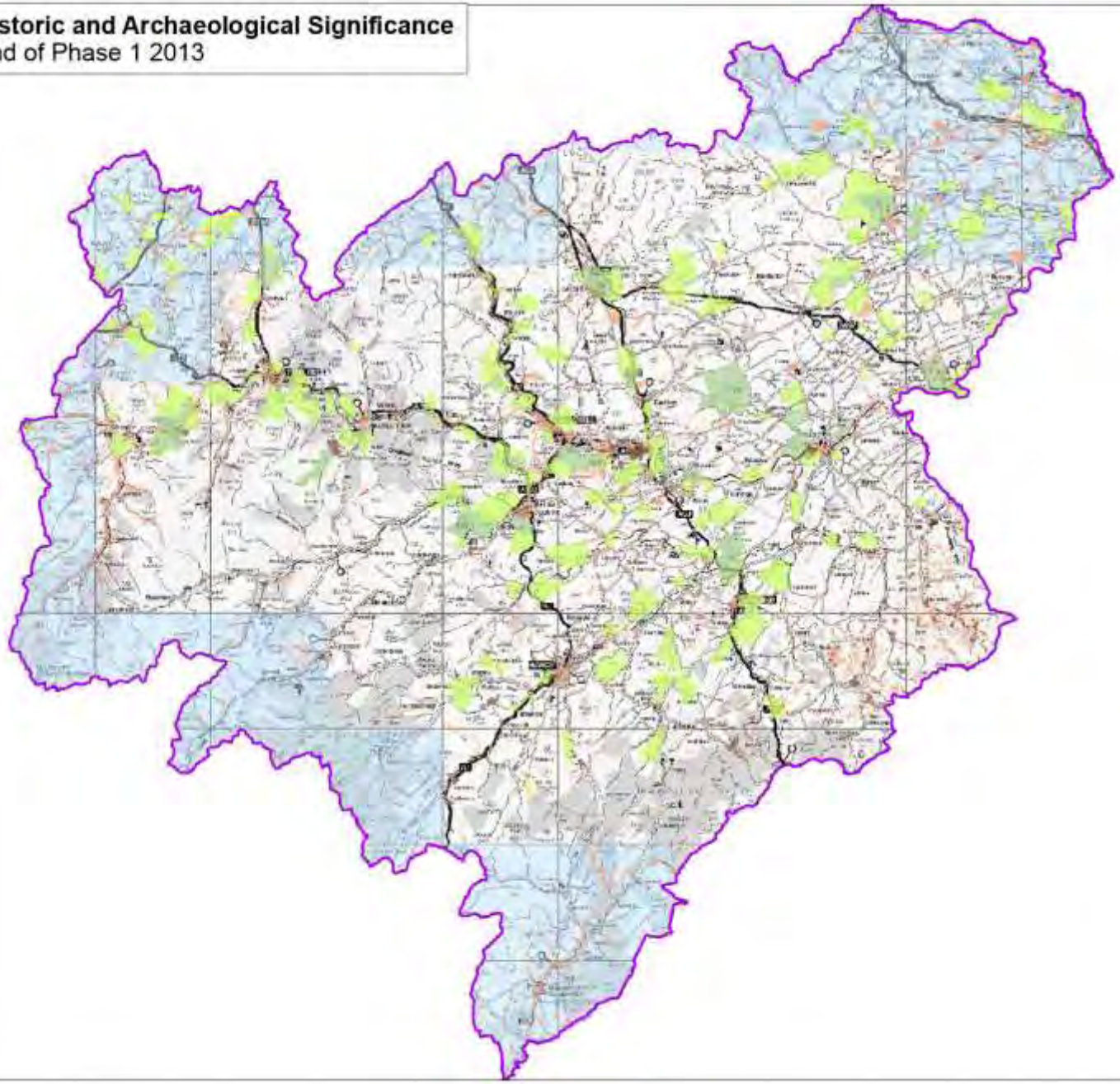
N

TWEED FORUM

Scottish Borders COUNCIL

Environment SYSTEMS

Historic and Archaeological Significance
End of Phase 1 2013



Legend

- SBC Area
- Scheduled Ancient Monuments
- Historic Gardens and Designed Landscapes (National dataset)
- SBC Designed Landscapes
- Historic Environment Record

Historic Landuse Assessment

- Historic Landuse Assessment

The areas of archaeological and historical significance offer an important ecosystem service. The sites represent an irreplaceable part of the Scottish Borders heritage they also provide a local sense of identity and great value for educational, recreational and tourism purposes. This map shows the major historic and archeologically sites in the borders. Those in darker colours have national significance and those in lighter colours local significance.

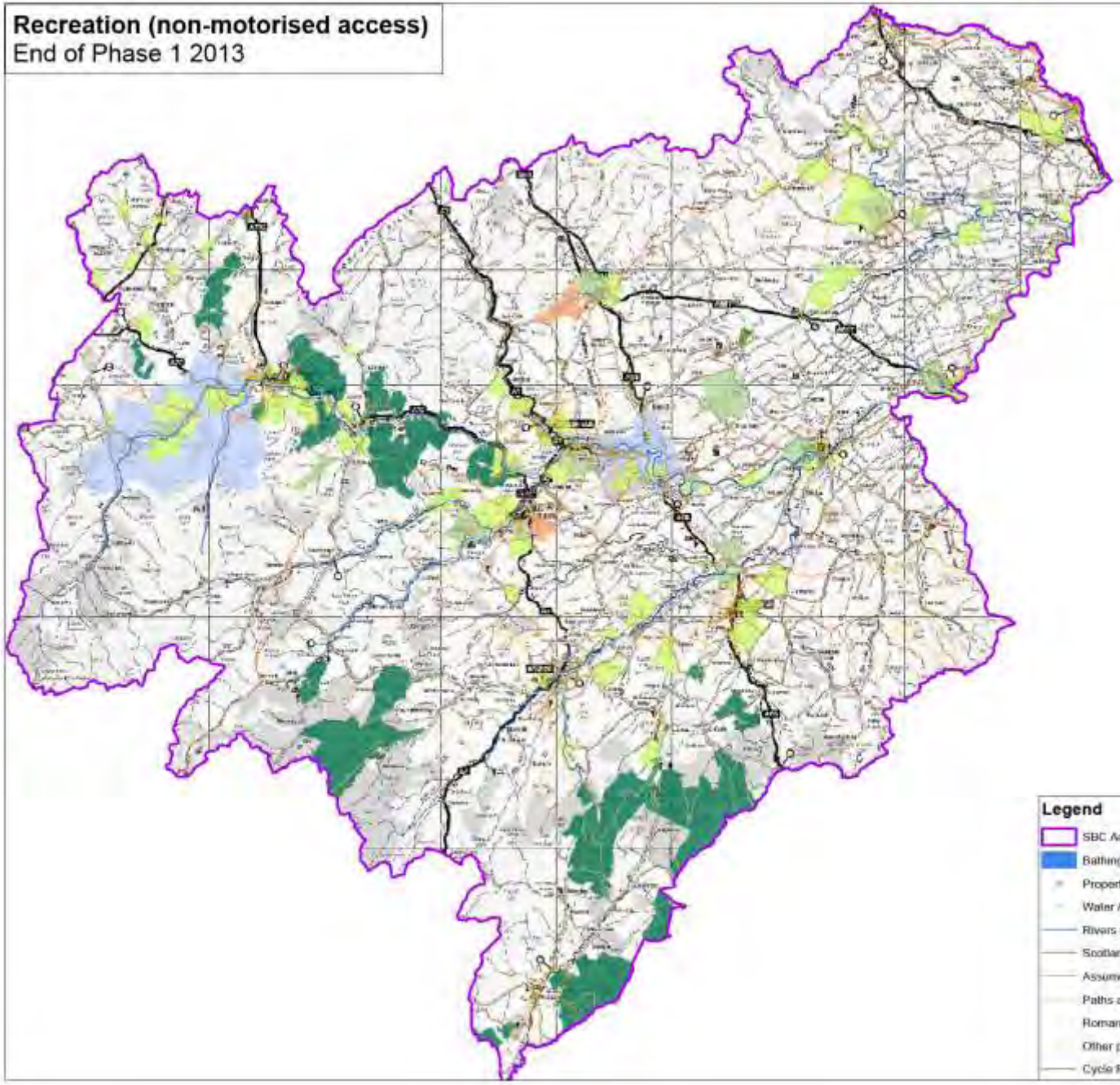
NEA Classification: Cultural services				
Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicator scoring
Historic and archaeological significance	Important historical and archaeological sites	Historic Scotland Scheduled Ancient Monuments SBC Historic Environment Records RCAHMS Historic Land Use Assessment	Presence of sites	High

0 5 10 20
Kilometres

N

TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

Recreation (non-motorised access)
End of Phase 1 2013



Recreation is an extremely important ecosystem service providing physical wellbeing and health benefits. This map shows where the environment is being used or could be used for recreational activity. Recreation can be defined as the use of natural and cultivated landscapes for pleasure. Different habitats provide opportunities and benefits for recreation often described and incorporated within environmental settings e.g. gardens, parks, woodlands and the wider countryside. Woodlands for example provide opportunities for cycling, walking, photography, horse riding and informal recreation. These 'settings' are places of interaction between people and nature and are fluid with no fixed boundaries. Recreation is often linked to environmental settings which are considered to contain lots to do such as local parks, woodlands or the coast. Factors which determine the level of use of these settings by people are access and how accessible different settings are to people.

This map shows where there are habitats, cultural sites, parks and gardens, together with trails and routes through habitats preferentially used for recreation. The map has been modelled to show the way the landform interacts with these features to provide an environmental setting around each of the recreational activities. Areas with many features are darker and the very light colours are those with no access points that are not visible from areas with good access points.

NEA Classification: Cultural Services

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicator supply
Recreation: non-motorised activity	Areas which contribute to recreational value Places associated with recreation	LDP Greenspace National Scenic Areas Historic Gardens and Designed Landscapes Properties in care	Presence of the resource Presence of the resource	Present Present
	Areas used for outdoor activities	Bathing waters Canoeing - river access points Common Good land Cycle Routes Horse riding routes Foot paths including Scotland's Great Trails Promoted Paths Paths around other key settlements NNR Scotland SWT reserves	Presence of the resource	Present

0 5 10 20
Kilometres

N

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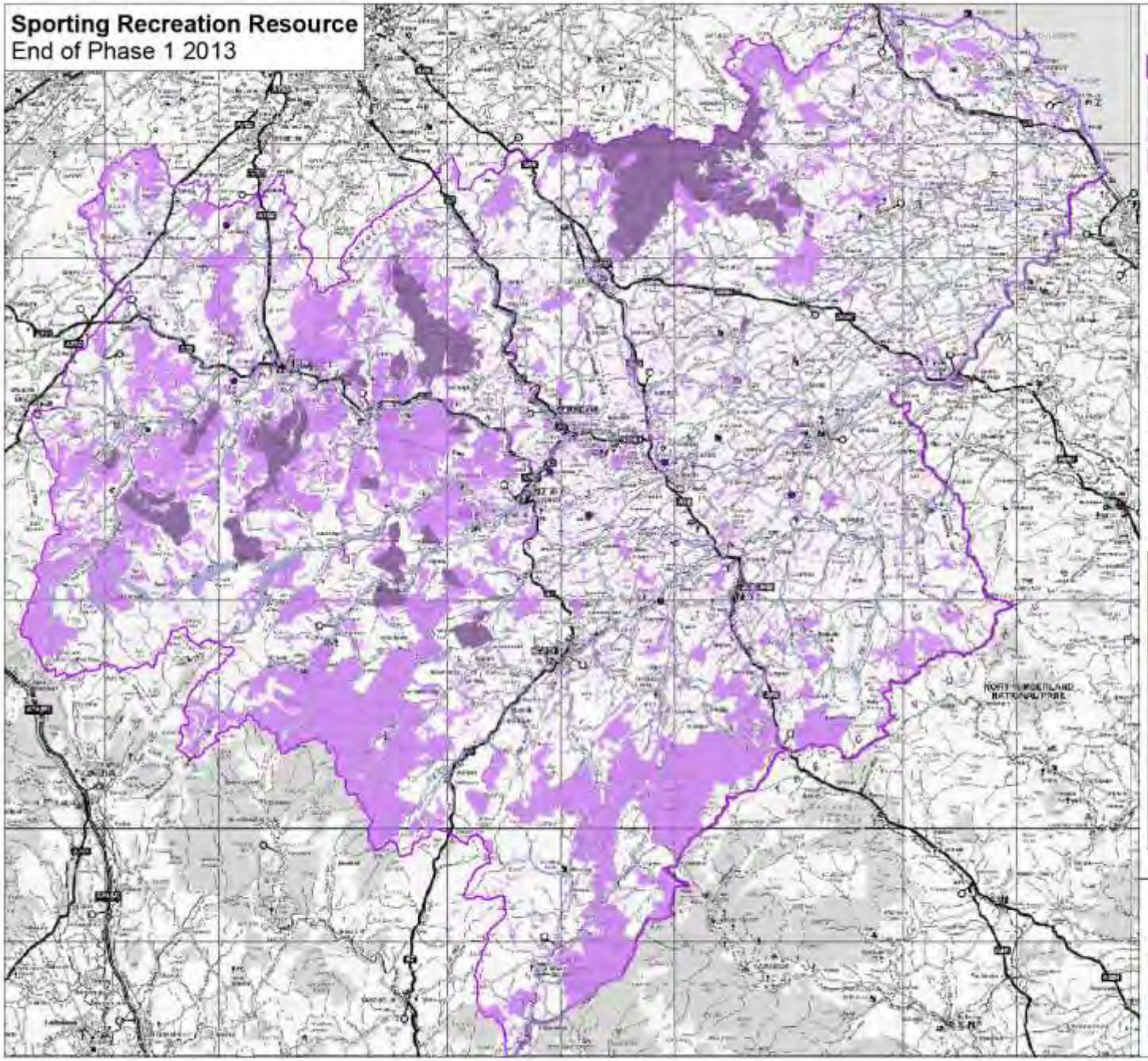
Legend

- SBC Area
- Bathing waters
- Properties in care
- Water Access Points
- Rivers used for canoeing
- Scotland's Great Trails
- Assumed/aspirational paths around Towns
- Paths around Towns
- Romans and revers route
- Other paths
- Cycle Routes
- Community woodland
- Forestry estates
- Historic Gardens and Designed Landscapes
- SBC Designed Landscapes Intersecting Paths
- National Nature Reserves Scotland
- Scottish Wildlife Trust Reserves
- Common good land
- LDP Greenspace
- National Scenic Areas

Sporting Recreation Resource
End of Phase 1 2013



Legend

- SBC Area
- Rivers and Lochs
- Woodlands and other heath
- Grouse Moors
- Known clay pigeon shooting

Sporting Recreation is an important industry in Scottish Borders providing not just the opportunity for outdoor recreation and the associated health benefits, but also employment and income through tourism. This map is modelled from data about the management, land form and habitats, in particular woodlands and heathland across the Borders. Management for grouse shooting has been modelled from satellite imagery where the intricate patterns of managed heather can be seen. Areas likely to be used for commercial shooting are darker colours and areas used for local ad hoc shooting are lighter colours.
The map is modelled and indicative only, more data about this important recreation type is being collated, and the map could be updated when this exercise is completed.

NEA Classification: *Cultural Services*

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Beneficiaries
Recreation: sporting	Many woodlands in the Borders are used in some way for shooting	Habitat Phase 1 habitat layer	Semi-natural woodland	low/ mod
	Distinctive management of heathland indicative of grouse moors	Derived grouse moors	Grouse moor presence	high
	Management of fish stocks	Fishing data	Rivers and lochs stocked for fishing	high

0 5 10 20
Kilometres

N

TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

Pilot Regional Land Use Framework: Baseline mapping, constraints & opportunity mapping and final framework
Stage 2 Report: Opportunity mapping

1 Introduction

This report covers stage 2 of the mapping element of the Scottish Regional Land Use Pilot. The part 1 report introduced the project and considered the approach and methods taken to create stock maps. This report covers the second stage of the project, which involved the production of Ecosystem Service Opportunity Maps.

The rationale for the production of the opportunity maps is spatially explicit, just as the creation of the stock maps. The method considers the feasibility of establishing an alternative habitat type or land use and/ or management that will enhance the delivery of a particular service, in a specific area. The speed of establishment of a viable, fully functioning habitat depends on its location in reference to the four key factors (Figure 1). The soil and geology need to be suitable and the habitat needs to be reinstated in an appropriate area of the landscape in terms of slope and hydrological relationships. Additionally, ecological networks and the management of the area must be appropriate.

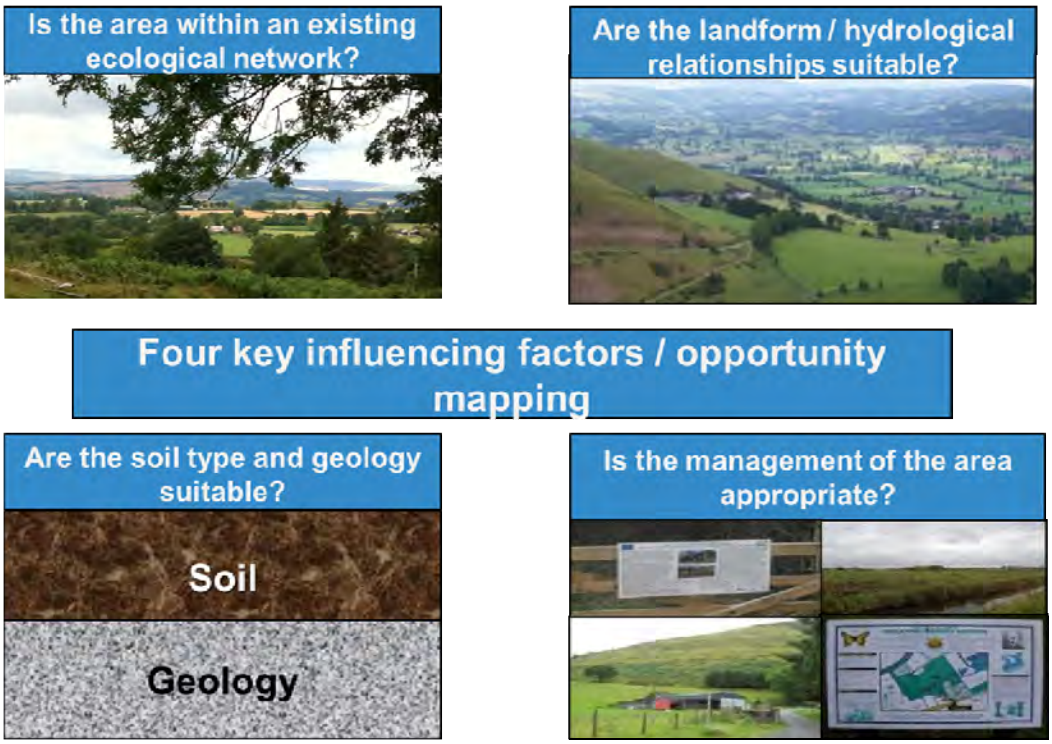


Figure 1: The four key factors when considering 'opportunity mapping'

Sections 1.1, 1.3, 1.2 and 1.4 summarise how these factors have been approached during the mapping of the opportunities.

1.1 Are the soil type and geology suitable?

Soil, as a host for many forms of life and a growing medium for terrestrial habitats, has an important influence on biodiversity and therefore on ecosystem services. In general, undisturbed soil maintains a higher level of biodiversity and therefore ecosystem service function; disturbed soils and bare soils have a much reduced biodiversity value (Pankhurst *et al*., 1997). Human management of the soil and the inherent nature of the soil itself affect the biodiversity it is able to support and ecosystem services provided. Both the physical and chemical properties of the soil are important to maintain the functioning of the soil environment and the ecosystem services provided. Soil functioning can be enhanced by specific management practices, and respond differently to being worked for agriculture. The geology also plays a key role in many ecosystem services directly on craggy hill tops where the soil is thin, and indirectly influencing the formation of topography, water chemistry and drainage.

Soil texture

The pore size (gaps between soil particles) and permeability (how easily water travels through the soil) control the amount of water and oxygen present in the soil and therefore available to soil processes. The porosity and permeability of the underlying geology are an important consideration when looking at opportunities for enhancing soil ecosystem services.

Availability of oxygen within the soil

The high presence of oxygen within mineral soils allows a varied assemblage of species to develop. Systems which are waterlogged, with little oxygen available are more acidic (lower in pH), only supporting specialist species which can cope with the conditions.

Soil pH

The pH of the soil influences species diversity, with neutral soils supporting the most diverse ecosystems. The pH of the soil is generally related to the geology it develops on, as the underlying rock provides material to the soil and affects drainage conditions.

Peat based soils have different characteristics and therefore a different mechanism for delivering ecosystem services than mineral soils. Peat based soils are waterlogged, causing an anaerobic environment (low in oxygen), causing rapid decay of organic matter and acidic conditions.

Sandy soils are mostly formed from large, rounded particles, which create large pore spaces and facilitate easy passage for water through the soil; they therefore are well aerated and drain freely but can be prone to draught.

Clay based soils are composed of small, platy particles, which align with one another, causing small pore sizes and adsorb water to their surfaces, rather than allowing free flow through the soil. Clay soils also compact easily, thus decreasing their water and oxygen holding capacity and reducing the

amount of biodiversity they are able to support. These soils can be prone to problems when cultivation is carried out.

Mixed loamy soils tend to have greater water holding capacity (Brady and Weil, 2002). Soil macrofauna, in particular earthworms, open up the macro pore spaces in soils and play an important role in maintaining soil biodiversity by allowing water and air to move freely within the soil system (Brady and Weil 2008).

Brown loamy soils are generally the most resilient to being worked during ploughing and re-seeding, maintaining more of their structure.

Soil and geology are particularly important in determining whether land is suitable for agricultural use and when considering the movement of water through the environment, playing a key role in where the opportunities for enhancing soil movement and storage can be realised.

Re-establishment of semi-natural habitats is dependent on soil conditions; in particular the pH and nutrient status of the soil can affect the outcome of a restoration scheme. Soils with a high nutrient burden support fast growing, competitive species. Nutrient status is important for agricultural crops and grass crops to maintain a good level of productivity. Areas that have recently been used for growing arable and productive grasslands are, therefore, generally unsuitable for restoration of native habitats which naturally occur on nutrient poor soils. Trying to restore habitats such as woodlands and heathlands on highly productive soil leads to failure as competitive species, such as grasses and nettles, generally swamp and 'out complete' all the plants of interest. It is only possible to undertake restoration on areas with high nutrient status if the topsoil is removed first. Because of the impact of removing soil resource we have not considered areas with high nutrient status within the opportunity maps.

The soil / geology types have been scored for the opportunity maps based on their likelihood to support the habitat types of interest. In particular the identification of pasture land, which is neither likely to be extremely species rich (and therefore a significant habitat with functioning ecosystem services in its own right) nor highly productive land, was key to identifying areas where different habitats may establish well. These grasslands were identified using remote sensing data and the Near Infra Red (NIR) band. This band is related to leaf properties and a high value normally equates to high productivity grassland. The species rich grassland was identified by the relationship between heterogeneity of the sward across the field and productivity in spring.

1.2 Are the landform / hydrological relationships suitable?

Landform is the shape of the land, including hill slope, aspect and altitude, hydrology is a description of how water moves through the landscape. Land use in inappropriate locations in the landscape (such as leaving steep slopes bare of vegetation as part of the cycle) can have a negative impact on water quality, meaning erosion and sedimentation are more likely. Specific landform and hydrological interactions are required to maintain soil and conditions suitable to allow different habitats to establish, therefore these must be considered when identifying opportunity areas.

In upland areas, opportunities to restore ecosystem services can involve restoring hydrological processes altered by previous management. An example of this type of restoration is the blocking of

grips in deep peat land to restore a fully functioning blanket bog. This stores a large volume of water, which can help provide fresh water during dry periods.

Interrupted landform and hydrological issues are also a problem in lowland, flood plain areas; here habitat restoration has the most impact with riparian or wet woodland and marshy grasslands.

These wetland and wet woodland areas provide multi-benefits. When the natural habitats are re-instated they help slow water moving through the environment, act as flood storage areas and capture carbon helping mitigate climate change. In addition, intact bog surfaces are normally completely covered in vegetation and therefore resilient to erosion; this is a significant problem in degraded peat areas where organic carbon can adversely colour river water. The restoration of habitats depends on restoring good soil and hydrological relationships which allow the desired plants to grow.

1.3 Is the area within an existing ecological network?

Formation of Ecological Networks: In the past large areas of semi-natural habitats covered the land. Each area was sufficiently large to contain a wide range of species with a correspondingly high genetic diversity. This ensured that the ecosystems supported by the habitats were resilient to change.

Over time, agricultural intensification and the establishment of softwood plantations reduced the size of the patches of semi-natural habitats. As the patches of native habitats become smaller, the habitats become more vulnerable to the influence of external factors, such as the ingress of weeds or nutrient enrichment, which in turn lead to the loss of more specialist, rarer plants and insect populations. Once a patch has become very small and isolated, many species die out as the habitat is of insufficient size to maintain the populations. The habitat loses its biodiversity value, together with its considerable contribution to the ecosystem in general. It no longer provides a refuge from predator species for small mammals and pollinating insects, water storage potential, and many other ecosystem functions. A study into the rate of decline of locally rare and scarce species in Berwickshire has shown that within 20 years, 42 of the 162 species of interest appeared to have been lost (Braithwaite, 2010).

Where there are still habitats patches that are sufficiently large and are connected to each other by smaller blocks of habitats, species can move between them and maintain their genetic resilience. These connected areas of habitat are called ecological networks.

Restoration of habitats within the network, or adjacent to it, has two advantages over the re-establishment of habitats in isolated areas. The first is that there are seed sources, insect vectors and animals near enough to colonise the areas quickly, so that a viable, fully functioning ecosystem is established in a much shorter period of time (Miller and Hobbs, 2007). The second is that strengthening the network actually has greater benefits for the delivery of ecosystem services than building isolated patches of habitat because the overall effect is the creation of a more connected and therefore ‘larger area’. This allows for more genetic diversity and less ‘edge effects’, where the edges of the habitats are vulnerable to alteration or contamination by the surrounding land use.

The importance of networks for the opportunity mapping can, therefore, be seen as establishment of new habitat areas, or restoration of degraded habitats, within the networks are more desirable that in areas outside the networks. There are three parts to the network;

- the habitat blocks which are within the reach of specialist species (those which only use the specific habitats, e.g. woodland birds) and slow moving animal/insects, which are called core areas;
- the areas where less specialised species can use other habitat blocks to move from one large area to another, which are referred to as the Moderate dispersal network. Areas suitable for habitat expansion within this region are referred to as 'preferred' areas; those which are further from the habitat, which are used by species which are able to move further from the habitat are known as high dispersal network and suitable areas for habitat recreation within this area are called 'potential' areas.
- Outside of these areas, the best opportunity for restoration of fully functioning habitats would be to undertake a very large block of re-instatement to make a new 'habitat node'.

Calculation of ecological Networks in the Scottish Borders: Three studies have been undertaken to calculate ecological networks within the SBC region. The first was a strategic evaluation of networks at a broad scale (Medcalf and Williams 2010). This considered woodland, grassland, heathland and wetland networks. The second was a more detailed woodland network project completed by Forest Research (Moseley and Ray, 2006) using their BEETLE model to look at specific woodland types. The third, the Integrated Habitat Network (IHN) (Scottish Natural Heritage, 2013) has been mapped for the whole of the Central Scotland Green Network, which includes the Scottish Borders. For five habitats, broadleaved woodland, wetland, neutral grassland, acid grassland and heathland it shows the core habitats and how these patches may be connected across the landscape.

In the opportunities mapping these network models have been combined to give the most complete picture possible.

1.4 Is the management of the area suitable?

Management of the land, or land use can indicate any changes to the soil and hydrology of the site, through inputs such as nutrients and changes in structure, which may make the site more or less suitable for the establishment of different habitats to enhance ecosystem service delivery. Additionally any economic impacts of a change in land use must to be considered. Often agricultural land is unsuitable for habitat restoration due to the high nutrient burden in the soil and its current high value with crop production and contribution to food security.

If land use change is undertaken, it will be most successful if the previous management has promoted conditions which are suitable for the new habitat which will allow them to establish and be resilient and fully functioning.

Areas have been considered as an opportunity if;

- The land is managed as a suitable habitat, but is in a degraded state, which can have environmental conditions reinstated to allow it to be a fully functioning ecosystem reliably delivering ecosystem services.
- Or if management practices can be changed within the area of interest which can allow the habitat to start to function fully again and therefore, improve the ecosystem services provided.

2 Building the ecosystem service maps

2.1 Ecosystem service Opportunities layers created

Map No.	Ecosystem service opportunity	Greatest potential for service enhancement
1	Opportunity to reduce risk of flooding and overland flow	Areas upstream of urban settlements on steep slopes where habitats could be restored to help regulate water (e.g. bogs and other wetland, woodland, heathland and hedges)
2	Woodland – timber provision	Opportunities exist across the Scottish Borders for softwood plantations. Sensitive and unsuitable areas have been removed including protected sites, areas of known deep peat and existing intensive agricultural land.
3	Woodland – native planting	Modelled using the existing data, including the WEAG data and the data on ecological networks together with where suitable woodland habitat occurs.
4	Biodiversity opportunities	Biodiversity can be enhanced at a number of levels in the Borders. This layer primarily acknowledges larger scale actions, such as restoration of degraded habitat where a change in management could facilitate restoration of the fully functioning ecosystem and habitat re-creation within and expanding the existing network.
5	Agriculture (Crops and livestock)	Land Capability of Agriculture classes 1 – 4.2 Highlighting land suitable for cropping which is currently not in intensive cultivation. Existing land in livestock and areas of existing crop, split by slopes of over 7^{o} which are prone to erosion and therefore may be less suitable for cropping in the future and may be preferred for livestock grazing.
6	Opportunities to improve water quality	Habitat restoration and re-creation where soils are degraded, where there is a risk of sedimentation, and where there is a chance of diffuse pollution from agricultural fields.
7	Soil Carbon opportunity	Degraded peat based soils, which are currently managed intensely, or degraded bog soils, which are heavily drained, and organo-mineral soils, which are intensively worked.
-	Recreation	The Land Reform (Scotland) Act 2003 conferred a duty on all Authorities and National Parks to, amongst other duties, prepare a Core Paths Plan which undergo full public consultation and are subject to review.

Map 1 of 7: Opportunities to reduce the risk of flooding and overland flow

Heavy rainfall events cause water to run quickly over the surface of the land or through soils to reach rivers and can cause flooding events. Some of these flooding events lead to severe social and economic consequences. The regulation of water is complex and is affected by obvious factors, such as climate (rainfall in particular), but also less obvious ones such as topography, soil, vegetation and land cover type (especially sealed surfaces, such as concrete and tarmac).

At its simplest, soil temporarily stores water that falls as rain as it percolates through the system towards rivers and streams, or into the groundwater resource. The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape.

Habitat, through its link to vegetation type and soil type, has an important influence on water quantity. This is linked largely to the structure of the vegetation present and its effect on infiltration. Trees and bushes have a complex structure, which slows water as it hits many layers of vegetation before it reaches the ground; this is known as interception.

Steep slopes shed water more rapidly than shallow slopes. Steep slopes are also more likely to be in the upper reaches of catchments and are characterised by small streams with rocky banks, which in times of heavy rainfall can quickly rise.

Management which adds to the ability of vegetation and soil type to slow the flow of water through the environment can be said to provide an opportunity to reduce overland flow and therefore down catchment flooding.

Opportunity to reduce risk of flooding and overland flow	**NEA service type Supporting opportunities**
This maps shows where the environment could be enhanced to slow the movement of rainfall through the land into rivers (also known as overland flow). The land's potential to reduce overland flow can be split into two types of action dependant on whether the restoration is in the headwater area or the river valley. Within the headwater areas storage of water can be enhanced by restoring degraded bog vegetation by blocking grips and by re-instating bog vegetation. Within the river valley planting of trees or shrub cover on the steeper valley sides can help slow the water reaching the river valley. Riparian planting and creation of wetlands can also help natural flood management, as can factors such as re-meandering the rivers and creating sacrificial flooding areas to be used in flood events.	

Key ecosystem service factors	Data used	Example attributes	Indicative scoring
Areas suitable for tree planting	Phase 1 habitats Scottish Borders Woodland strategy	Acid grassland Scrub Bracken Where planting will add to the riparian corridor	Suitable Most suitable
Upland habitats which can be re-wetted and restored to promote water infiltration	Phase 1 habitats	Degraded habitats	Suitable for restoration
Drainage routes suitable for re-wetting	SCIMAP	Output of drainage routes	Suitable

Map 2 of 7: Opportunities for woodland (softwood plantations):

The opportunity maps for woodland use information gathered from projects run by Forestry Research for Forestry Commission Scotland. Opportunities for woodland have been shown as two maps. The opportunities for softwood plantations are created from the Land Capability for Forestry model. This model uses soil type, slope and climatic and altitudinal information to suggest the most suitable forestry crop for any area of land.

Opportunities for woodland (softwood plantations)	NEA service type Provisioning opportunities
This map shows where there are currently opportunities to plant new forest to provide timber / fibre for wood-fuel resource. The model takes account of the quality of the land and its current usage. The FC Land Capability for Forestry model was used to show areas appropriate for commercial forestry opportunities which were not on deep peat soils or on designated sites. Although plantation forestry could be grown on the high quality arable land in The Borders this is a very unlikely land-use option and therefore this land has not been included in the layer. Existing plantation forestry areas are shown, as are existing woodland.	

Key ecosystem service factors	Data used	Example attributes	Indicative scoring
Land Capability for Forestry	Scottish Land Capability for Forestry	Grade 1- 4.2	Suitable
Areas unsuitable	IACS JHI Peat depth Designated areas	Currently cropped Peat Under designation	unsuitable

Map 3 of 7: Opportunities for woodland (broadleaved native woodland)

Opportunities for planting new woodland with native broadleaved species have been the subject of a number of studies in the Scottish Borders. These include the strategic level analysis work by

Medcalf and Williams (2010), and detailed work by Ray et al (2003). Both these studies considered the existing woodland networks and the possible areas of planting based on suitable soil, management and plant community conditions. In addition The Woodland Expansion Advisory Group (WEAG) has recently completed a study to find the best areas for woodland expansion in Scotland. Again this study includes looking for suitable areas away from deep peat soils and productive arable land within the woodland network. It particularly considers where riparian woodland could be introduced. All three studies have been combined to show the opportunity areas for native woodland planting.

Opportunities for woodland (broadleaved native woodland)			**NEA service type Provisioning opportunities**
This map shows where there are currently opportunities to plant new native tree species to create or expand broadleaved woodlands.			
Key ecosystem service factors	**Data used**	**Example attributes**	**Indicative value**
Soil type, landform, climatic interactions	Scottish Land Capability for Forestry	Grade 1- 4.2	Suitable
Existing woodland suitability assessments	Woodland strategy	Preferred Potential	Most opportunity Moderate opportunity
	Scottish Borders Woodland network opportunities	Preferred Potential	Most opportunity Moderate opportunity
	Woodland expansion advisory group	Suitable for native species	Most opportunity
Areas unsuitable	IACS JHI Peat depth Designated areas	Currently cropped Peat Under designation	unsuitable

Map 4 of 7: Areas with potential to enhance biodiversity and nature conservation

Opportunities to enhance biodiversity exist throughout the Scottish Borders. This map focusses on areas where there is a significant chance to enhance larger blocks of native habitats. It addresses two main types of action to enhance biodiversity:

- The first is to undertake specific management on degraded habitats or native habitats that are currently in situ to re-establish the full range of biodiversity in these areas.
- The second is to restore habitats within ecological networks where appropriate soil and vegetation conditions exist. Areas around existing native habitats of high ecological value, for example around designated sites, give the highest opportunity to enhance overall biodiversity as these areas will expand the range of existing species and buffer sensitive species from outside effects.

Additionally, there are many small scale actions that will enhance and support native biodiversity across the region, including hedgerow creation and maintenance, grass margins around fields, leaving verges uncut and promotion of planting wildlife friendly species in gardens. These are widespread actions that are relevant in all areas of the Borders and therefore have not been explicitly mapped as part of this stage.

Biodiversity opportunity	**NEA service type Supporting opportunities**
This map shows where there are currently opportunities to enhance biodiversity. Areas of degraded habitat where with a change in management could facilitate restoration of the fully functioning ecosystem. Areas within the ecological networks which are of suitable soil type, for example low productivity but species poor grassland with suitable soil and slope conditions, for restoration of semi-natural habitats. Existing areas of high quality habitat have been included as they require ongoing sensitive management to maintain and enhance their condition.	

Key ecosystem service factors	**Data used**	**Example attributes**	**Indicative scoring**
Habitats	Habitat: Phase 1 habitat layer Rural Development Plan	 Existing high quality habitat Degraded habitat Areas that can be restored to habitat – scrub, bracken, poor improved grassland Land unsuitable for biodiversity enhancement Semi-natural habitats	 Existing Most opportunity Some opportunity Unsuitable Existing
Location within the landscape – surrounding vegetation types	Networks: Forest Research Integrated habitat network	Within the network Outside the network	high low
Identification as suitable	Borders habitat networks	Potential for habitat re-creation	high
Management means land is unlikely to be restored	Management: IACS NFI	Forestry Arable	low

Map 5 of 7: Opportunities for extending agricultural cropping and livestock management:

The Scottish Land Capability for Agriculture was modelled in 1981 (as part of the Soil Survey for Scotland) and updated in 2008 (Brown et al. 2008), by considering the most relevant of the 'key factors' for agricultural productivity. The factors considered were soil type and geology, landform, especially slope, and climate. They did not include management considerations, such as distance to market, in the analysis. The maps produced show areas appropriate for different types of farming in Scotland. Thirteen classes were identified which are indicative of the land's agricultural capability.

The SLCA is the official agricultural classification system used in Scotland by agriculturalists, planners, estate agents and others as a basis for land valuation.

Opportunities for agriculture	**NEA service type: Provisioning Opportunities**

This map shows the areas with a potential to be used for agriculture based on the Land Capability for Agriculture. This is displayed with the existing cropped areas and those which support livestock from the stock mapping phase of the project.

The lower the land classification, the wider the range of crops. Grade 1 and 2 land can grow a very wide range of crops, Grade 3 and 4.1 land can grow good yields of certain crops including cereals while Grade 4.2 to 5.1 land can grow occasional crop or good agricultural grassland for silage. Grade 5.2 to 6 land is only able to support poorer quality grasses or rough grassland.

These classes have been used to divide the area into land with high potential to become cropped, some potential to be used for cropping or little to no opportunity for cropping.

This map indicates possible courses of actions for discussion rather than prescriptively suggesting a set way forward. It should be regarded as part of a decision support tool to guide thinking.

Key ecosystem service factors	**Data used**	**Example attributes**	**Indicative scoring**
Soil type, landform, climatic interactions	Scottish Land Capability for Agriculture	Grade 1- 3.2 Grade 4 -5.1 Grade 5.2 -6	High opportunity Some opportunity Little to no opportunity
Slope	Nextmap DTM	Slope >7°	For consideration
Unavailable	MasterMap Urban MasterMap water	Built up Water	Unavailable

Map 6 of 7: Opportunities for improving water quality

Water quality is an important issue in the Borders, as sediment and pollution reaching the rivers adversely affect fish stocks. There are quality targets set by the Water Framework Directive and penalties for infringement. Principles from restoration ecology, as well as habitat and water modelling data were used to categorise land with a good potential for different types of restoration activity. This mapping uses soil type, vegetation cover and landform as well as land management to show which areas of land have the greatest potential to further help purify and filter the water. The areas with the most opportunity are those with the highest potential for restoration, located in areas prone to erosion and near to the river channels.

Opportunities for improving water quality	NEA service type Supporting opportunities
Restoration and protection of areas at risk of erosion for both peat and mineral soil or enhancement of the filtering capacity of the soil by suitable habitat restoration. Also creating vegetation strips which intercept the pathways of pollutants washed off the land.	

Key ecosystem service factors	Data used	Example attributes	Indicative value
Areas at most risk of erosion	SCIMAP (Met Office rainfall, Phase 1 habitats and NextMap DTM)	Output of erosion risk High Low	 Most opportunity Some opportunity
Proximity to water courses	MasterMap water	Proximity to water to intercept pollution	Moderate opportunity
Upland habitats which can be re-wetted and restored to promote water infiltration	Phase 1 habitats	Degraded habitats suitable for restoration	Some opportunity

Map 7 of 7: Opportunities to enhance Soil Carbon Storage

Soil carbon storage is an important ecosystem service which helps ameliorate the effects of climate change by binding carbon dioxide from the atmosphere and preventing the release of carbon from the land. Soil carbon storage results from interactions of different ecological processes. The amount of organic matter present within the soil profile is an important component, which contributes to the service. Soil organic matter is a heterogeneous mixture of organic compounds that are highly enriched in carbon ranging from fresh plant residues (leaf litter) to highly decomposed material known as humus. Soil organic carbon levels of different soil types are directly related to the amount of organic matter contained in the soil form the growth and death of plant roots and foliage, as well as indirectly form transfer of carbon-enriched compounds from roots to soil microbes. Peat based soils contain the most carbon, whilst sandy soils contain much less.

Soil Carbon opportunity	NEA service type Supporting opportunities

This map shows where there is an opportunity to enhance soil carbon storage.

Opportunities for enhancing soil carbon differ depending on the soil type. Peat based soils are composed of a large percentage of organic carbon. Opportunities for enhancement include re-establishing soil processes which actively incorporate carbon in the soil. This includes re-establishing peat forming habitats, such as blanket bogs, on degraded mires and on deep peat soils which have previously been planted with coniferous plantation.

Good carbon management is also important on arable land. Carbon is lost from soil by oxidation following ploughing and crop removal. Replacing this carbon significantly enhances the soils ability to maintain its cohesion and allows it to maintain an open structure with good water holding capacity. Arable land is therefore shown as having a moderate ability for carbon storage.

Key ecosystem service factors	Data used	Example attributes	Indicative scoring
Presence of organic carbon in the soil (especially on degraded habitats)	JHI Soils (including SHN soil carbon classification)	Organic soils Mineral soils	High opportunity Low
Degraded habitats which can be restored to fully functioning diverse ecosystems	Habitat data from Phase 1 survey and NVC classifications	Degraded bog Intact broadleaved woodland	High Low
Land Under arable cultivation	IACs data	Land used for cropping and temporary grass	Moderate opportunity to retain carbon in the soil by good carbon management.

Recreation opportunities:

Recreation opportunities in Scotland can be seen to exist in most locations since the Land Reform Scotland Act (2003) introduced new rights for responsible public access to land and the countryside. Everyone has the right to access most land and inland water in Scotland providing they:

- Take responsibility for their own actions
- Respect the interests of other people
- Care for the environment

The provision of signed footpaths enhances access and usage of the environment. In order to facilitate access to the countryside the Scottish Government has designated a process of 'core path' identification. Within this legislation, areas for recreation provision are the responsibility of the local authority. Scottish Borders Council has drawn up a plan for a system of paths (core paths) to give the public reasonable access throughout the area. A process of consultation with the local access forum,

landowners and managers, SNH and others, has fed into a working plan which has been officially adopted. The provision of a core path network provides greater opportunity for people to enjoy the countryside. The network as a whole caters for everyone, including those with disabilities. Maps can be downloaded from the council website[1]. The core path network is kept under review and the council will continue to work with the local access forum to keep the plan up-to-date and amended as necessary.

The mapping of recreation opportunities is therefore part of the 'core path' process. Existing comprehensive and legislative processes relating to recreation opportunities are considered along the core path network (see stock map) and will be updated and amended through this process.

[1] http://www.scotborders.gov.uk/info/1504/walking_cycling_and_horse_riding/346/view_paths_near_you

2.2 Response from stakeholders

The opportunity maps were developed with key stakeholders and shown in the consultation exercises at public meetings in seven sub-catchments within the Scottish Borders. Agricultural opportunities were generally acknowledged, but with little current opportunity for expansion given the economic climate. Longer term the importance of good quality agricultural land may come to be important under climate change impact. Woodland expansion was the most contentious ecosystem service topic, especially in the upland catchments. Concern was expressed by sheep farmers that woodland expansion should be limited on upland pasture to retain the viability of their enterprises. Conservation bodies saw the value of native woodland planting, as did some land owners who farmed easily flooded land. Natural flood management was also perceived in a mixed way, with landowners who had drained or put in hard flood defences to maximise their agricultural potential seeing it as a conflict with their desire for agricultural productivity, whilst others saw the value in schemes that would reduce the risk of flooding to some of the towns. Water quality opportunity in the establishment of buffer zones was again differently perceived as conservation bodies and fishermen saw its value, while land owners thought it was a conflict with maximising land use productivity. Opportunities for enhancing carbon storage were less controversial and generated few discussions. Recreation opportunities were acknowledged and several local groups exist in the borders who are currently working up plans to create and locally support more footpaths. Biodiversity and opportunities for nature conservation were mostly seen as a positive driver for tourism related with the beauty of the Scottish Borders.

2.3 Next Steps

The opportunity maps will be finalised following a final consultation exercise by the steering group. These and the stock maps will then be further developed into the online tool during Phase 3.

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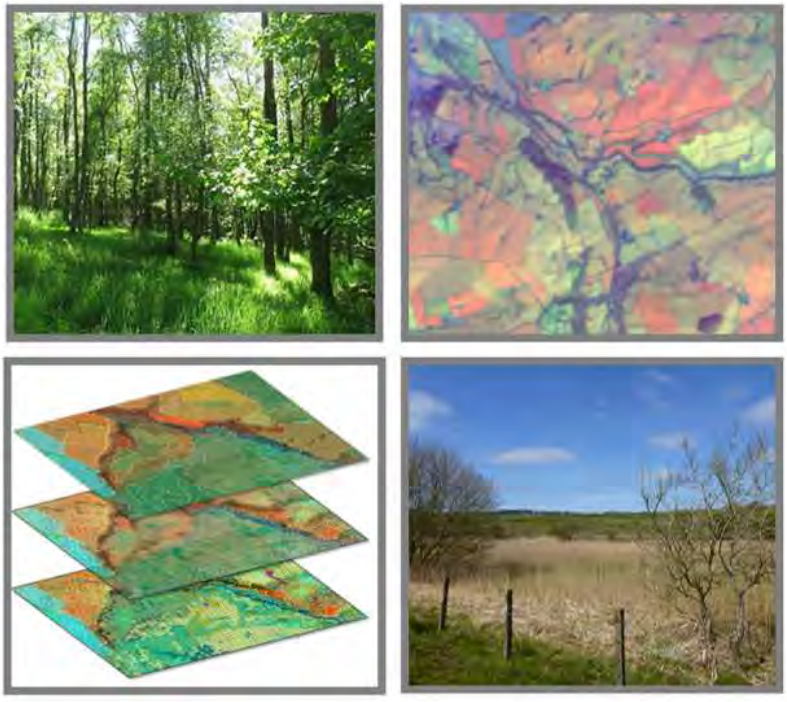
Pilot Regional Land Use Framework: Baseline mapping, constraints & opportunity mapping and final framework

Stage 3 Report: Interaction and multi-benefit mapping



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Contents

1 Introduction

1.1 The Scottish Borders and the regional land use framework

The land resource of the Scottish Borders provides a range of important ecosystem services, which are benefits the people who live in the Borders receive from the natural environment; it includes environmental, social and economic benefits. These are a fixed and finite resource, with demands from the population continually increasing and changing. Scotland's first Land Use Strategy (LUS), published in 2011, set out a vision for future land use in the country to 2050, with a focus on three objectives relating to the economy, environment and communities - the three pillars of sustainability. Key elements of the strategy are partnership working, developing a shared vision for the land using innovative approaches and solutions.

To contribute to the wider strategy, the Scottish Government developed two LUS pilot projects in Scottish Borders and Aberdeenshire, to develop pilot regional land use framework, to consider a wide range of land uses in an area, with a broad range of objectives. Each pilot is local authority led and will help to facilitate the delivery of policies, strategies and objectives in relation to integrated land use by providing a framework to guide decisions about land use.

The pilot framework is to be a tool to guide decisions about land use and management, based on an ecosystems approach, that operates locally (with local support and at a local scale) but takes into account regional and national requirements and statutory planning processes.

1.2 This aims of this report

This report covers Stage 3 of the mapping element of the Scottish Regional Land Use Pilot. The Stage 1 baseline report introduced the project, considered the approach and methods taken to create stock maps. The second report covered Stage 2 of the project which involved the production of ecosystem service opportunity maps. In this stage we considered the way the stock and opportunities maps could be used together to show the potential constraints in delivering a range of ecosystem services and where there may be multi-benefits to changing land use. These maps are not intended to be prescriptive but to show where different impacts might be felt (e.g. on food production) and where opportunities occur to achieve multiple goals.

To identify competition and conflict within land use change and provide information on which to develop and prepare frameworks is based on three broad steps to:

- **Take account of how ecosystems work**; Nature connects across landscapes, so we need to consider the broad and local scales. The capacity of ecosystems to respond to impacts and provide resources is not infinite. Ecosystems are dynamic so we must recognise that change will happen. By using up-to-date information, embracing adaptive management principles, and trying to sustain nature's multiple benefits, we can ensure that nature continues to contribute to Scotland's growth.
- **Take account of services that ecosystems provide to people**, such as regulating floods and climate, providing food, fuel and water, and contributing to quality of life, culture and wellbeing.
- **Involve people in decision making,** especially those who benefit from ecosystem services and those who manage them. This means valuing people's knowledge, helping people to participate, and giving people greater ownership and responsibility.

These three steps will be considered throughout and broadly guide the work of developing and preparing the frameworks.

1.3 The Scottish Borders and the ecosystem services it provides

The Scottish Borders is a diverse region with a number of internationally significant and nationally and locally important habitat types including, woodland, wetland, species rich native grasslands and heathland. It also contains high quality agricultural land as well as internationally significant waterbodies. The Scottish Borders covers the majority of the Tweed Catchment which makes it ideal for an ecosystem approach as management at this scale can incorporate full water flow effects.

Each area of land in the Scottish Borders contributes to a range of ecosystem services. The wildlife and natural habitats of the Borders, including the River Tweed are valued by local people for how they add to the sense of place, provide recreation potential and create scenic quality of the area. They are also important for their less obvious benefits to people such as their effects on natural systems, including the regulation of water flow through the landscape, which impacts on flooding, and carbon sequestration, which helps to mitigate the effects of climate change. The hidden value of these ecosystems by their soil processes and landscape features as well as the management imposed upon them all affect the ecosystem services they provide.

1.4 Project aims

The aim of the pilot project is to use an ecosystems approach:

- to consider existing and land uses future in a collective and integrated way;
- to establish a means to prioritise or guide decisions so as to optimise the use of the land; and
- to identify competition or conflicts relating to land use change and provide information which might in due course help inform decisions that seek to resolve them.

The maps produced as part of this pilot aim to contribute to the delivery of the Land Use Strategy (LUS) and be used as an on-going resource locally. By presenting information about the hidden ecosystem services of the land they aim to assist in the delivery of the Scottish Biodiversity Strategy, the 2020 Challenge, helping to articulate the aspirations for the preservation of our natural habitats and the development of an ecosystem approach at a more local level. Looking at the opportunities to enhance ecosystem services and the best places for action, they may also, in time, help to contribute to CAP (Common Agricultural Policy) Reform by assisting with targeting and prioritisation for Scottish Rural Development Programme (SRDP) and assist in meeting the objectives of the Water Framework Directive as described in the River Basin Management Plans (RBMP) and Flood Risk Management plans (FRMP).

The aim of these maps and the ecosystem information is to provide a mechanism which considers existing and future land uses in a collective and integrated way with a view to optimising the use of the land. This information could potentially be used to establish a mechanism to prioritise or guide decisions by highlighting possible competing or conflicting uses.

The spatial mapping project is overseen by a project steering group chaired by Scottish Borders Council, with members from SBC, Tweed Forum, University of Dundee and Scottish Government. Further expert stakeholder input has been provided by the Tweed Forum Key Stakeholder Group.

Specifically this part of the projects aims to explore the main drivers affecting land use in the Borders, both at the current time, those which are likely to impact over the next 5-10 years, and beyond.

It is necessary to think at all 3 timescales as many decisions and choices made now will impact across the timescales. The drivers considered are likely to cause large impacts on the landscape of the Borders and should be evaluated for their relative merits and any issues which may be caused.

2 Method

Interaction maps were created by considering potential opportunities against existing stocks of ecosystem services. A target opportunity map was compared against existing stock layers which were identified to possibly cause issues and therefore limit the ability to carry out the opportunity, showing where constraints to the delivery of the service are.

The multi-benefit maps were created by combining a number of opportunity maps to show the areas which will give the most benefit if actions were taken to develop the service. The extent of the main opportunity map under consideration was compared and combined with other opportunity layers which were considered to work in-combination to provide multiple benefits.

The interactions and multi-benefits to be assessed were evaluated using a matrix of interactions (Appendix 1). The potential opportunity and therefore the potential land use change was considered (column on the left of the matrix), and how this would interact with the existing ecosystem service provision of the land (across the rows of the matrix). The type of interaction (positive, negative or mixed) has been shown by positive and negative symbols.

This initial analysis highlighted interactions which have the most impact on the Borders, and those with relationship to important policy delivery. Each layer to be included was checked against the scientific rules behind them, to assess if the methods were suitable to describe the interactions and how that interaction may develop in relation to the 'rules' applied to prepare the layers. Therefore this impacted on whether it was suitable to describe the interactions using the available data. This formed the basis for interaction and multi-benefit mapping (described in Figure 1) and the final set of maps agreed by the Steering Group is shown in Table 1.

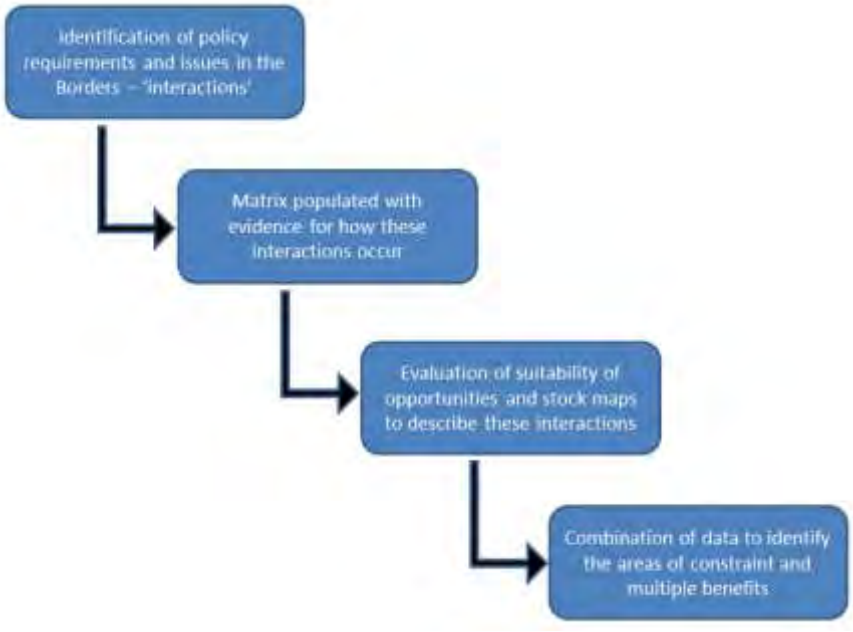


Figure 1: Process summary defining which interactions and multi-benefits to be mapped as part of Stage 3

Table 1: Map sets produced for key interactions and multi-benefits

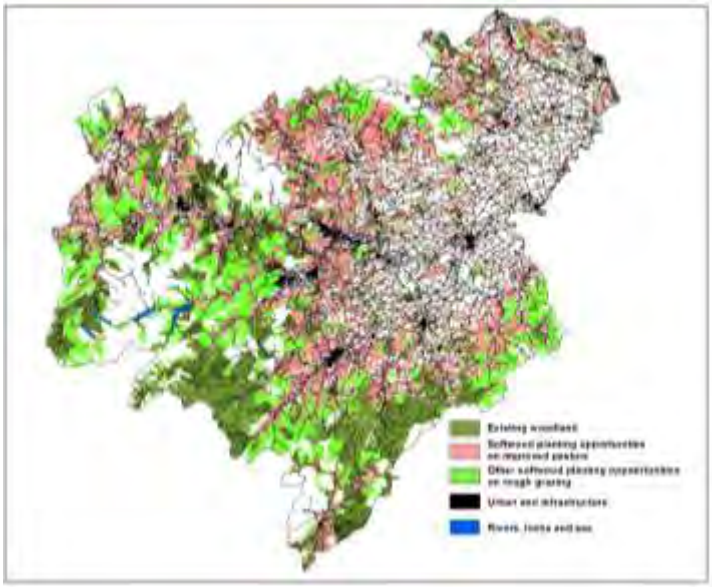
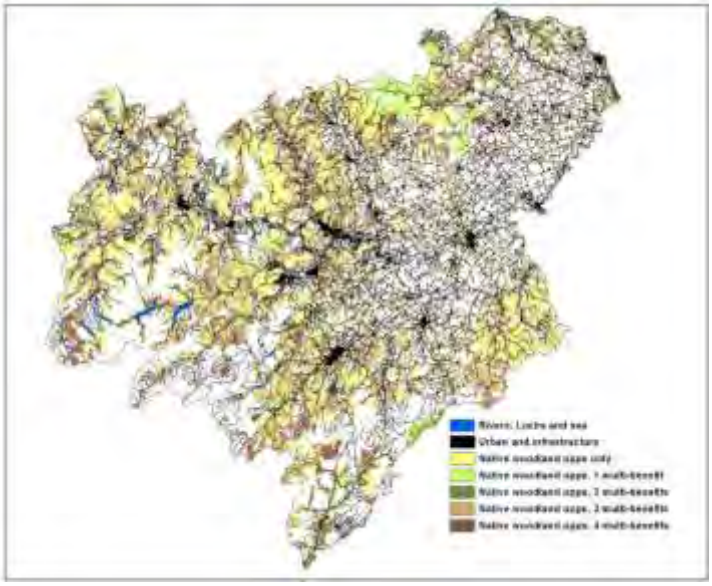
Map set	Theme	Interaction	Multi-benefit
Map set 1 *Timber and Woodland vs food production*	Timber and woodland planting opportunities (Woodland opportunities vs existing agriculture)	Potential interaction between expanding woodland and current pasture	Potential multiple benefits of planting native and mixed woodland

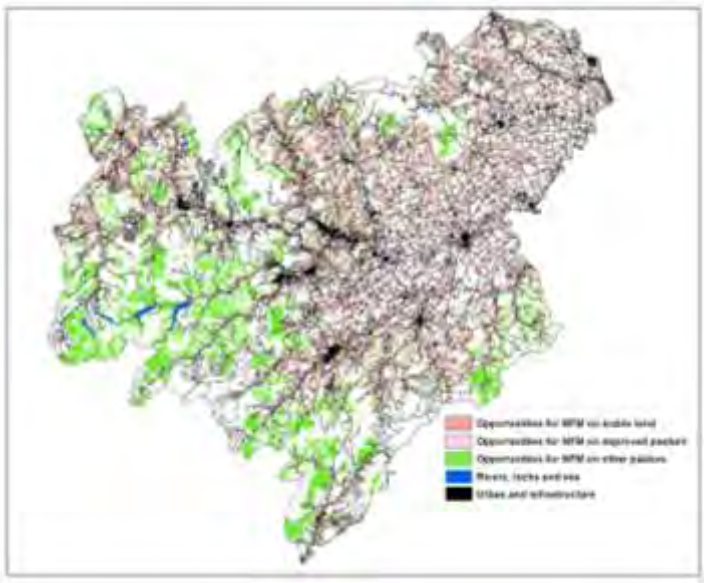
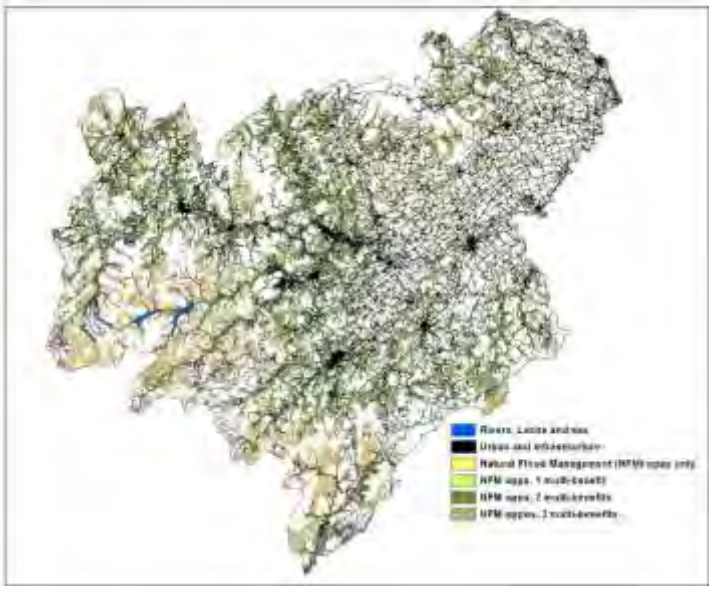
Map set	Theme	Interaction	Multi-benefit
Map set 2 *Flood risk vs food production*	Carrying out Natural Flood Management (NFM) (NFM opportunities vs existing agriculture)	Potential interaction between creating NFM and agriculture	Potential multiple benefits of creating NFM
Map set 3 *The water environment – diffuse pollution control vs food production*	Carrying out diffuse pollution control to improve water quality (Diffuse pollution opportunities vs agricultural productivity)	Potential interaction between opportunities for improving water quality and current agriculture	Potential multiple benefits of improving water quality
Map set 4 *Food production – livestock and crops vs biodiversity*	Enhancing Food production and its interaction with biodiversity (Food production opportunities could 'negatively' impact vs biodiversity)	Potential interaction between opportunities for expanding and intensifying agricultural land and biodiversity	No multi-benefit identified
Map set 5 *Food production – livestock and crops vs water quality (diffuse pollution control)*	Enhancing Food production and its interaction with diffuse pollution control (food production opportunities could 'negatively' impact vs diffuse pollution control)	Potential interaction between agricultural opportunities and areas important for water quality	No multi-benefit identified
Map set 6 *Softwood timber production vs water quality (diffuse pollution control)*	Enhancing Softwood production and its interaction with diffuse pollution control (Active forest operations could 'negatively' impact on diffuse pollution control)	Potential interaction between softwood plantation opportunities and areas important for controlling water quality	Potential multiple benefits of opportunities for softwood plantations
Map set 7 *Biodiversity vs Softwood timber production*	Interaction between enhancing biodiversity and the existing softwood plantations (Map showing interaction where enhancing biodiversity opportunities could impact on softwood plantations)	Potential interaction between enhancing biodiversity and existing softwood plantations	Potential multiple benefits of opportunities for biodiversity around softwood trees
Map set 8 *Food production – Soil carbon storage vs agriculture (soil & vegetation)*	Interaction between carrying out activity to enhance carbon storage in the soil and agricultural productivity (actions to enhance soil carbon opportunities vs agricultural productivity)	Potential Interactions between soil carbon opportunities and agriculture NB this is most likely to be a negative effect in the uplands or on deep peat which could be re-wetted to re-establish peat forming processes, this may result in the land becoming too wet for grazing for some or most of the year. Enhancing carbon management on other land is likely to benefit agricultural productivity.	Potential multiple benefits of opportunities for soil carbon

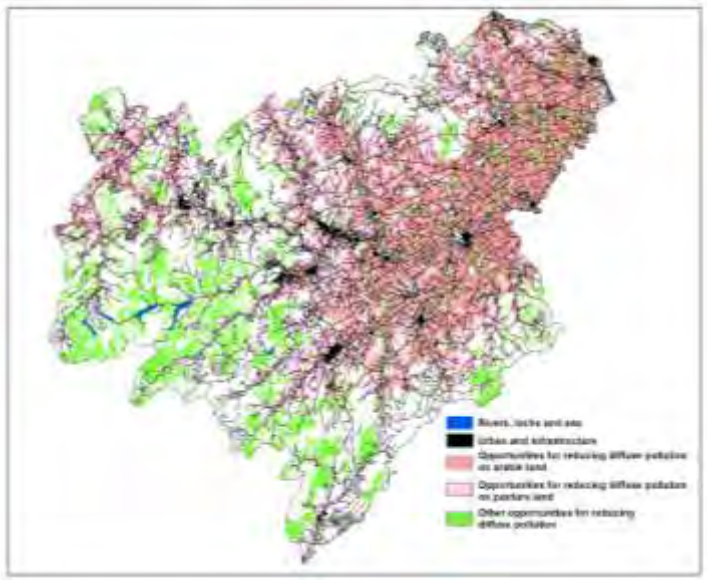
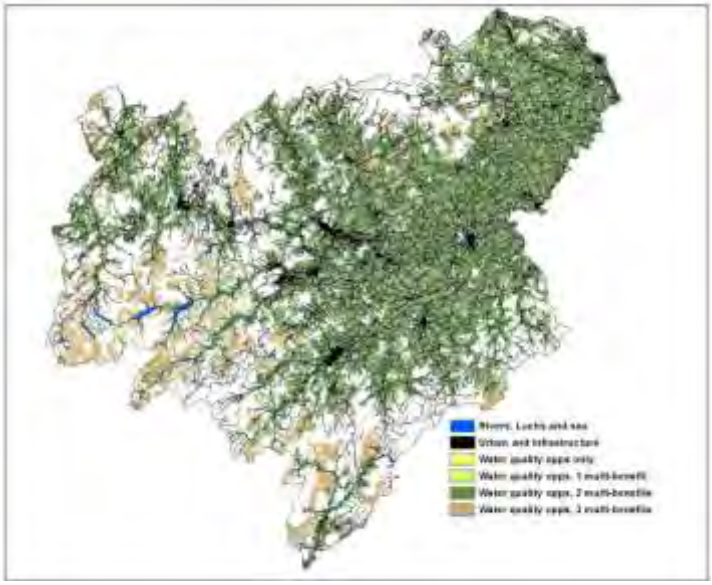
Map set	Theme	Interaction	Multi-benefit
Map set 9 *Nature Conservation vs Food production*	Interaction between enhancing biodiversity and agricultural productivity (Map showing interaction where enhancing biodiversity opportunities could 'negatively' impact on agricultural productivity)	Potential interaction between enhancing biodiversity and agricultural production NB not all actions to enhance biodiversity will impact productivity of agriculture.	Potential multiple benefits of opportunities for biodiversity

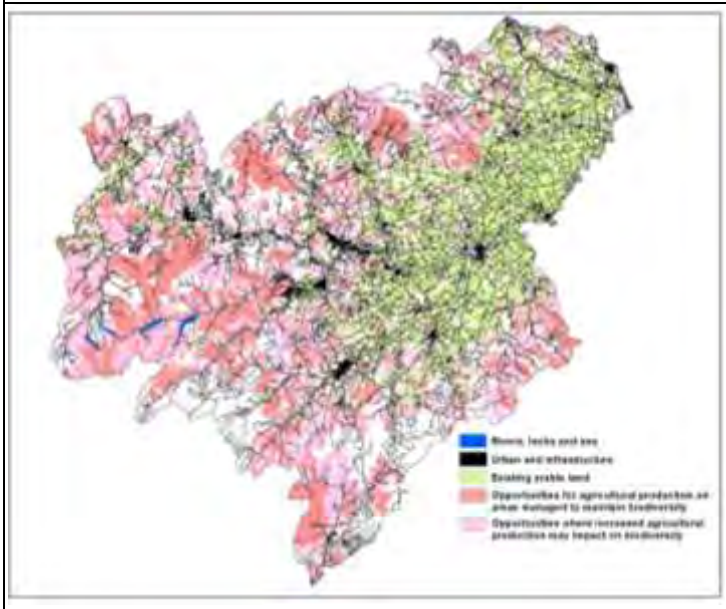
3 Results

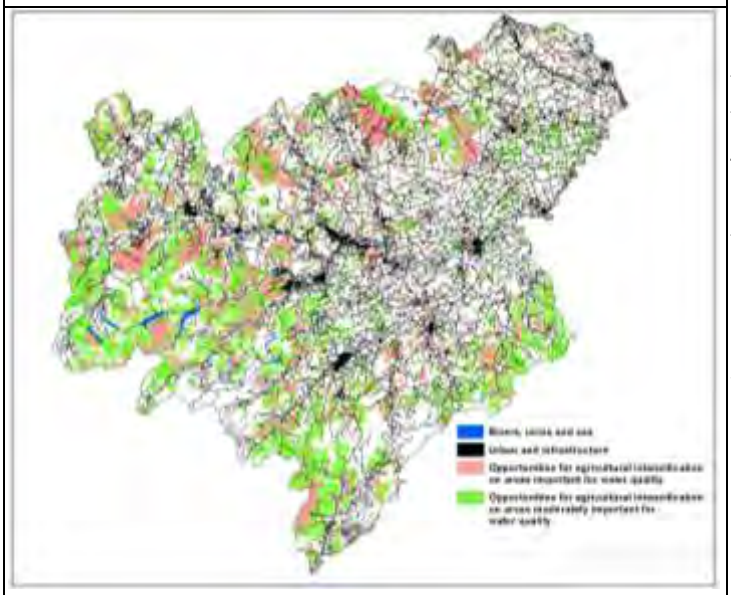
The following maps present the interactions between specific stock map considerations and the potential multiple benefits of opportunity sites for service enhancement to NFM, water quality, biodiversity and soil carbon storage. These themes relate directly to legislation from the European Commission, UK Government and Scottish Government for land and water management and achieving targets. The maps therefore provide an appreciation of opportunities in land management within an integrated framework to enable stakeholders and decision makers within the Scottish Borders to evaluate land use proposals holistically.

Map set 1 - Timber and Woodland vs food production	
Map 1a - Interaction 	Map 1a highlights the areas of current woodland stock within the region and potential areas of expansion of plantations on rough and improved pasture. These designations do not indicate where softwood planting should occur, but rather where consideration of the economics between livestock rearing and woodland are relevant. This interaction map highlights the area under most pressure in the Borders, sometimes referred to as the squeezed middle. There is an extensive distribution of sites. Primarily in the upland fringe and bordering the lowland arable region, with small areas present within this area of higher agricultural productivity.
Map 1b - Multi-benefits 	Map 1b highlights the areas within the Scottish Borders where planting of native and mixed woodland could additionally provide benefits of NFM, water quality, biodiversity and soil carbon storage. Within upland areas of the region there are extensive areas in which up to four additional benefits could be realised through the sensitive expansion of woodland. These are interspersed with areas of fewer multi-benefits, highlighting the importance of woodland position within a catchment in achieving multiple services. The lowland, arable region has dispersed areas of primarily high potential benefit sites.

Map set 2 - Flood risk vs food production	
Map 2a - Interaction 	Map 2a highlights the potential areas suitable for NFM which are currently under agricultural management as cropped land, improved pasture and rough pasture. From the map there is a clear division of agricultural land use between the upland and lowland areas of the region, as this is where the different types of agriculture occur. The implementation of NFM in the high agricultural productivity regions may be limited by the need to protect the high quality arable land and therefore food production.
Map 2b - Multi-benefits 	Map 2b displays the sites located across the Scottish Borders that represent NFM opportunity regions. The majority of sites within the region which are suitable would provide multiple services if developed for NFM, including water quality, biodiversity and soil carbon storage. Slopes and valleys in the uplands potentially offer additional service capacity if focussed to FRMPs and these continue within the riparian corridor into the lower reaches of the Tweed and Teviot catchments. Sub-catchments across the region display capacity for increased services under NFM, including the land surrounding channels that drain the lowland arable and improved pasture areas.

Map set 3 - The water environment – diffuse pollution control vs food production	
Map 3a - Interaction 	Map 3a shows the distribution of areas with opportunities to reduce diffuse pollution and improve water quality through changes in management, against areas currently under agricultural management for cropping or pasture. Taking land out of or lessening production in arable areas could impact on food production in the Borders. Small scale improvements such as the maintenance of grassland buffer zones between watercourses and crops and improved pasture by increased control of livestock around banksides and transmission zones would improve water quality.
Map 3b - Multi-benefits 	Map 3b illustrates the distribution of potential benefits across sites identified as important to water quality enhancement. Additional benefits include NFM, biodiversity and soil carbon storage. The distribution of high improvement sites within the uplands largely corresponds with NFM, located on hill slopes and valleys that correspond to the river network source and filtration zones. Within the lowland arable region the majority of land constitutes opportunity area to improve water quality and to derive 2-3 additional benefits through the implementation of RBMPs.

<table>
<tr><td colspan="2">Map set 4 - Food production – livestock and crops vs biodiversity</td></tr>
<tr><td>Map 4a - Interaction
  </td><td>Map 4a displays the opportunity areas within the region for expanding and intensifying agriculture in relation to the current biodiversity and nature conservation value. The map is generated from sites identified for moderate and high value in the biodiversity and nature conservation stock map and agricultural land use opportunity and stock maps.

The map highlights the potential vulnerability of biodiversity within the uplands if agricultural expansion or intensification were to occur. This highlights how potential shifts in agricultural practice due to climate change or increasing food security would impact on biodiversity resilience.</td></tr>
<tr><td colspan="2">Map set 5 - Food production – livestock and crops vs water quality (diffuse pollution control)</td></tr>
<tr><td>Map 5a - Interaction
  </td><td>Map 5a presents the current opportunity areas for agricultural expansion and intensification and how these correspond with areas important for the regulation of water quality.

The identified regions are divided into areas of high and moderate importance for water quality provided by land across catchments from the stock map, including source, transmission, filtering and delivery of water to channels and water stores.

By intensifying grazing and arable production, diffuse pollution is likely to increase. In areas which are already important for this service (control of diffuse pollution) reducing the efficacy of this service will have a larger impact.</td></tr>
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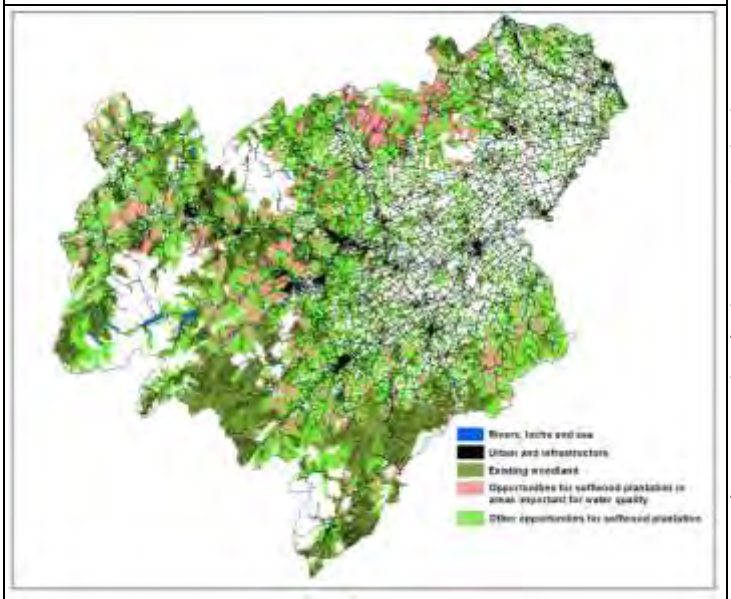
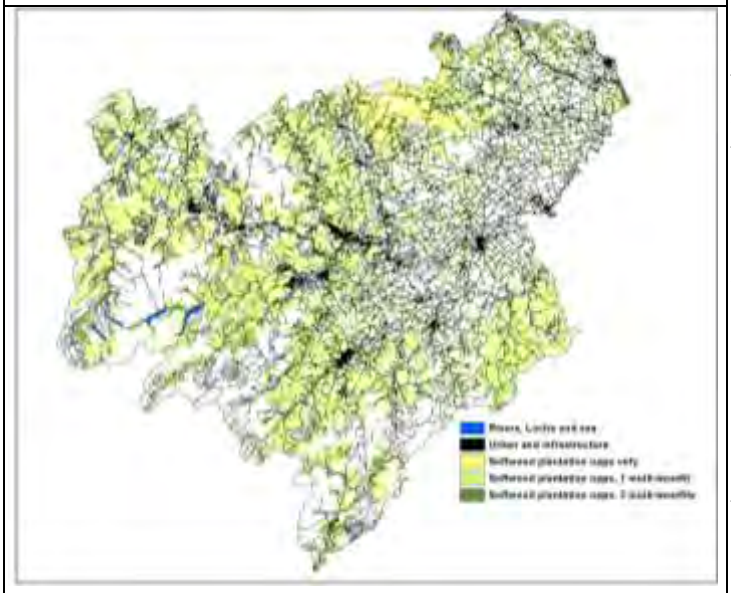
<table>
<tr><td colspan="2">Map set 6 - Softwood timber production vs water quality (diffuse pollution control)</td></tr>
<tr><td>Map 6a - Interaction
  </td><td>Map 6a provides the locations of current softwood woodland and opportunity areas within the region for expanding these plantations and where these correspond with areas important to diffuse pollution and subsequent water quality.

Land development for forestry often includes ploughing of surface soils and the release of stored pollutants. Therefore consideration of sites relative to the wider catchment and services of land parcels to water quality are important.

There are areas within upland sub catchments that could potentially degrade water quality if planted.</td></tr>
<tr><td>Map 6b - Multi-benefits
  </td><td>Map 6b shows the potential for multiple benefits derived from the expansion of sites suitable for softwood plantation, these being NFM (if managed sensitively for example avoiding clear felling) and carbon sequestration.

Upland areas of the region display larger individual sites for increased services, corresponding commonly with un-forested areas within sub-catchments.

Lowland regions display a large number of discrete service capacity sites that cover a range of locations across the field land parcels.</td></tr>
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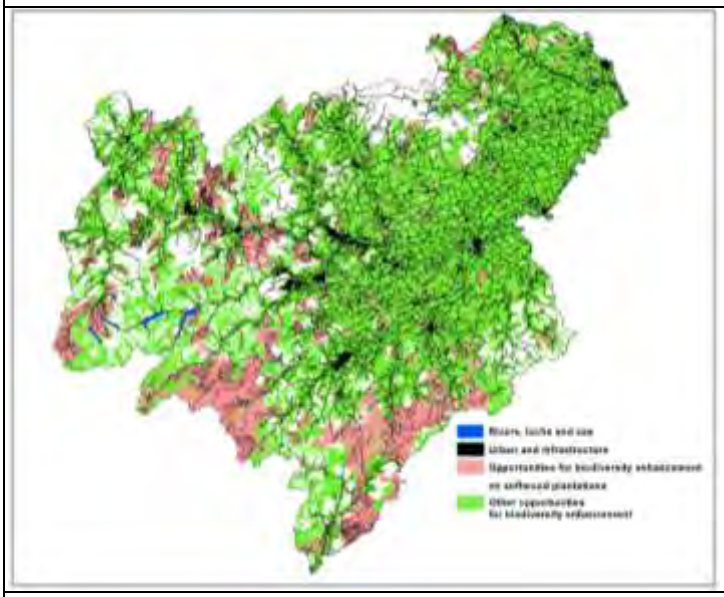
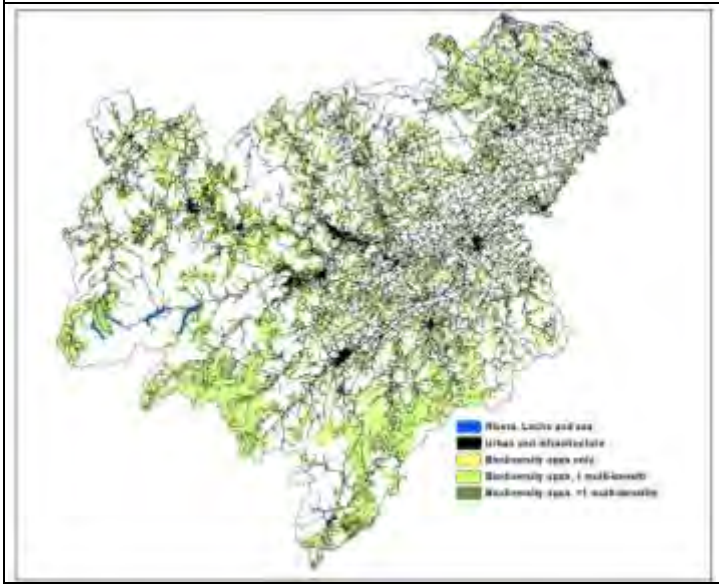
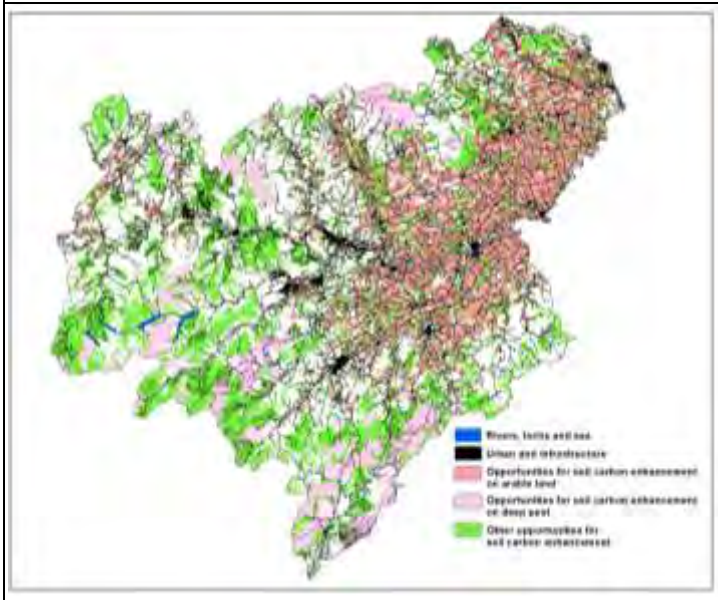
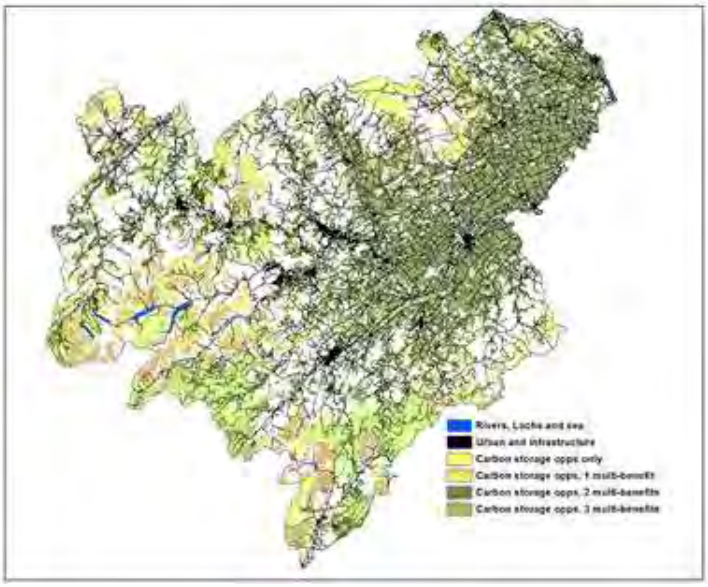
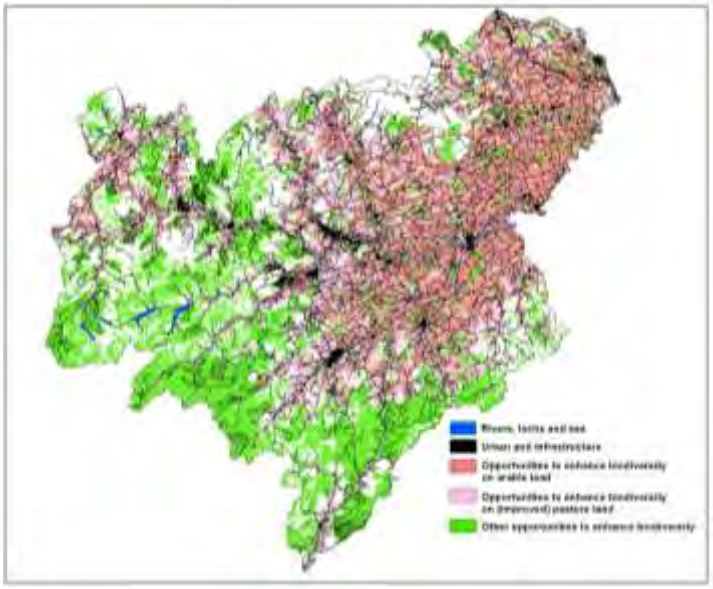
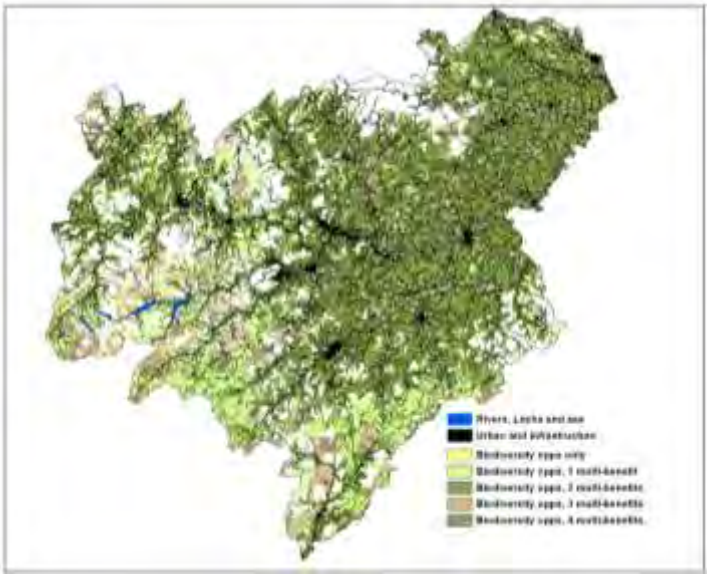
Map set 7 - Biodiversity vs Softwood timber production	
Map 7a - Interaction 	Map 7a shows the areas of present softwood stock that could be improved to increase the biodiversity value of woodland as well as wider opportunity areas. This provides a strategic view of softwood plantation development within a wider biodiversity framework. All present softwood forestry land has a capacity for improved biodiversity. This includes restructuring and replanting with more diverse mixed tree species after felling, thereby providing a timber resource while supporting a higher biodiversity interest.
Map 7b - Multi-benefits 	Map 7b illustrates where biodiversity could be enhanced around softwood plantations, to additionally promote where water quality and soil carbon, if the planting and subsequent management is sensitive to this. Notably upland woodland is a region for potential improvement with the inclusion of large conifer forestry units as sites for enhancement Woodland that occurs along riverine corridors and the field mosaic of the lowland arable region presents potential for a full range of stated services.

Map set 8 – Soil carbon storage opportunities v. agriculture	
Map 8a - Interaction 	Map 8a displays the areas in which soil carbon capture and storage could be improved relative to the present land use, these being; arable, on deep peat, especially with degraded habitat and others which include other habitat improvements to fully functioning ecosystems on organic soils. Historic drainage of peatland across the Scottish Borders has reduced soil carbon capacity. The map highlights regions where re-wetting strategies including ditch blocking and planting might enhance soil carbon. Of note is the difference in capacity between functional peatlands and other soil and ecosystem types in carbon sequestration and storage capability. Continual ploughing of organic rich arable land can causes the loss of carbon from the soil. Sensitive working of cropped land and grazing programmes can reduce this, and help to rebuild soil carbon reserves.
Map 8b - Multi-benefits 	Map 8b displays the sites that present opportunities to improve soil carbon storage and where they may additionally provide benefits to biodiversity and water quality. Through reverting historical drainage management, the re-establishment of functional wetland systems enhances soil carbon storage. Large upland areas have the potential to supply all the benefits associated with re-wetting of soils, with forestry planted on peat presenting a financial barrier, limiting the scope of this. The lowland arable and improved pasture presents a large potential resource for improvement providing 2-3 services across the region.

Map set 9 - Nature Conservation vs Food production	
Map 9a - Interaction 	Map 9a illustrates the opportunity areas for enhancing biodiversity highlighting the interactions with agricultural land use, including cropping and improved pasture. Improvements to management to enhance biodiversity would not always impact on agricultural productivity; however it may result in some land being taken out of production. The map highlights the significant spatial extent for improvement sites across the region.
Map 9b - Multi-benefits 	Map 9b illustrates the opportunity areas to enhance biodiversity and subsequent potential for multiple services to be provided.. The services include NFM, water quality and soil carbon storage. The upland regions provide a range of potential improvement sites with high service capacity within un-forested areas. Extending from upland zones along catchment networks, into the lowland regions, there is a large potential area for enhancement of biodiversity by reducing the intensity of agricultural land use, in conjunction with a range of additional benefits.

4 Discussion

For this part of the land use framework the map data was combined to show key interactions between current stock and specific opportunities. In addition, multi-benefits were identified by undertaking analysis for one ecosystem service opportunity added to the stock for other opportunities.

Each of the map sets are focused around particular issues in the Borders and particular key policies driving land use change. Therefore, this series of maps presents interactions which may be encountered under different scenarios presented by policy or national drivers, such as the intensification and expansion of agriculture under the requirement for food security or the requirement to plant significant areas of forestry.

The map sets highlight interactions between potential options for development of ecosystem services. They show the areas which are under pressure from a range of different drivers which often include the replacement of a land use type with another offering limited benefit. Coupling the interaction maps with multi-benefit maps, showing where expansion to one service under consideration will provide additional benefits to other services may provide a stronger case for any change in habitat or land use.

By highlighting issues and potential areas where multiple benefits can be achieved, choices for the land can be discussed and reviewed to provide a compromise that minimises dis-benefit to the ecosystem services provided by the land. The information can be used by land managers, decision makers, stakeholders and communities to inform how initiatives and proposals relate to land use.

Cultural services and opportunities were not mapped during either phase of the project as limited data was available and the type of data available was not quantifiable. However certain considerations such as the most important historic sites were incorporated when mapping other service opportunities, e.g. being unsuitable for woodland expansion. A sub-project led by SBC and Historic Scotland is piloting an approach to identify Historic Land Use Value and data which may feed into the mapping process in the future.

Ecosystem service analysis and maps are not restricted to those included in this report. Evidence required to account for potential scenarios for other issues can be generated using a similar method of combining existing stock and opportunities maps to highlight locations of key interactions and where multiple opportunities exist.

5 Conclusion

These map sets have been carefully compiled to target specific land use issues relevant to the Borders, which can be described spatially. They highlight known issues in a strategic way which can be used to communicate them to a wider audience. This process works across disciplines, drawing on knowledge from different specialisms and presenting them in a systematic accessible way. It builds on existing knowledge about the way land uses interact with ecosystem services. As such they provide a powerful tool for decision making, highlighting where multiple requirements of the land will conflict or coalesce.

Maps give a good way of showing relative values between services in a common setting with all the features on equal footing so local parties can continue to discuss the way forward.

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Appendix 1: Matrix of interactions and multiple benefits between ecosystem services in the Scottish Borders:

(+++ large to + small beneficial interaction / --- large to - small antagonistic effect)

Existing ecosystem services

		Existing Land Use								
		Food production – livestock and crops	Timber and Woodland	Renewable Energy (wind farms)	Natural flood management	Diffuse pollution control	Carbon storage (soil & vegetation)	Recreation	Development sites	Biodiversity
Possible New Land Use	Food production – livestock and crops		- -[1]	+	- -	- - -	-	- +	-	- -
	Timber and Woodland	- -		—	- +	++	+ (+)	+ -	-	-
	Renewable Energy (wind farms)	—	-		-	-	- -	- -	+	-
	Natural flood management	- -	+	+		+ +	+ + +	+	- - -	+ +
	Diffuse pollution control	-	+	+	+		+	+ -	- +	+ + +
	Carbon storage (soil & vegetation)	- (+)	—	+ - -	+	++		+	- - -	+ +
	Recreation	-	+++	- -	+	-	+ -		- +	-
	Development sites	- - -	- - -	- +	- - -	- - -	- - -	-		- - +
	Biodiversity	-	+	+	++	++	+	+	+	

Proposed expansion of service

Yellow - interaction maps (9) incl. softwood conifer plantation

Blue – Multi-benefit maps (15) incl. native woodland expansion

References for individual fields:

Food Production → Timber and Woodland
Agro-forestry rare in borders → woodland planting causes loss of arable land
Timber and Woodland → Food Production
Agro-forestry rare in borders → creation of arable land requires felling of existing forest

Food Production → Renewable Energy
Establishment of wind farm on arable land possible with minimal loss of crops/pasture
Renewable Energy → Food production
Food production on fields/pasture possible

Food Production → Natural Flood management
Arable land and grassland susceptible to down-slope flow (steeper slopes increase susceptibility) towards rivers (Calder et al. 2008, Reaney et al. 2011)
Reduction measures include: riparian woodlands (interception of runoff) (Nisbet et al. 2011), other measures to reduce runoff (e.g. ploughing perpendicular to surface flow) listed in DEFRA (2009) → cause different degrees of loss of land contributing directly to food provision
Natural Flood Management → Food production
Conversion of features contributing to flood management into farmed land → loss of e.g. riparian woodlands, floodplains or wetlands, the latter being of particular relevance (Mitsch and Gosselink); Arable land and grassland susceptible to down-slope flow (steeper slopes increase susceptibility) towards rivers (Calder et al. 2008, Reaney et al. 2011)

Food Production → Diffuse Pollution Control
Shelterbelts (intercepting spray drift of fertilisers) can help to reduce the impact (Nisbet et al. 2011) of agriculture as source of diffuse pollution (Leaf et al. 2002, Mainstone and Parr 2002, Heathwaite et al. 2005, Lane et al. 2006) → Establishment of those causes some degree of loss of land contributing directly to food production.
Diffuse Pollution Control → Food Production
Agriculture (the use of fertilisers therein) is the main source of diffuse pollution (Leaf et al. 2002, Mainstone and Parr 2002, Heathwaite et al. 2005, Lane et al. 2006)→ conversion of features contributing to the control of diffuse pollution (e.g. forests (Nisbet et al. 2011) to fields/pastures increases diffuse pollution, whereby soil type, climate, topography, hydrology, land use and land management influence how strong of a source individual parts of the land are (Heathwaite et al. 2005, Lane et al. 2006)

Food Production → Carbon Storage
Carbon-wise management of agricultural land can benefit carbon storage, e.g. through soil management/conservation (Hagon et al. 2013) → different measures cause difference degrees of reduction of arable productivity
Carbon Storage → Food Production
Arable land stores less carbon in soil and vegetation than most other habitats (Ostle et al. 2009, Alonso et al. 2012, Hagon et al. 2013) and available evidence suggests that some agricultural management practices can lower the carbon level at which soils saturate (Six et al. 2002); particularly strong impact if agricultural development includes deforestation (directly through loss of vegetation carbon, indirectly through increased soil erosion) (Foley et al. 2005, Eswaran et al. 1993, Davari et al. 2010) or drainage of peatlands (Ostle et al. 2009), the latter of which can cause CO_2-emissions (Natural England 2010, Bain et al. 2011)

Food Production → Recreation
Creation of either a well-developed network of footpaths (promoted on arable land under the Countryside and Rights of Way Act (2000) or recreational facilities, such as a playing field, will cause loss of food provision for the land being converted.
Recreation → Food Production
Food provision possible along a network of footpaths
Conversion of a playing field would cause loss in recreational resources

Food Production → Development Sites
No food provision on developed sites, with exception of housing of livestock and processing factories
Development Sites → Food production
No food provision on developed sites, with exception of housing of livestock and processing factories

Food Production → Biodiversity
Increasing species richness of primary producers and structural heterogeneity by planting of species rich grass mixes and hedgerows aids in maintaining biodiversity around arable land (Carvell et al. 2007, Osborne et al. 2008, Blake et al. 2011, UK National Ecosystem Assessment 2011, Fabian et al. 2013); these biodiversity supporting forms of management can cause some degree of productivity loss
Biodiversity → Food Production
Agriculture is considered one important driver of species loss (Dirzo and Raven 2003, Foley et al. 2005, Davari et al. 2010). Agriculture causes spatial and temporal homogeneity of land, where heterogeneity would be needed to supply resources throughout the year, which would maintain species-rich communities (Benton et al. 2003); therefore, conversion of species-rich land into arable land will cause loss of biodiversity

Timber and Woodland → Renewable Energy
Establishment of a wind farm requires some degree of felling to take place
Renewable Energy → Timber and Woodland
Planting of woodland around a wind farm will neither increase nor decrease the amount of energy gained from the wind farm

Timber and Woodland → Natural Flood Management
Woodlands slow down runoff (Nisbet et al. in Calder et al. 2008, Nisbet et al. 2011) and intercept precipitation (Teklehaimanot et al. 1991, Crockford and Richardson 2000), which promotes entry of water into the soil, as opposed to the next waterway. Suitable management of the forest can increase this effect (e.g. promotion of high structural diversity) – measures such as this benefit the forest itself as well.

Natural Flood Management → Timber and Woodland
Woodlands slow down runoff (Nisbet et al. in Calder et al. 2008, Nisbet et al. 2011) and intercept precipitation (Teklehaimanot et al. 1991, Crockford and Richardson 2000), which promotes entry of water into the soil, as opposed to the next waterway. This effect is reduced if active forestry takes place in the woodland, as clear cuts for machinery access can provide a flow path (with high erosion risk) during strong precipitation events (Hartanto et al. 2003).

Timber and Woodland → Diffuse Pollution Control
The presence of forests on the water flow path from a farm to the next water way (e.g. in form of riparian buffers) reduces the amount of diffuse pollution to the water way (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011). Management for diffuse pollution control will benefit

the woodland as well, as a functioning woodland provides the best control of diffuse pollution (Nisbet et al. 2011).

Diffuse Pollution Control → Timber and Woodland
The presence of forests on the water flow path from a farm to the next water way (e.g. in form of riparian buffers) reduces the amount of diffuse pollution to the water way (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011). However, active forestry in the woodland can reduce this effect, if, for example, the understorey is kept clear (Hartanto et al. 2003).

Timber and Woodland → Carbon Storage
Woodlands are an important habitat for terrestrial carbon storage, both in the soil and in the vegetation (Milne and Brown 1997, Broadmeadow and Matthews 2003, Alonso et al. 2012). Consequently, timber and woodland is one of the most beneficial habitats in regards of carbon storage. Carbon sequestration is highest during the full-vigour phase of growth (Broadmeadow and Matthews 2003, Alonso et al. 2012); consequently, woodlands can potentially be managed to maximise carbon uptake (Broadmeadow and Matthews 2003).

Carbon Storage → Timber and Woodland
Woodlands are an important habitat for terrestrial carbon storage, both in the soil and in the vegetation (Milne and Brown 1997, Broadmeadow and Matthews 2003, Alonso et al. 2012). Carbon sequestration is highest during the full-vigour phase of growth (Broadmeadow and Matthews 2003, Alonso et al. 2012), so that establishment of woodland can be highly beneficial in regards of carbon sequestration. However, active forestry in the forest can lead to increased erosion by dragging trees and disturbing litter layer and debris (Hartanto et al. 2003), which reduces the potential for carbon storage in the soil.

Timber and Woodland → Recreation
Woodlands are generally perceived as aesthetically and atmospherically pleasant and, therefore, important areas for recreation (Natural England 2009). Establishing an accessible network of footpaths in a woodland area benefits the recreational resource of the area greatly.
This is not the case in areas of intensive forestry, which, due to machinery, are not as peaceful an environment and can present hazards to health and safety.

Recreation → Timber and Woodland
The establishment of a new woodland in an area used for recreation by walkers benefits the recreational resource of the area; however, if the woodland is established on a playing field (or another recreational facility that depends on free space), then the establishment of woodland minimises the recreational potential of this area.

Timber and Woodland → Development Sites
Building of, for example, a factory requires clear cutting of the existing woodland.

Development Sites → Timber and Woodland
No potential for forestry on building sites.

Timber and Woodland → Biodiversity
Biodiversity-friendly management of woodlands, e.g. the re-establishment of native woodlands, has the potential to benefit biodiversity (Calder et al. 2008) through, for example, increased heterogeneity of the woodland as a habitat, which will benefit the level of biodiversity that can be maintained (Tews et al. 2004, Levine and HilleRisLambers 2009). This is of particular relevance if the

newly established woodland contributes to an existing network (Warren et al. 2001, Travis 2003, Opdam and Wascher 2004).

Biodiversity → Timber and Woodland
Active forestry often focusses on some target species and thereby reduces the heterogeneity of the woodland as a habitat, which, in turn, affects the level of biodiversity that can be maintained (Tews et al. 2004, Levine and HilleRisLambers 2009).
Replacing one species-rich habitat, e.g. spcies-rich grassland, with a woodland will not benefit biodiversity, as the new habitat will take time to reach its full biodiversity potential, while the majority of species from the previous habitat are lost.

Renewable Energy → Natural Flood Management
Features contributing to natural flood management (e.g. (riparian) woodlands (Teklehaimanot et al. 1991, Crockford and Richardson 2000, Nisbet et al 2011)) can be created on/around wind farms without causing losses to the energy provided by these farms.

Natural Flood Management → Renewable Energy
Natural flood management is provided by areas such as woodlands (Nisbet et al. 2011), flood plains or wetlands, the latter of which are of particular importance (Mitsch and Gosselink); establishment of a wind farm will cause some degree of damage to either of these habitats, an effect that is strongest if a wetland needs to be drained to allow for the wind farm to be built.

Renewable Energy → Diffuse Pollution Control
Features aiding in the control of diffuse pollution, such as woodlands (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011) can be established on/around a wind farm without reducing the amount of energy gained through the farm.

Diffuse Pollution Control → Renewable Energy
The establishment of a wind farm will require the clearing of some features aiding in the control of diffuse pollution (e.g. woodlands (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011), an effect that will be particularly strong if the area of the wind farm to be built is on the direct flow path between a farm and a nearby waterway (Heathwaite et al. 2005, Lane et al. 2006).

Renewable Energy → Carbon Storage
Some features beneficial to the carbon sequestration rate of a habitat (e.g. creation of a woodland (Milne and Brown 1997, Broadmeadow and Matthews 2003, Alonso et al. 2012)) can be established without causing a loss of energy from the wind farm.

Carbon Storage → Renewable Energy
The establishment of a wind farm on land of high value to carbon sequestration will require either the felling of parts of the woodland or the drainage of wetland, both of which will reduce the amount of carbon that can be stored (Woodland: Foley et al. 2005, Eswaran et al. 1993, Davari et al. 2010; Wetland: Ostle et al. 2009, Natural England 2010, Bain et al. 2011). Additionally, soil disturbance during construction works will cause losses of previously stored soil carbon (Hartanto et al. 2003, Scottish Executive 2007, Alonso et al. 2012).

Renewable Energy → Recreation

The recreational value of areas within the direct vicinity of a wind farm is reduced, as wind farms are commonly considered as “unattractive” (Johansson and Laike 2007).

Recreation → Renewable Energy
The creation of a wind farm within range of a network of footpaths for ourdoors activities such as mountain walking makes this network less attractive (Johansson and Laike 2007).
Renewable Energy → Development Sites
Some form of development can take place without impacting the energy gained from a wind farm. If, however, the development site leads to reduced wind flow over the wind farm, the energy generation of the wind farm is reduced.

Development Sites → Renewable Energy
Existing housing or industrial sites have limited potential for renewable wind energy on a large scale.

Renewable Energy → Biodiversity
Areas containing a wind farm can be made more useable for wildlife through the establishment of more species-rich vegetation with higher structural diversity, which increases the amount of wildlife species that can be supported (Tews et al. 2004, Levine and HilleRisLambers 2009).

Biodiversity → Renewable Energy
Renewable energy can have a negative impact on biodiversity: in case of wind turbines through displacement, habitat change/loss or barrier formation on migration pathways (Drewitt and Langston 2006) and injuries/mortality caused to birds (Erickson et al. 2001, Drewitt and Langston 2006, De Lucas et al. 2008), particularly raptors (De Lucas et al. 2008) (even though this is argued to not be s significant source of mortality compared to other manmade structures (Erickson et al. 2001, De Lucas et al. 2008)) or acoustic disturbance of marine mammals, potentially causing area avoidance (Nedwell et al. 2003, Gill 2005, Bailey et al. 2010) or disturbance of local habitats/communities (Gill 2005).

Natural Flood Management → Diffuse Pollution Control
Flood mitigation and water purification can be addressed by similar management measures, such as woodland buffer zones (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011), wetland conservation/restoration (Holden et al. 2004, Acreman et al. 2011, Bain et al. 2011) and management practices avoiding pronounced erosive surface flow (e.g. ploughing perpendicular to the flow path of the water or establishing hedgerows) (Heathwaite et al. 2005, DEFRA 2009)
However, some measures aiding in the control of diffuse pollution, such as a hedgerow preventing spray drift (Nisbet et al. 2011), will have only a comparatively small impact on flood control.

Diffuse Pollution Control → Natural Flood Management
Water purification and flood mitigation can be addressed by similar management measures, such as woodland buffer zones (Mainstone and Parr 2002, Calder et al. 2008, Nisbet et al. 2011), wetland conservation/restoration (Holden et al. 2004, Acreman et al. 2011, Bain et al. 2011) and management practices avoiding pronounced erosive surface flow (e.g. ploughing perpendicular to the flow path of the water or establishing hedgerows) (Heathwaite et al. 2005, DEFRA 2009)
This interaction is particularly strong if large areas are taken out of arable production to restore wetlands or floodplains, as can be necessary to re-establish natural flood control within a catchment (Mitsch and Gosselink 2000).

Natural Flood Management → Carbon Storage
Management practices that contribute to carbon storage include (a) the plantation of woody plants (Crockford and Richardson 2000, Hartanto et al. 2003, Calder et al. 2008), thereby increasing

potential for natural flood control through increased rates of infiltration (DEFRA 2009, Nisbet et al. 2011, Alonso et al. 2012, Hagon et al. 2013) or (b) conservation/restoration of areas such as peatlands, which not only store high amounts of carbon, but also contribute to flood control by storing water after precipitation events (Holden 2005, Acreman et al. 2011, Bain et al. 2011).

Carbon Storage → Natural Flood Management
Management practices that contribute to water regulation include (a) increasing infiltration rates through the plantation of woody species (Crockford and Richardson 2000, Hartanto et al. 2003, Calder et al. 2008), which increases the potential for vegetation carbon storage (DEFRA 2009, Nisbet et al. 2011, Alonso et al. 2012, Hagon et al. 2013) or (b) conservation/restoration of areas such as peatlands, which store high amounts of carbon in the soil in addition to contributing to flood control (Holden 2005, Acreman et al. 2011, Bain et al. 2011).
Therefore, management for flood mitigation will often further benefit the carbon storage potential of the area.

Natural Flood Management → Recreation
On an existing flood management site, enhancing the recreation could be a form of protection, as people enjoy the countryside and habitats and it is less likely to revert to alternative management.

Recreation → Natural Flood Management
Water regulation often includes the plantation of woodland or hedgerows (Crockford and Richardson 2000, Calder et al. 2008, DEFRA 2009), as they slow down runoff (Nisbet et al. in Calder et al. 2008, Nisbet et al. 2011) and intercept precipitation (Teklehaimanot et al. 1991, Crockford and Richardson 2000), which promotes entry of water into the soil, as opposed to the next waterway. Both benefits recreation, as woodlands are generally perceived as aesthetically pleasing (Natural England 2009), while hedgerows contribute to a more structurally diverse landscape, which is, again, perceived as more attractive than homogenous ones (Natural England 2009, Church et al. 2011). The same is true for a natural waterway, as opposed to an artificially straightened one.

Natural Flood Management → Development Sites
All kinds of paved surfaces prevent entry of water into the soil, thereby causing rapid surface flow towards the next waterway, which can then cause downstream flooding (Bolund and Hunhammar 1999, Pauleit and Duhme 2000, Perry and Nawaz 2008).

Development Sites → Natural Flood Management
All kinds of paved surfaces prevent entry of water into the soil, thereby causing rapid surface flow towards the next waterway, which can then cause downstream flooding (Bolund and Hunhammar 1999, Pauleit and Duhme 2000, Perry and Nawaz 2008).
Therefore, the conversion of a development site into land beneficial to flood mitigation requires the removal and re-vegetation of the site.

Natural Flood Management → Biodiversity
The biodiversity of an area benefits from structural diversity (Tews et al. 2004, Levine and HilleRisLambers 2009) – measures to promote structural diversity include the plantation of woodlands or hedgerows, both of which also contribute to flood mitigation (Crockford and Richardson 2000, Calder et al. 2008, DEFRA 2009).

Biodiversity → Natural Flood Management
Measures to aid flood control often include the plantation of woodland or hedgerows (Crockford and Richardson 2000, Calder et al. 2008, DEFRA 2009), both of which increase habitat heterogeneity, which benefits biodiversity (Tews et al. 2004, Levine and HilleRisLambers 2009).

Diffuse Pollution Control → Carbon Storage
Carbon storage potential of a habitat can be increased through the establishment of woody plants (vegetation carbon) (DEFRA 2009, Nisbet et al. 2011, Alonso et al. 2012, Hagon et al. 2013) or the restoration of wetlands (soil carbon) (Holden 2005, Acreman et al. 2011, Bain et al. 2011); both of these measures also contribute to water purification (Mainstone and Parr 2002, Holden et al. 2004, Calder et al. 2008, Acreman et al. 2011, Bain et al. 2011, Nisbet et al. 2011).

Carbon Storage → Diffuse Pollution Control
Diffuse pollution control is related to erosion prevention on arable land (Heathwaite et al. 2005, Lane et al. 2006, DEFRA 2009) and the plantation of woodlands, to intercept runoff before entering riverine systems (Calder et al. 2008, Nisbet et al. 2011, Broadmeadow et al. 2014). Both measures, the latter more so than the first, do benefit carbon storage to some extent (Milne and Brown 1997, Boradmeadow and Matthews 2003, Alsonso et al. 2012).
However, other important measures for diffuse pollution control, such as reduction of inputs (Mainstone and Parr 2002), are not related to carbon sequestration.

Diffuse Pollution Control → Recreation
Diffuse Pollution Control is achieved through natural wetlands and dense vegetation (Acreman et al. 2011, Nisbet et al. 2011); creation of recreational features in either of these types of habitats will reduce the amount of pollution control the area can provide.

Recreation → Diffuse Pollution Control
In cases were diffuse pollution is mitigated by the plantation of hedgerows (reduce spray drift) (DEFRA 2009, Nisbet et al. 2011) or woodlands (intercept polluted runoff before reaching waterways) (Calder et al. 2008, Nisbet et al. 2011, Broadmeadows et al. 2014), recreation can benefit as well, as woodlands are generally perceived as aesthetically pleasing (Natural England 2009), while hedgerows contribute to a more structurally diverse landscape, which is, again, perceived as more attractive than homogenous ones (Natural England 2009, Church et al. 2011). The establishment of any of the features mentioned above on a recreational areas, such as playing fields, reduces the recreational value of the site.

Diffuse Pollution Control → Development Sites
Development sites do not contribute to the control of diffuse pollution, as they facilitate rapid surface flow of polluted water to the next waterways (Pauleit and Duhme 2000, Perry and Nawaz 2008). Additionally, factories can be point sources of pollution (Jarvie et al. 2006).

Development Sites → Diffuse Pollution Control
If the control of diffuse pollution provided by a developed site is enhanced through the establishment of some vegetation on the site, this does not have a negative impact on the developed site itself.
If pollution control is achieved through conversion, then the developed site cannot be maintained.

Diffuse Pollution Control → Biodiversity
Measures taken for enhanced biodiversity, such as woodland and/or hedgerow establishment, also benefit the water purification potential of the area (Calder et al. 2008, DEFRA 2009, Nisbet et al. 2011, Broadmeadows et al. 2014).
Biodiversity → Diffuse Pollution Control
Measures for diffuse pollution control benefit (a) biodiversity on land, through increased heterogeneity (Tews et al. 2004, Levine and HilleRisLambers 2009) caused by the establishment of woodland and/or hedgerows (Calder et al. 2008, DEFRA 2009, Nisbet et al. 2011, Broadmeadows et

al. 2014) and (b) freshwater biodiversity, as potentially regime-shift causing eutrophication in rivers is avoided (Leaf et al. 2002, Hilton et al. 2006, Conley et al. 2009, Acreman et al. 2011). In cases of artificial wetlands being used for water purification (Shutes 2001), habitat for wetland species is created.

Carbon Storage → Recreation
In cases where the creation of recreational features requires clear cutting of (parts of) a woodland or drainage of wetland, the amount of carbon the site can store is reduced.
In cases where woodland is planted to increase the attractiveness of a neighbourhood, carbon storage potential of the area benefits as well, as woodlands are a substantial store for terrestrial carbon (Milne and Brown 1997, Braodmeadow and Matthews 2003, Alonso et al 2012, Hagon et al. 2013).

Recreation → Carbon Storage
Woodlands are a substantial store for terrestrial carbon (Milne and Brown 1997, Braodmeadow and Matthews 2003, Alonso et al 2012, Hagon et al. 2013). Woodland conservation/reforestation can therefore benefit carbon storage as well as recreation, as woodlands are generally perceived as aesthetically pleasing (Natural England 2009).
Restoration/conservation of peatlands benefits carbon storage (Natural England 2010) and can have some recreational benefit (Acreman et al. 2011), even though health and safety concerns make wetlands less suitable for many recreational activities than woodlands are.
Management of arable land for maximised carbon storage only benefits recreation if hedgerows, tree belts or buffer strips are used (Hagon et al. 2013), as these increase the structural heterogeneity of the landscape, which is perceived as aesthetically pleasing (Natural England 2009, Church et al. 2011).

Carbon Storage → Development Sites
During construction, soil disturbance (Scottish Executive 2007, Alonso et al. 2012) and clear-cutting of vegetation (Milne and Brown 1997, Alonso et al. 2012) or drainage of peatlands (Natural England 2010, Bain et al. 2011) cause carbon emissions. After construction, paved surface covering soil and a lack of vegetation prevent carbon storage at these sites (Milne and Brown 1997). In case of factories, development sites can be a continuous source of carbon emission.
Development Sites → Carbon Storage
Substantial carbon storage is not possible on developed sites; to achieve carbon storage, re-vegetation is required, which means that all paved surfaces need to be removed.

Carbon Storage → Biodiversity
Measures benefitting biodiversity often benefit carbon storage as well, particularly in case of the plantation of woody plants, e.g. hedgerows on arable land (Hagon et al. 2013).

Biodiversity → Carbon Storage
Many measures benefitting carbon storage (restoration/conservation of woodland/peatland, plantation of hedgerows on farms) (Milne and Brown 1997, Broadmeadow and Matthews 2003, Alonso et al. 2012, Hagon et al. 2013) also benefit biodiversity, as habitat heterogeneity is promoted (Tews et al. 2004, Levine and HilleRisLambers 2009). In regards of soil disturbance (Scottish Executive 2007, Alonso et al. 2012), this refers primarily to the below-ground biodiversity (Haygarth and Ritz 2009).

Recreation → Development Sites
If the recreation is a site such as a playground or park, development will replace the service. However if recreation is a footpath then it is possible to keep it and with sensitive development

enhance some aspects of it. During construction, no recreation can take place on development sites. In case of factories, recreation is inhibited, as industrial buildings are generally perceived as aesthetically unpleasant

Development Sites → Recreation
On an existing development site, recreation can often be added without loss of development income in the form of small paths, play areas or greens that add to the value of properties, alternatively on a large industrial site recreation may be inhibited for safety or aesthetic reasons.

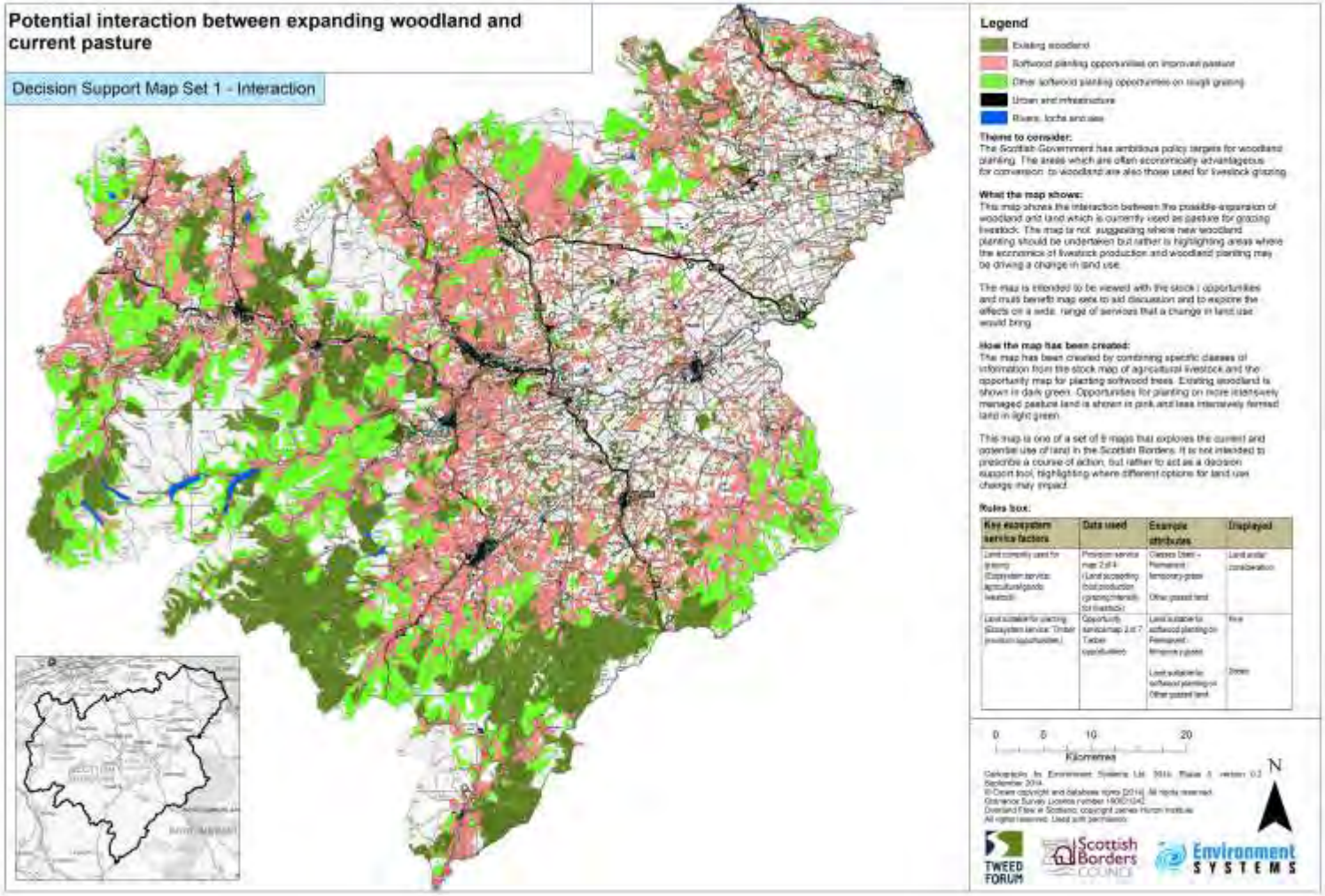
Recreation → Biodiversity
Heterogeneous, species-rich habitats are perceived as pleasant by many recreationists (Natural England 2009, Church et al. 2011); therefore, conservation of biodiversity will benefit the recreation value of a site.

Biodiversity → Recreation
Intensive recreational use of natural areas can cause disturbance to the local wildlife (Cole 1993, George and Crooks 2006, Steven et al. 2011), thereby reducing biodiversity within the area. How strong this effect is depends on habitat, behaviour of recreationists and, in case of protected areas, management measures (Eagles et al. 2002).

Development Sites → Biodiversity
Some measures of biodiversity conservation, e.g. the establishment of some degree of vegetation, can be taken without impacting the benefits gained from the developed sites. This vegetation can act as corridor, for wildlife to be able to cross the site (Bennett 1990, Beier and Noss 1998).

Biodiversity → Development Sites
Development sites cause habitat loss, which can reduce the biodiversity of an area. It is possible to put biodiversity measure into new developments to enhance habitats and species such as water features, natural planting and species specific shelter features.

Appendix 2


Potential interaction between expanding woodland and current pasture
Decision Support Map Set 1 - Interaction
Legend
Existing woodland
Softwood planting opportunities on improved pasture
Other softwood planting opportunities on rough grazing
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
The Scottish Government has ambitious policy targets for woodland planting. The areas which are often economically advantageous for conversion to woodland are also those used for livestock grazing.
What the map shows:
This map shows the interaction between the possible expansion of woodland and land which is currently used as pasture for grazing livestock. The map is not suggesting where new woodland planting should be undertaken but rather is highlighting areas where the economics of livestock production and woodland planting may be driving a change in land use.
The map is intended to be viewed with the stock / opportunities and multi benefit map sets to aid discussion and to explore the effects on a wide range of services that a change in land use would bring.
How the map has been created:
The map has been created by combining specific classes of information from the stock map of agricultural livestock and the opportunity map for planting softwood trees. Existing woodland is shown in dark green. Opportunities for planting on more intensively managed pasture land is shown in pink and less intensively farmed land in light green.
This map is one of a set of 8 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for land use change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
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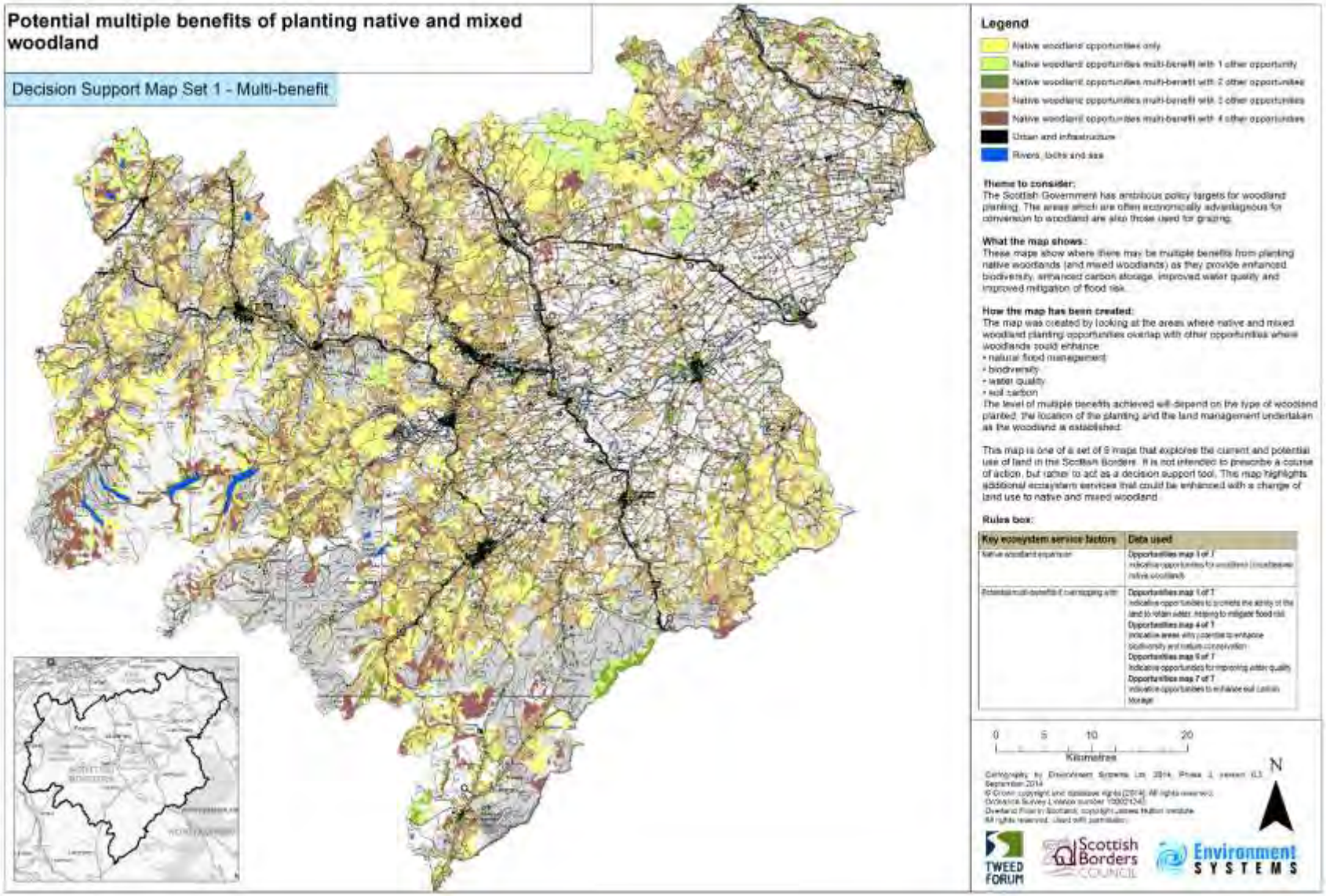
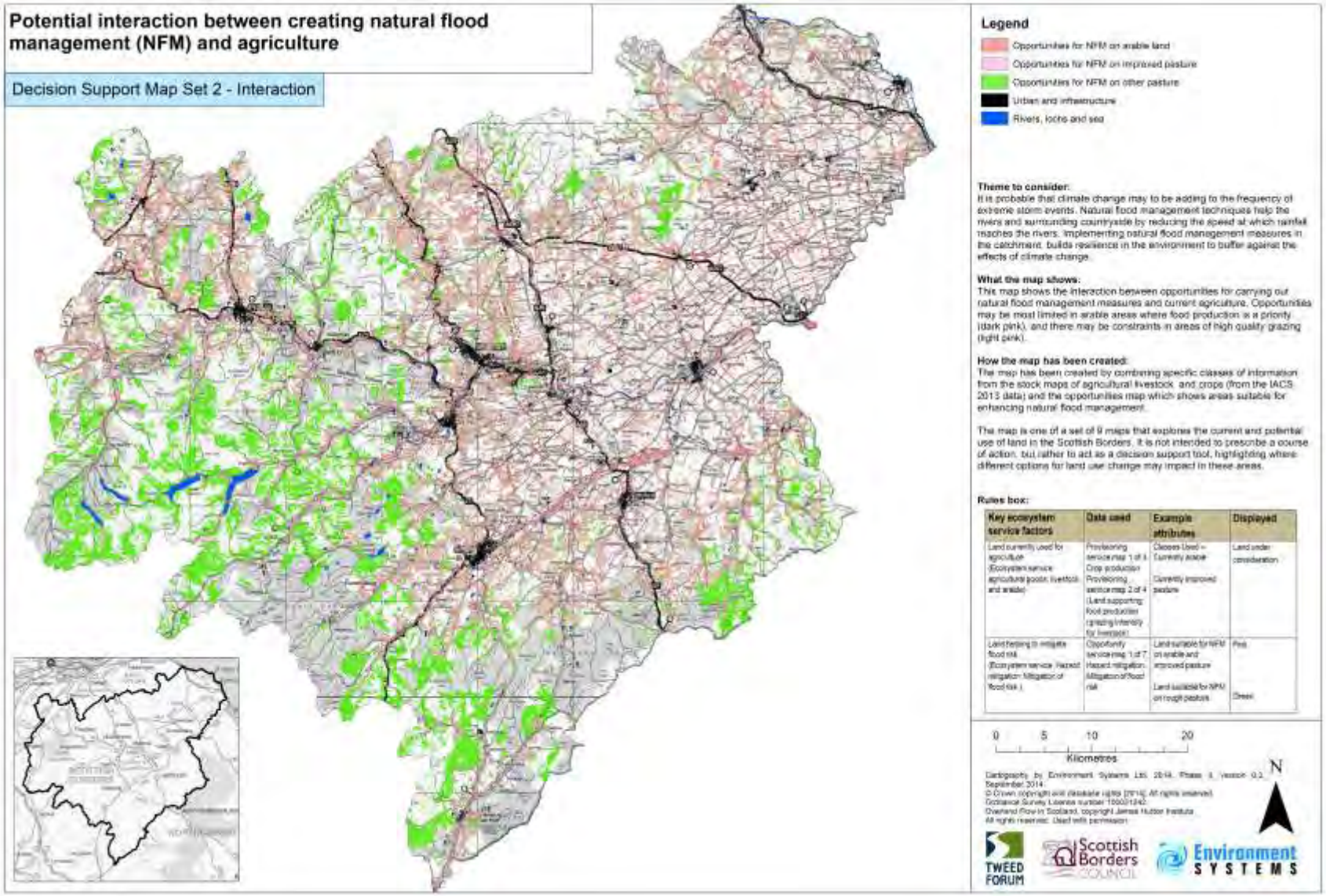
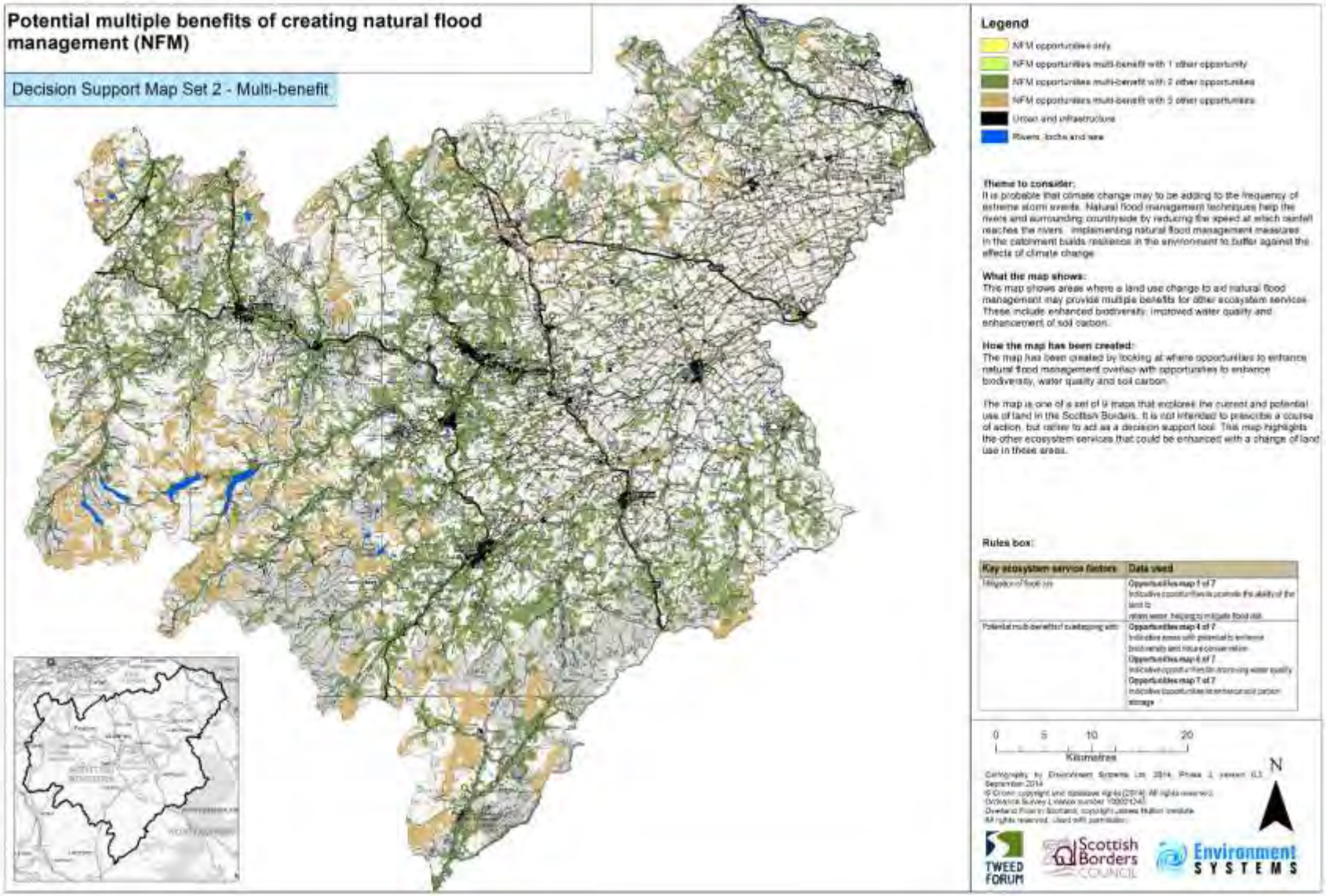
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential multiple benefits of planting native and mixed woodland
Decision Support Map Set 1 - Multi-benefit
Legend
Native woodland opportunities only
Native woodland opportunities multi-benefit with 1 other opportunity
Native woodland opportunities multi-benefit with 2 other opportunities
Native woodland opportunities multi-benefit with 3 other opportunities
Native woodland opportunities multi-benefit with 4 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Items to consider:
The Scottish Government has ambitious policy targets for woodland planting. The areas which are often economically advantageous for conversion to woodland are also those used for grazing.
What the map shows:
These maps show where there may be multiple benefits from planting native woodlands (and mixed woodlands) as they provide enhanced biodiversity, enhanced carbon storage, improved water quality and improved mitigation of flood risk.
How the map has been created:
The map was created by looking at the areas where native and mixed woodland planting opportunities overlap with other opportunities where woodlands could enhance:
• natural flood management
• biodiversity
• water quality
• soil carbon
The level of multiple benefits achieved will depend on the type of woodland planted, the location of the planting and the land management undertaken as the woodland is established.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights additional ecosystem services that could be enhanced with a change of land use to native and mixed woodland.
Rules box:
Key ecosystem service factors
Data used
Native woodland expansion
Opportunities map 1 of 7
indicative opportunities for woodland creation/restoration native woodlands
Potential multi-benefits if overlapping with
Opportunities map 1 of 7
indicative opportunities to promote the ability of the land to retain water, helping to mitigate flood risk
Opportunities map 4 of 7
indicative areas with potential to enhance biodiversity and nature conservation
Opportunities map 5 of 7
Indicative opportunities for improving water quality
Opportunities map 7 of 7
indicative opportunities to enhance soil carbon storage
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential interaction between creating natural flood management (NFM) and agriculture
Decision Support Map Set 2 - Interaction
Legend
Opportunities for NFM on arable land
Opportunities for NFM on improved pasture
Opportunities for NFM on other pasture
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
It is probable that climate change may to be adding to the frequency of extreme storm events. Natural flood management techniques help the rivers and surrounding countryside by reducing the speed at which rainfall reaches the rivers. Implementing natural flood management measures in the catchment builds resilience in the environment to buffer against the effects of climate change.
What the map shows:
This map shows the interaction between opportunities for carrying out natural flood management measures and current agriculture. Opportunities may be most limited in arable areas where food production is a priority (dark pink), and there may be constraints in areas of high quality grazing (light pink).
How the map has been created:
The map has been created by combining specific classes of information from the stock maps of agricultural livestock and crops (from the IACS 2013 data) and the opportunities map which shows areas suitable for enhancing natural flood management.
The map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for land use change may impact in these areas.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land currently used for agriculture (Ecosystem service: agriculture (pasture, livestock and arable))
Provisioning service map 1 of 3: Crop production
Provisioning service map 2 of 4 (Land supporting food production (grazing intensity for livestock))
Classes Used = Currently arable
Currently improved pasture
Land under consideration
Land having to mitigate flood risk (Ecosystem service: Hazard mitigation: Mitigation of flood risk)
Opportunity service map 1 of 7: Hazard mitigation: Mitigation of flood risk
Land suitable for NFM on arable and improved pasture
Land suitable for NFM on rough pasture
Pink
Green
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential multiple benefits of creating natural flood management (NFM)
Decision Support Map Set 2 - Multi-benefit
Legend
NFM opportunities only
NFM opportunities multi-benefit with 1 other opportunity
NFM opportunities multi-benefit with 2 other opportunities
NFM opportunities multi-benefit with 3 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
It is probable that climate change may to be adding to the frequency of extreme storm events. Natural flood management techniques help the rivers and surrounding countryside by reducing the speed at which rainfall reaches the rivers. Implementing natural flood management measures in the catchment builds resilience in the environment to buffer against the effects of climate change.
What the map shows:
This map shows areas where a land use change to aid natural flood management may provide multiple benefits for other ecosystem services. These include enhanced biodiversity, improved water quality and enhancement of soil carbon.
How the map has been created:
The map has been created by looking at where opportunities to enhance natural flood management overlap with opportunities to enhance biodiversity, water quality and soil carbon.
The map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights the other ecosystem services that could be enhanced with a change of land use in these areas.
Rules box:
Key ecosystem service factors
Data used
Opportunities map 1 of 7
Opportunities map 4 of 7
Opportunities map 6 of 7
Opportunities map 7 of 7
0
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Kilometres
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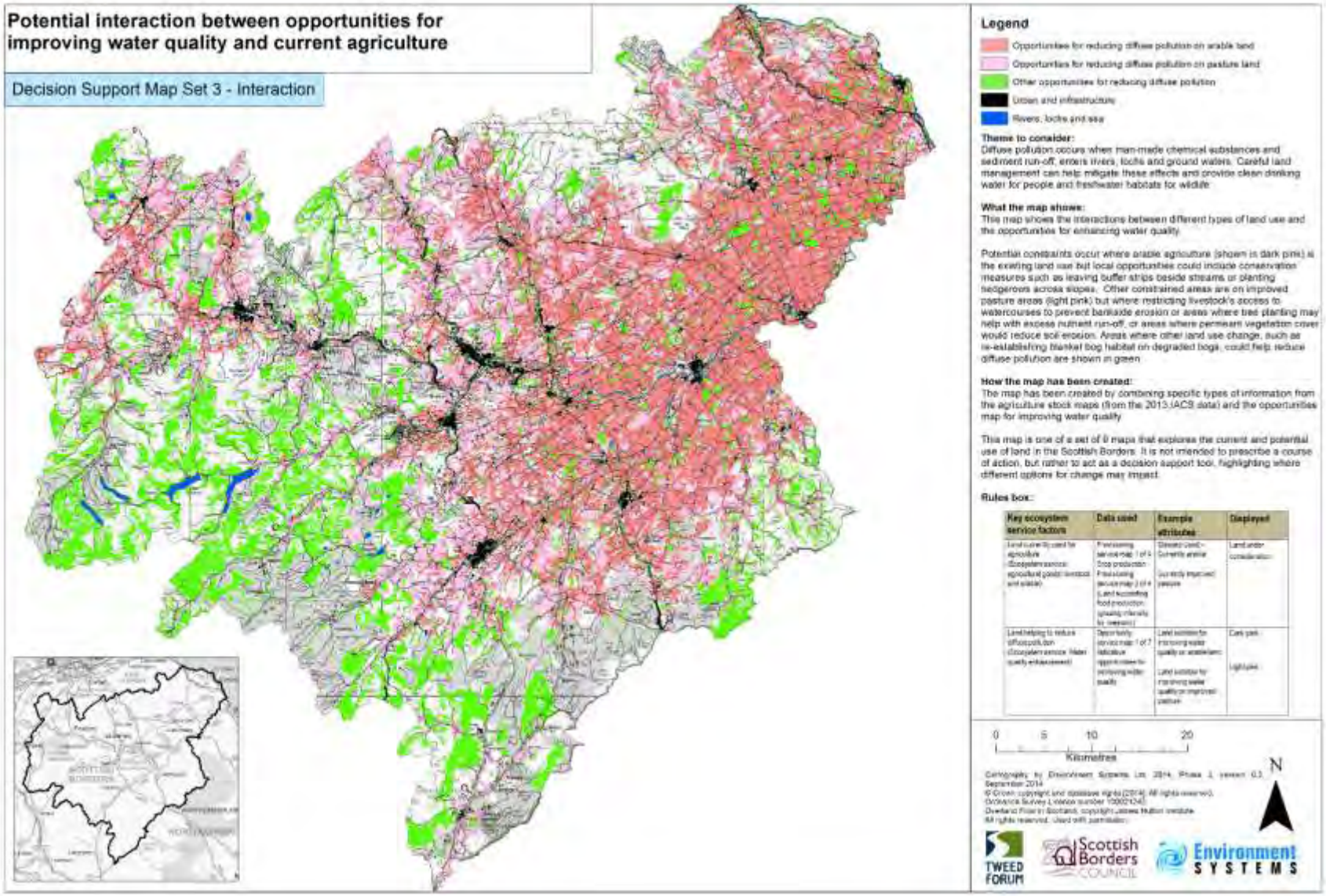
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential interaction between opportunities for improving water quality and current agriculture
Decision Support Map Set 3 - Interaction
Legend
Opportunities for reducing diffuse pollution on arable land
Opportunities for reducing diffuse pollution on pasture land
Other opportunities for reducing diffuse pollution
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Diffuse pollution occurs when man-made chemical substances and sediment run-off, enters rivers, lochs and ground waters. Careful land management can help mitigate these effects and provide clean drinking water for people and freshwater habitats for wildlife
What the map shows:
This map shows the interactions between different types of land use and the opportunities for enhancing water quality.
Potential constraints occur where arable agriculture (shown in dark pink) is the existing land use but local opportunities could include conservation measures such as leaving buffer strips beside streams or planting hedgerows across slopes. Other constrained areas are on improved pasture areas (light pink) but where restricting livestock's access to watercourses to prevent bankside erosion or areas where tree planting may help with excess nutrient run-off, or areas where permeant vegetation cover would reduce soil erosion. Areas where other land use change, such as re-establishing blanket bog habitat on degraded bogs, could help reduce diffuse pollution are shown in green
How the map has been created:
The map has been created by combining specific types of information from the agriculture stock maps (from the 2013 IACS data) and the opportunities map for improving water quality
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
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Kilometres
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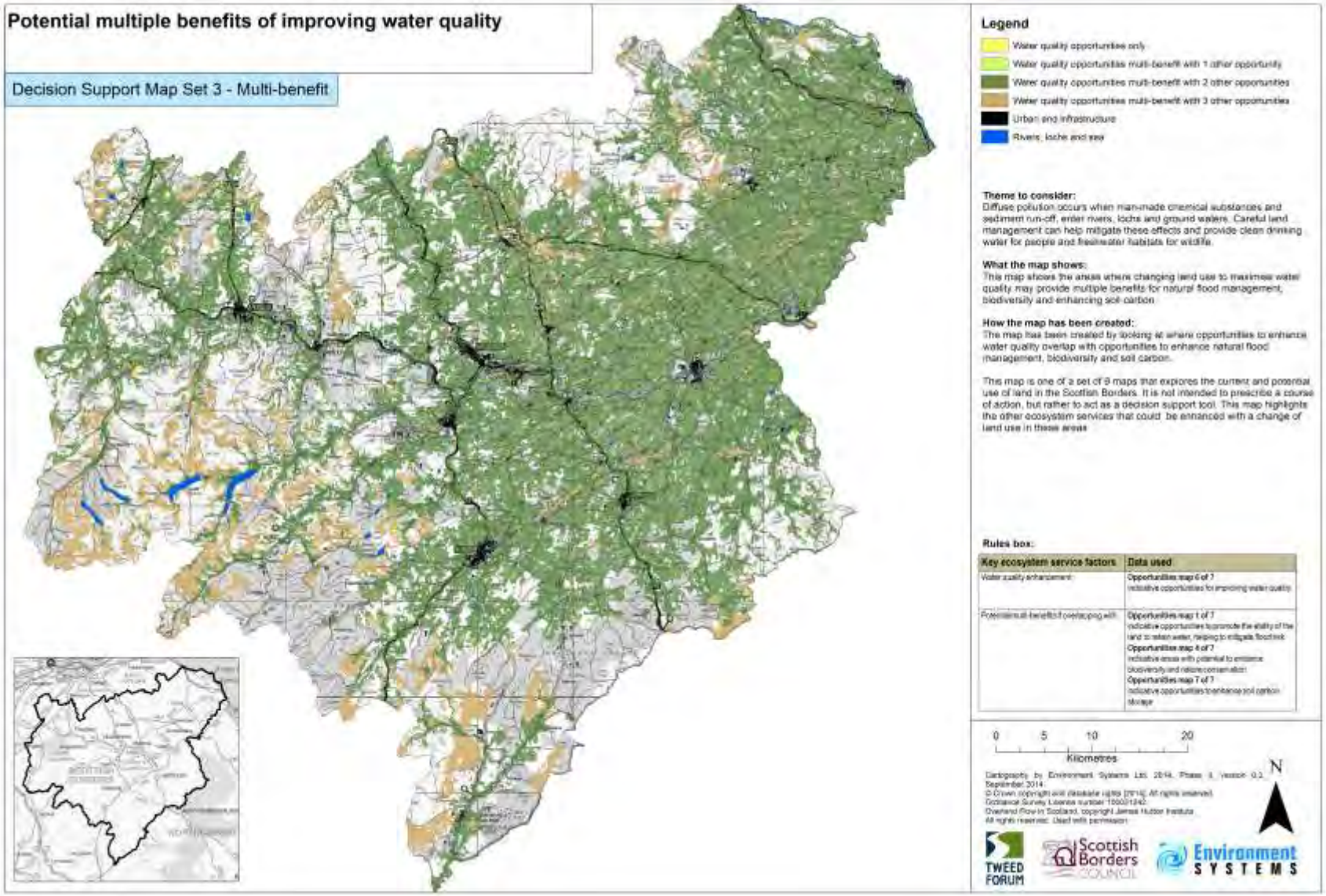
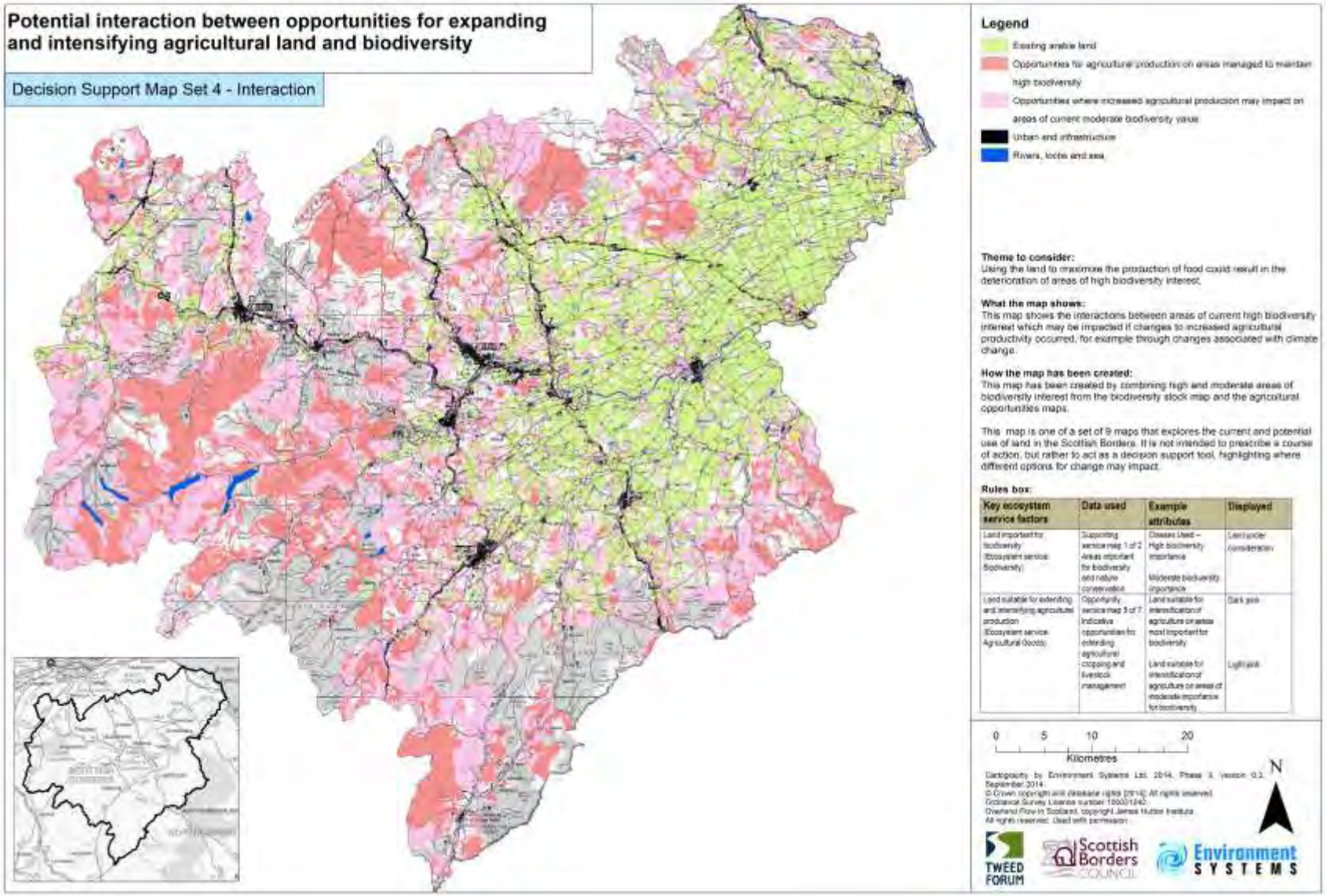
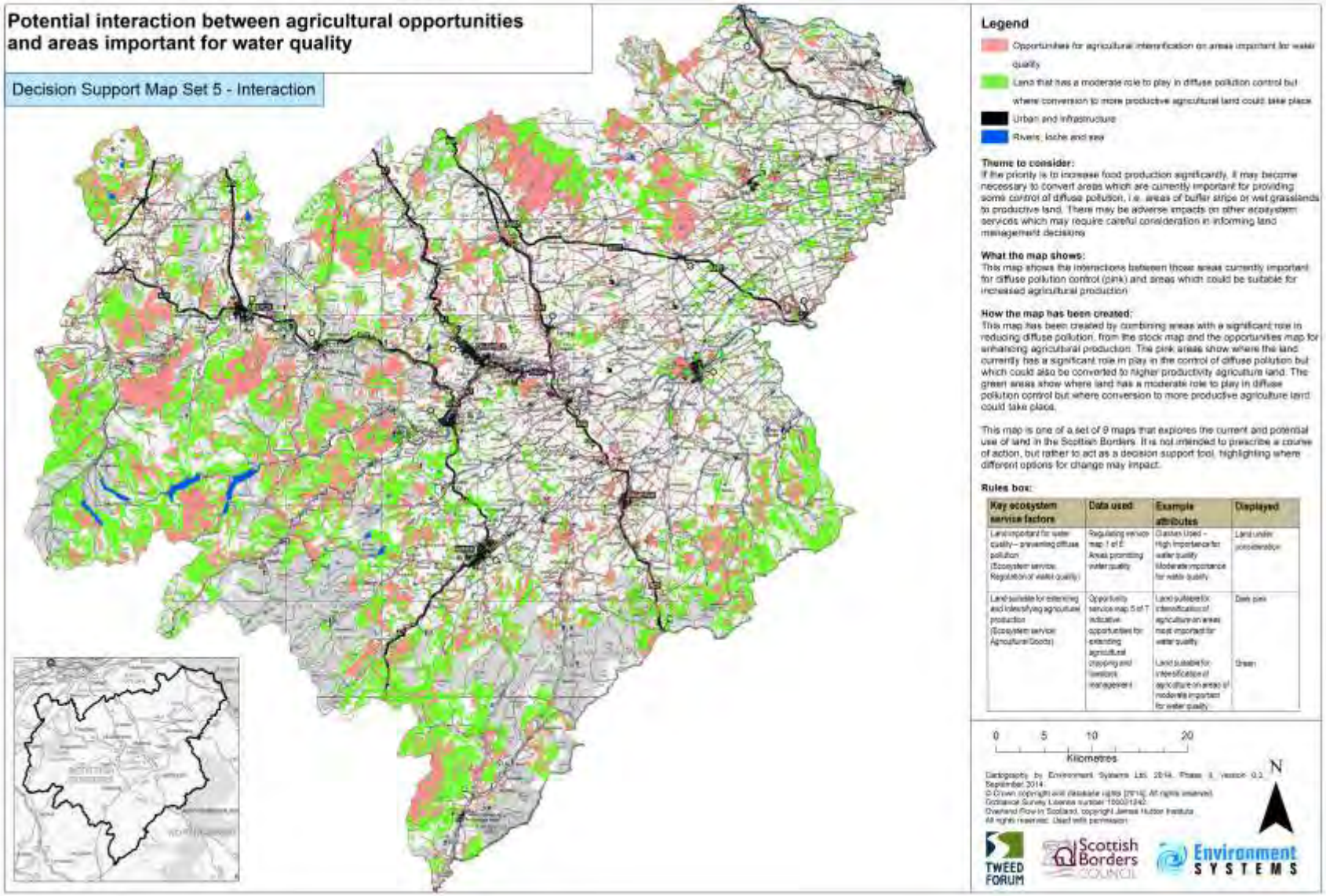
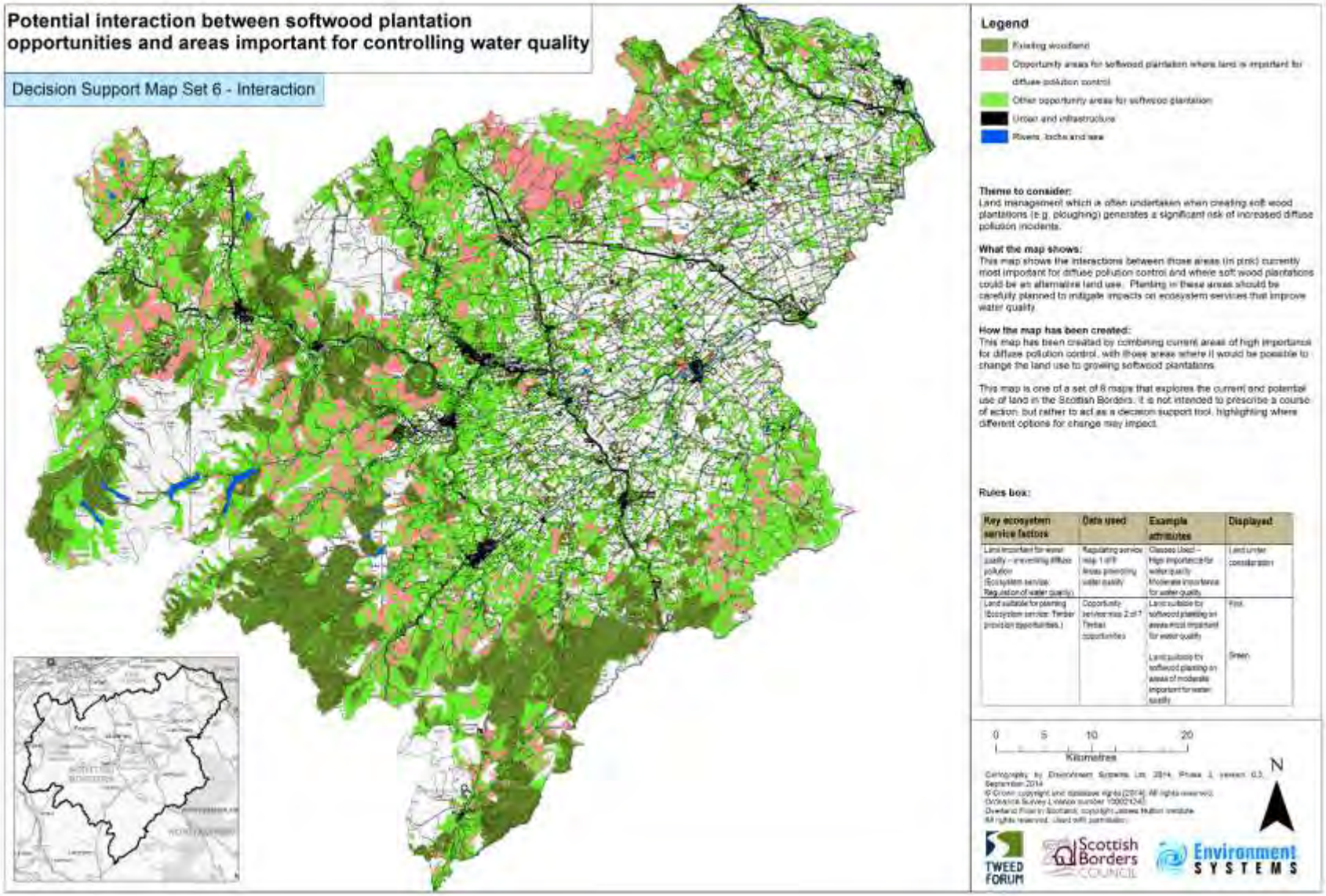
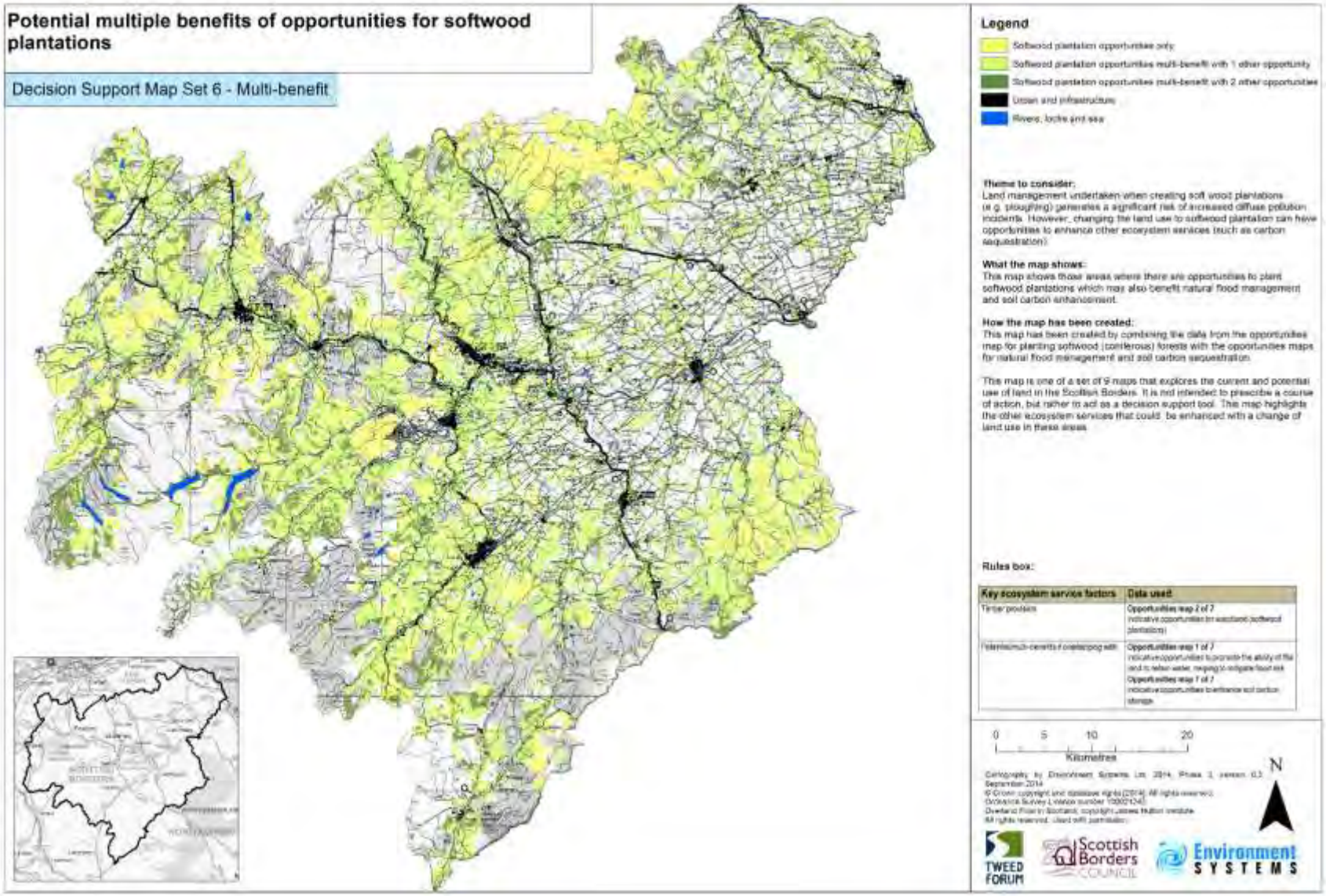
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

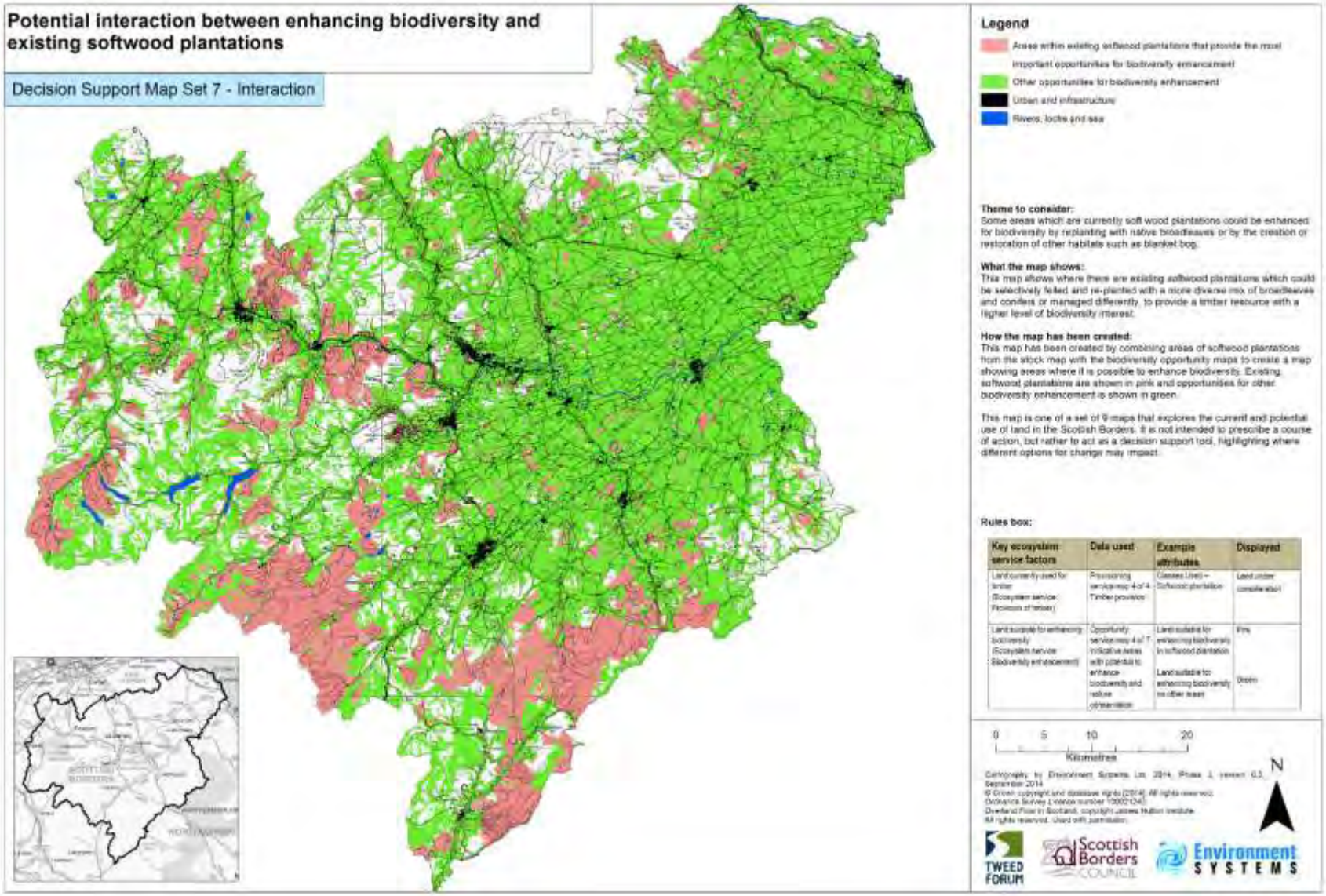

Potential multiple benefits of improving water quality
Decision Support Map Set 3 - Multi-benefit
Legend
Water quality opportunities only
Water quality opportunities multi-benefit with 1 other opportunity
Water quality opportunities multi-benefit with 2 other opportunities
Water quality opportunities multi-benefit with 3 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Diffuse pollution occurs when man-made chemical substances and sediment run-off, enter rivers, lochs and ground waters. Careful land management can help mitigate these effects and provide clean drinking water for people and freshwater habitats for wildlife.
What the map shows:
This map shows the areas where changing land use to maximise water quality may provide multiple benefits for natural flood management, biodiversity and enhancing soil carbon.
How the map has been created:
The map has been created by looking at where opportunities to enhance water quality overlap with opportunities to enhance natural flood management, biodiversity and soil carbon.
This map is one of a set of 8 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights the other ecosystem services that could be enhanced with a change of land use in these areas
Rules box:
Key ecosystem service factors
Data used
Water quality enhancement
Opportunities map 6 of 7
Indicative opportunities for improving water quality
Potential multi-benefits overlapping with
Opportunities map 1 of 7
Opportunities map 4 of 7
Opportunities map 7 of 7
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

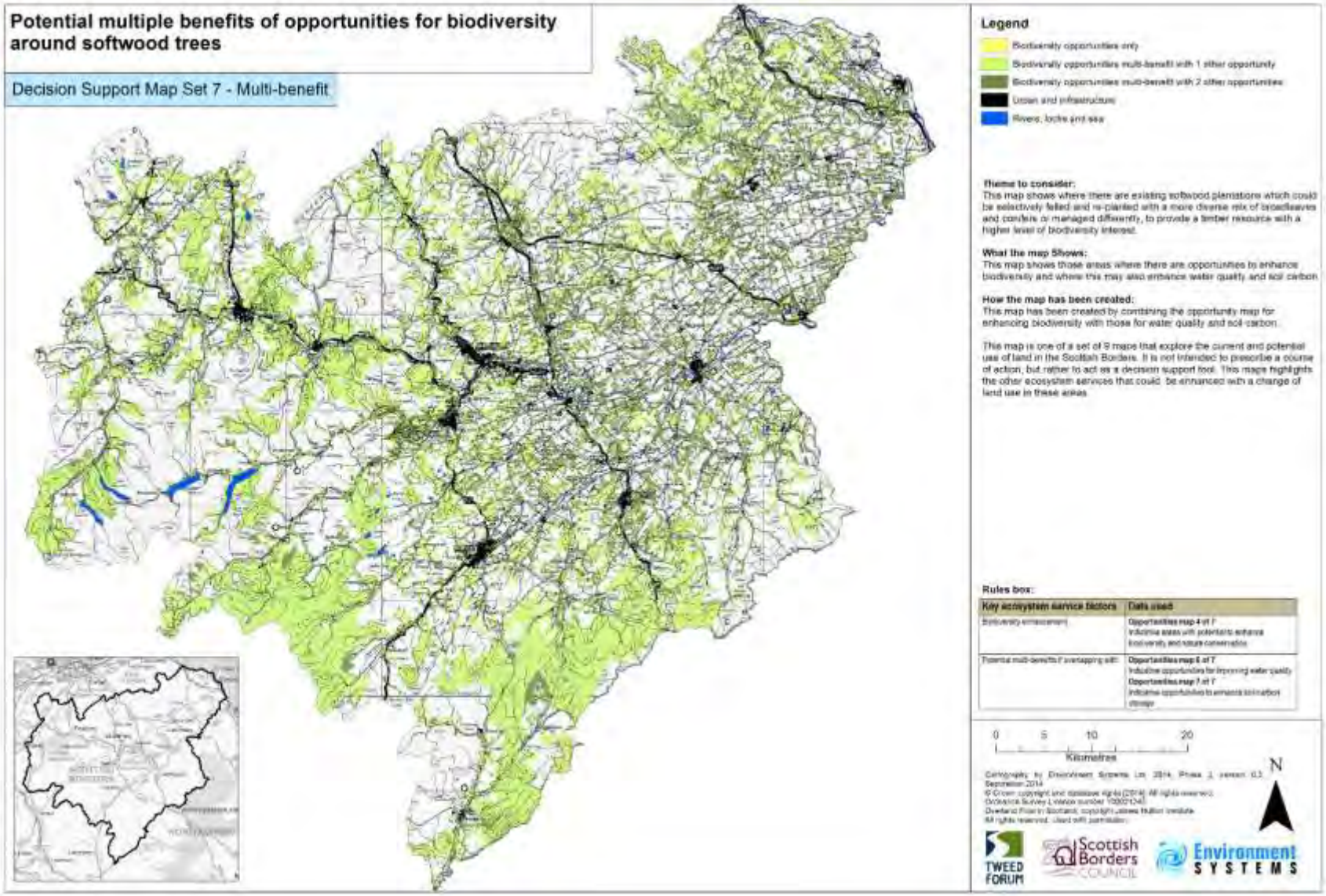

Potential interaction between opportunities for expanding and intensifying agricultural land and biodiversity
Decision Support Map Set 4 - Interaction
Legend
Existing arable land
Opportunities for agricultural production on areas managed to maintain high biodiversity
Opportunities where increased agricultural production may impact on areas of current moderate biodiversity value
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Using the land to maximise the production of food could result in the deterioration of areas of high biodiversity interest.
What the map shows:
This map shows the interactions between areas of current high biodiversity interest which may be impacted if changes to increased agricultural productivity occurred, for example through changes associated with climate change.
How the map has been created:
This map has been created by combining high and moderate areas of biodiversity interest from the biodiversity stock map and the agricultural opportunities maps.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land important for biodiversity (Ecosystem service: Biodiversity)
Supporting service map 1 of 2 Areas important for biodiversity and nature conservation
Classes Used – High biodiversity importance
Moderate biodiversity importance
Land under consideration
Land suitable for extending and intensifying agricultural production (Ecosystem service: Agricultural Goods)
Opportunity service map 3 of 7 Indicative opportunities for extending agricultural cropping and livestock management
Land suitable for intensification of agriculture on areas most important for biodiversity
Land suitable for intensification of agriculture on areas of moderate importance for biodiversity
Dark pink
Light pink
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

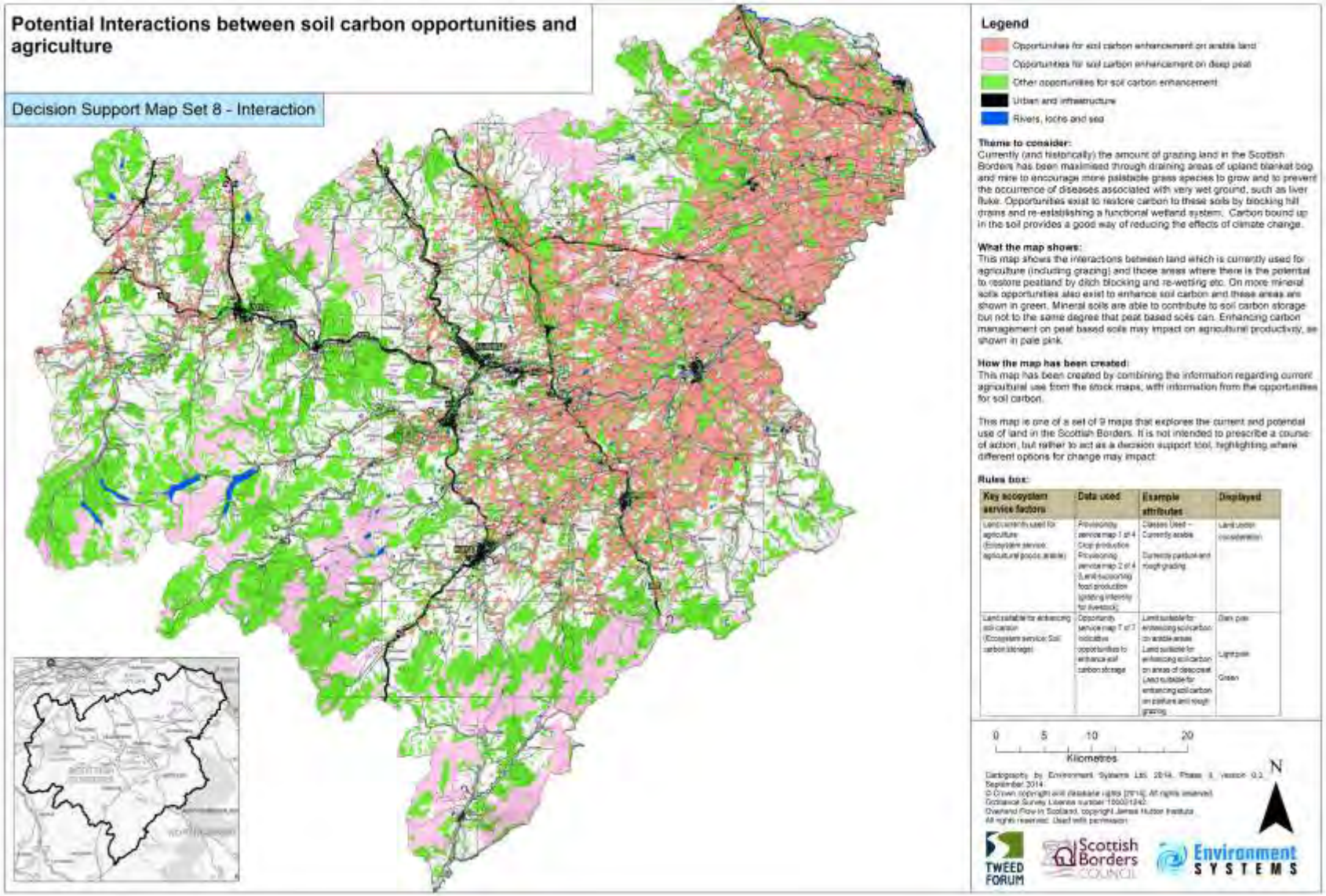

Potential interaction between agricultural opportunities and areas important for water quality
Decision Support Map Set 5 - Interaction
Legend
Opportunities for agricultural intensification on areas important for water quality
Land that has a moderate role to play in diffuse pollution control but where conversion to more productive agricultural land could take place
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
If the priority is to increase food production significantly, it may become necessary to convert areas which are currently important for providing some control of diffuse pollution, i.e. areas of buffer strips or wet grasslands to productive land. There may be adverse impacts on other ecosystem services which may require careful consideration in informing land management decisions
What the map shows:
This map shows the interactions between those areas currently important for diffuse pollution control (pink) and areas which could be suitable for increased agricultural production
How the map has been created:
This map has been created by combining areas with a significant role in reducing diffuse pollution, from the stock map and the opportunities map for enhancing agricultural production. The pink areas show where the land currently has a significant role in play in the control of diffuse pollution but which could also be converted to higher productivity agriculture land. The green areas show where land has a moderate role to play in diffuse pollution control but where conversion to more productive agriculture land could take place.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land important for water quality – preventing diffuse pollution (Ecosystem service: Regulation of water quality)
Regulating service map 1 of 5: Areas promoting water quality
Classes Used – High importance for water quality Moderate importance for water quality
Land under consideration
Land suitable for extensifying and intensifying agricultural production (Ecosystem service: Agricultural Goods)
Opportunity service map 5 of 7 indicative opportunities for extending agricultural cropping and livestock management
Land suitable for intensification of agriculture on areas most important for water quality
Land suitable for intensification of agriculture on areas of moderate importance for water quality
Dark pink
Green
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

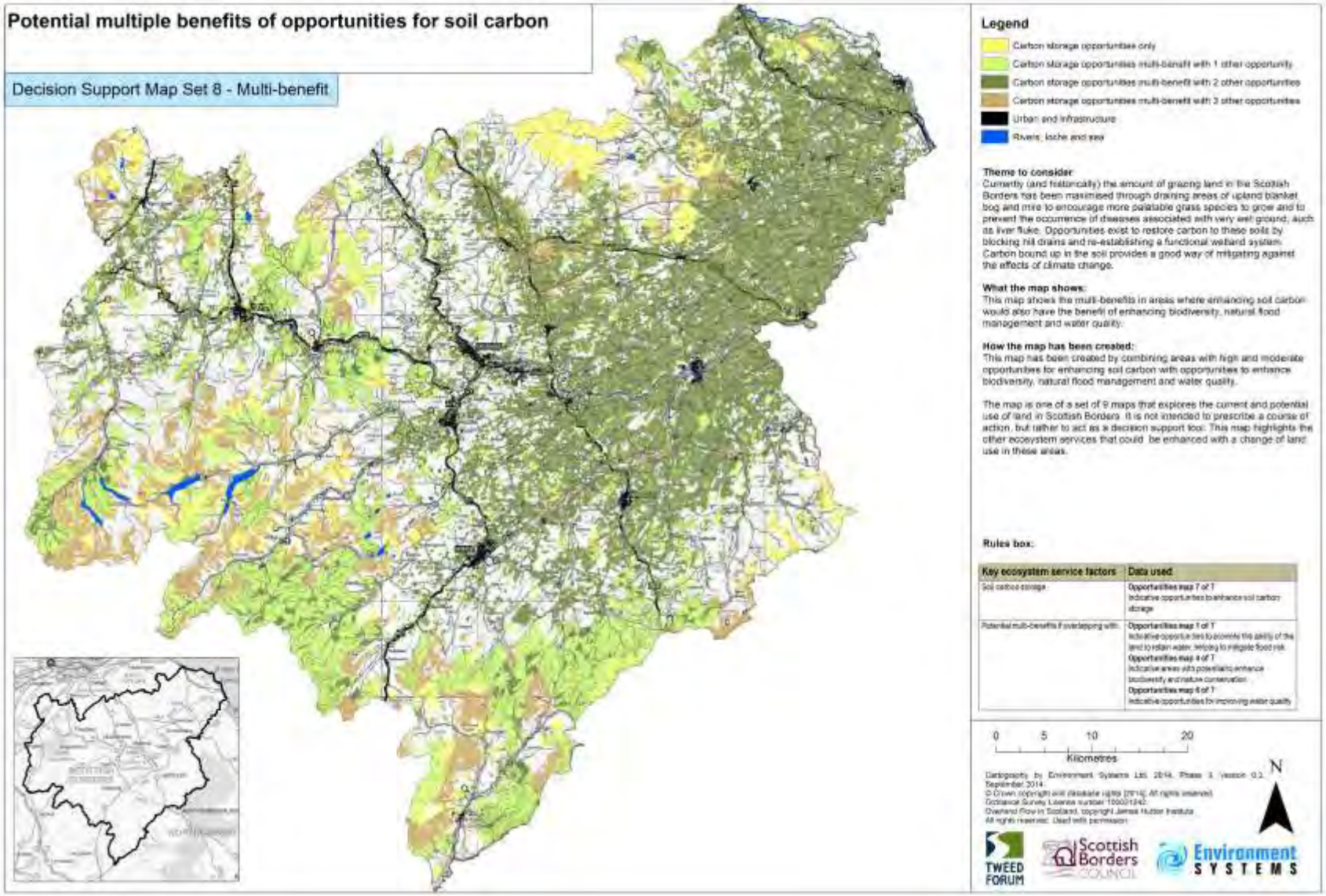

Potential interaction between softwood plantation opportunities and areas important for controlling water quality
Decision Support Map Set 6 - Interaction
Legend
Existing woodland
Opportunity areas for softwood plantation where land is important for diffuse pollution control
Other opportunity areas for softwood plantation
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Land management which is often undertaken when creating soft wood plantations (e.g. ploughing) generates a significant risk of increased diffuse pollution incidents.
What the map shows:
This map shows the interactions between those areas (in pink) currently most important for diffuse pollution control and where soft wood plantations could be an alternative land use. Planting in these areas should be carefully planned to mitigate impacts on ecosystem services that improve water quality.
How the map has been created:
This map has been created by combining current areas of high importance for diffuse pollution control, with those areas where it would be possible to change the land use to growing softwood plantations.
This map is one of a set of 6 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land important for water quality – preventing diffuse pollution (Ecosystem service: Regulation of water quality)
Regulating service resp 1 of 7 Areas preventing water quality
Classes Used – High importance for water quality Moderate importance for water quality
Land under consideration
Land suitable for planting (Ecosystem service: Timber provision opportunities.)
Opportunity service resp 2 of 7 Timber opportunities
Land suitable for softwood planting on areas most important for water quality
Land suitable for softwood planting on areas of moderate important for water quality
First
Green
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

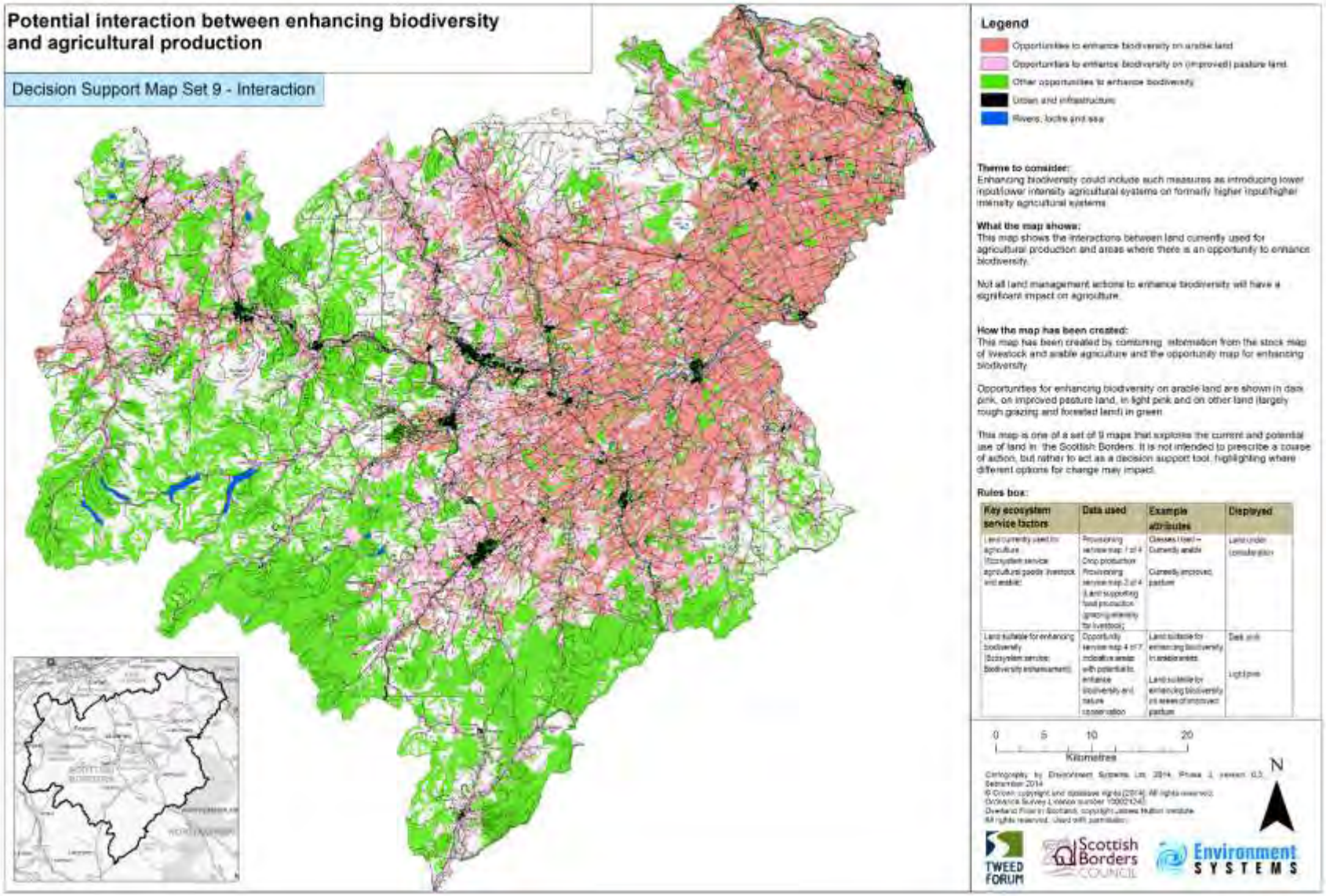

Potential multiple benefits of opportunities for softwood plantations
Decision Support Map Set 6 - Multi-benefit
Legend
Softwood plantation opportunities only
Softwood plantation opportunities multi-benefit with 1 other opportunity
Softwood plantation opportunities multi-benefit with 2 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Land management undertaken when creating soft wood plantations (e.g. ploughing) generates a significant risk of increased diffuse pollution incidents. However, changing the land use to softwood plantation can have opportunities to enhance other ecosystem services (such as carbon sequestration).
What the map shows:
This map shows those areas where there are opportunities to plant softwood plantations which may also benefit natural flood management and soil carbon enhancement.
How the map has been created:
This map has been created by combining the data from the opportunities map for planting softwood (coniferous) forests with the opportunities maps for natural flood management and soil carbon sequestration.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights the other ecosystem services that could be enhanced with a change of land use in these areas.
Rules box:
Key ecosystem service factors
Data used
Timber provision
Opportunities map 2 of 7
Potential multi-benefits if overlapping with
Opportunities map 1 of 7
Opportunities map 7 of 7
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS

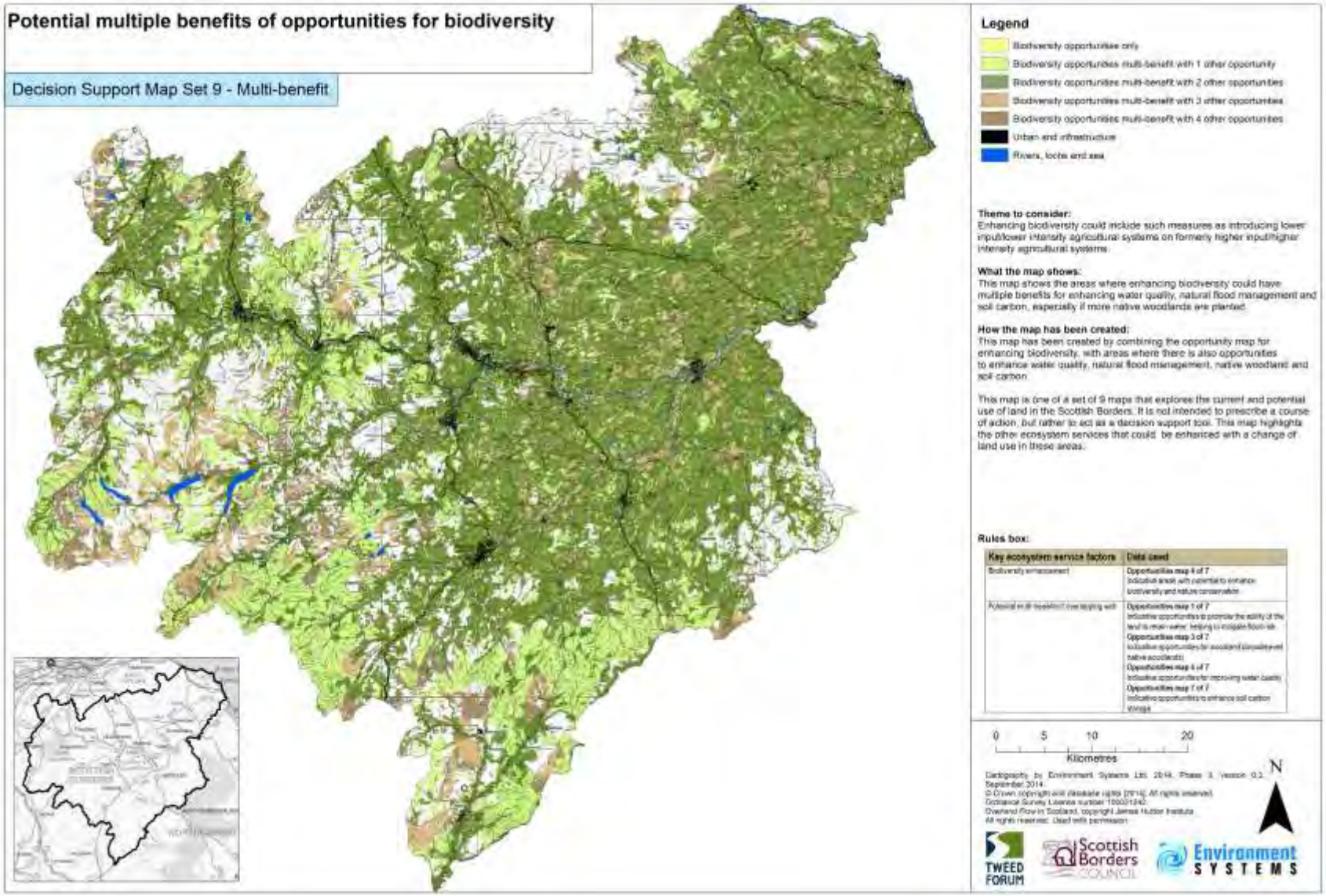

Potential interaction between enhancing biodiversity and existing softwood plantations
Decision Support Map Set 7 - Interaction
Legend
Areas within existing softwood plantations that provide the most important opportunities for biodiversity enhancement
Other opportunities for biodiversity enhancement
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Some areas which are currently soft wood plantations could be enhanced for biodiversity by replanting with native broadleaves or by the creation or restoration of other habitats such as blanket bog.
What the map shows:
This map shows where there are existing softwood plantations which could be selectively felled and re-planted with a more diverse mix of broadleaves and conifers or managed differently, to provide a timber resource with a higher level of biodiversity interest.
How the map has been created:
This map has been created by combining areas of softwood plantations from the stock map with the biodiversity opportunity maps to create a map showing areas where it is possible to enhance biodiversity. Existing softwood plantations are shown in pink and opportunities for other biodiversity enhancement is shown in green.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land currently used for timber (Ecosystem service: Provision of timber)
Land suitable for enhancing biodiversity (Ecosystem service: Biodiversity enhancement)
Land suitable for enhancing biodiversity in softwood plantation
Land suitable for enhancing biodiversity in other areas
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential multiple benefits of opportunities for biodiversity around softwood trees
Decision Support Map Set 7 - Multi-benefit
Legend
Biodiversity opportunities only
Biodiversity opportunities multi-benefit with 1 other opportunity
Biodiversity opportunities multi-benefit with 2 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Items to consider:
This map shows where there are existing softwood plantations which could be selectively felled and re-planted with a more diverse mix of broadleaves and conifers or managed differently, to provide a timber resource with a higher level of biodiversity interest.
What the map Shows:
This map shows those areas where there are opportunities to enhance biodiversity and where this may also enhance water quality and soil carbon.
How the map has been created:
This map has been created by combining the opportunity map for enhancing biodiversity with those for water quality and soil carbon.
This map is one of a set of 9 maps that explore the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This maps highlights the other ecosystem services that could be enhanced with a change of land use in these areas.
Rules box:
Key ecosystem service factors
Data used
Opportunities map 7 of 7
Kilometres
0
5
10
20
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential Interactions between soil carbon opportunities and agriculture
Decision Support Map Set 8 - Interaction
Legend
Opportunities for soil carbon enhancement on arable land
Opportunities for soil carbon enhancement on deep peat
Other opportunities for soil carbon enhancement
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Currently (and historically) the amount of grazing land in the Scottish Borders has been maximised through draining areas of upland blanket bog and mire to encourage more palatable grass species to grow and to prevent the occurrence of diseases associated with very wet ground, such as liver fluke. Opportunities exist to restore carbon to these soils by blocking hill drains and re-establishing a functional wetland system. Carbon bound up in the soil provides a good way of reducing the effects of climate change.
What the map shows:
This map shows the interactions between land which is currently used for agriculture (including grazing) and those areas where there is the potential to restore peatland by ditch blocking and re-wetting etc. On more mineral soils opportunities also exist to enhance soil carbon and these areas are shown in green. Mineral soils are able to contribute to soil carbon storage but not to the same degree that peat based soils can. Enhancing carbon management on peat based soils may impact on agricultural productivity, as shown in pale pink.
How the map has been created:
This map has been created by combining the information regarding current agricultural use from the stock maps, with information from the opportunities for soil carbon.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land currently used for agriculture (Ecosystem service: agricultural goods available)
Provisioning service map 1 of 4 Crop production
Provisioning service map 2 of 4 Land supporting food production (grazing intensity for livestock)
Classes Used – Currently arable
Currently pasture and rough grazing
Land cover considerations
Land suitable for enhancing soil carbon (Ecosystem service: Soil carbon storage)
Opportunity service map 7 of 7 indicative opportunities to enhance soil carbon storage
Land suitable for enhancing soil carbon on arable areas
Land suitable for enhancing soil carbon on areas of deep peat
Land suitable for enhancing soil carbon on pasture and rough grazing
Dark pale
Light pale
Green
0 5 10 20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential multiple benefits of opportunities for soil carbon
Decision Support Map Set 8 - Multi-benefit
Legend
Carbon storage opportunities only
Carbon storage opportunities multi-benefit with 1 other opportunity
Carbon storage opportunities multi-benefit with 2 other opportunities
Carbon storage opportunities multi-benefit with 3 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Theme to consider
Currently (and historically) the amount of grazing land in the Scottish Borders has been maximised through draining areas of upland blanket bog and mire to encourage more palatable grass species to grow and to prevent the occurrence of diseases associated with very wet ground, such as liver fluke. Opportunities exist to restore carbon to these soils by blocking hill drains and re-establishing a functional wetland system. Carbon bound up in the soil provides a good way of mitigating against the effects of climate change.
What the map shows:
This map shows the multi-benefits in areas where enhancing soil carbon would also have the benefit of enhancing biodiversity, natural flood management and water quality.
How the map has been created:
This map has been created by combining areas with high and moderate opportunities for enhancing soil carbon with opportunities to enhance biodiversity, natural flood management and water quality.
The map is one of a set of 9 maps that explores the current and potential use of land in Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights the other ecosystem services that could be enhanced with a change of land use in these areas.
Rules box:
Key ecosystem service factors
Data used
Soil carbon storage
Opportunities map 7 of 7
Indicative opportunities to enhance soil carbon storage
Potential multi-benefits if overlapping with:
Opportunities map 1 of 7
Opportunities map 4 of 7
Indicative areas with potentials enhance biodiversity and nature conservation
Opportunities map 6 of 7
Indicative opportunities for improving water quality
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential interaction between enhancing biodiversity and agricultural production
Decision Support Map Set 9 - Interaction
Legend
Opportunities to enhance biodiversity on arable land
Opportunities to enhance biodiversity on (improved) pasture land
Other opportunities to enhance biodiversity
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Enhancing biodiversity could include such measures as introducing lower input/lower intensity agricultural systems on formerly higher input/higher intensity agricultural systems
What the map shows:
This map shows the interactions between land currently used for agricultural production and areas where there is an opportunity to enhance biodiversity.
Not all land management actions to enhance biodiversity will have a significant impact on agriculture.
How the map has been created:
This map has been created by combining information from the stock map of livestock and arable agriculture and the opportunity map for enhancing biodiversity.
Opportunities for enhancing biodiversity on arable land are shown in dark pink, on improved pasture land, in light pink and on other land (largely rough grazing and forested land) in green.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool, highlighting where different options for change may impact.
Rules box:
Key ecosystem service factors
Data used
Example attributes
Displayed
Land currently used for agriculture (Ecosystem service: agricultural goods: livestock and arable)
Provisioning service map 1 of 4 Crop production Provisioning service map 3 of 4 Land supporting food production (grazing intensity for livestock)
Classes Used – Currently arable
Currently improved pasture
Land under consideration
Land suitable for enhancing biodiversity (Ecosystem service: Biodiversity enhancement)
Opportunity service map 4 of 7 Indicative areas with potential to enhance biodiversity and nature conservation
Land suitable for enhancing biodiversity in arable areas
Land suitable for enhancing biodiversity in areas of improved pasture
Dark pink
Light pink
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS


Potential multiple benefits of opportunities for biodiversity
Decision Support Map Set 9 - Multi-benefit
Legend
Biodiversity opportunities only
Biodiversity opportunities multi-benefit with 1 other opportunity
Biodiversity opportunities multi-benefit with 2 other opportunities
Biodiversity opportunities multi-benefit with 3 other opportunities
Biodiversity opportunities multi-benefit with 4 other opportunities
Urban and infrastructure
Rivers, lochs and sea
Theme to consider:
Enhancing biodiversity could include such measures as introducing lower input/lower intensity agricultural systems on formerly higher input/higher intensity agricultural systems.
What the map shows:
This map shows the areas where enhancing biodiversity could have multiple benefits for enhancing water quality, natural flood management and soil carbon, especially if more native woodlands are planted.
How the map has been created:
This map has been created by combining the opportunity map for enhancing biodiversity, with areas where there is also opportunities to enhance water quality, natural flood management, native woodland and soil carbon.
This map is one of a set of 9 maps that explores the current and potential use of land in the Scottish Borders. It is not intended to prescribe a course of action, but rather to act as a decision support tool. This map highlights the other ecosystem services that could be enhanced with a change of land use in these areas.
Rules box:
Key ecosystem service factors
Data used
Biodiversity enhancement
Opportunities map 4 of 7
Indicative areas with potential to enhance biodiversity and nature conservation
Opportunities map 1 of 7
Opportunities map 3 of 7
Opportunities map 6 of 7
Opportunities map 7 of 7
0
5
10
20
Kilometres
N
TWEED FORUM
Scottish Borders COUNCIL
Environment SYSTEMS