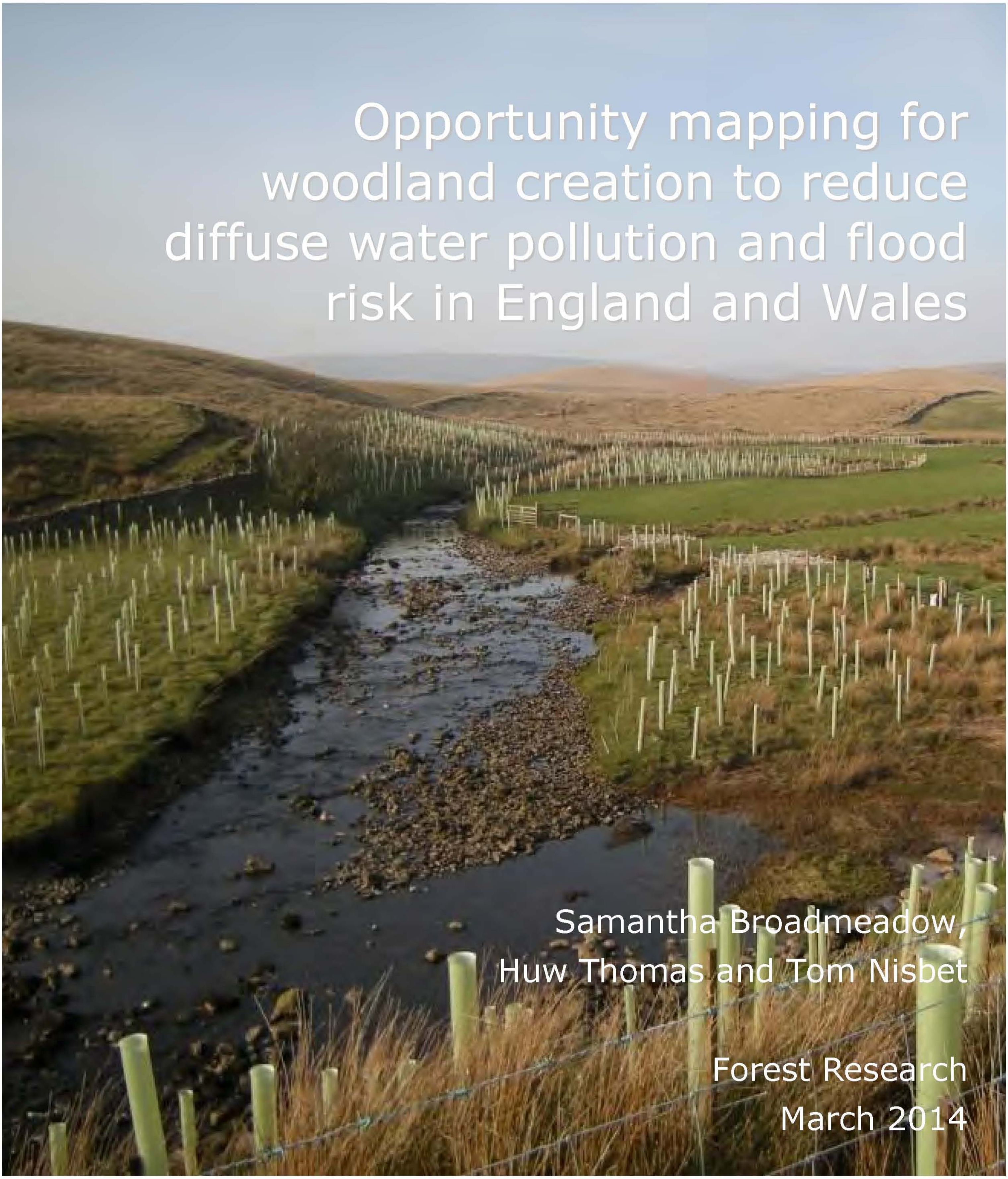
Forest Research

Opportunity mapping for woodland creation to reduce diffuse water pollution and flood risk in England and Wales



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1. Objective

To provide GIS spatial datasets and maps which identify opportunities for woodland creation to reduce rural diffuse pollution and flood risk across England and Wales. This will enable FC England, Natural England, the Environment Agency, Natural Resources Wales and partners to better target grant aid for woodland creation to help deliver positive outcomes for water quality and flood risk management. The maps will also assist other stakeholders to target woodland planting outside of the grant aid system.

2. Background

Government policy continues to support woodland creation to deliver multiple benefits for society, including for carbon sequestration, biodiversity and landscape improvement. The importance of woodland water services is increasingly being recognised by regulators, including the positive role that forestry can play in meeting the objectives of the Water Framework Directive (WFD). This includes helping to tackle some of the more difficult water quality issues, in particular the control of diffuse pollution from rural and urban sources. Woodland creation can help by establishing a low input but productive land cover with significant pollutant trapping potential. Targeted planting on pollutant sources and pathways has been shown to be effective at reducing diffuse nutrient, pesticide and sediment delivery to watercourses (Nisbet et al., 2011). Riparian woodland can deliver additional benefits through the provision of shade and improved morphology and functioning of stream bank and instream habitats.

Another water service provided by woodland is the ability to 'slow the flow' and reduce downstream siltation, both of which can help to alleviate flood risk. Managing the risk of flooding to householders is a major challenge facing the UK and one that is expected to increase in the future with climate change. Government policy recognises the importance of working with natural processes and Catchment Flood Management Plans identify general areas where beneficial changes to land-use and/or land-management (including woodland creation) is recommended to alleviate flood risk over the next 100 years.

In order to realise these water benefits we need to engage in landscape scale planning to identify, map and target areas where woodland creation would be most effective. Opportunity mapping was developed to facilitate this task and has been applied to a number of catchments and regions in England and Scotland in recent years. In 2012, a national opportunity map was produced for England to help guide the targeting of the Forestry Commission's new Additional Contribution payment for woodland creation to deliver water benefits. This mapping was at a relatively coarse scale and assessed opportunities for planting at the level of WFD river water bodies and CFMP policy units. This project builds on previous work and provides more detailed national opportunity maps for using woodland to help reduce a range of diffuse pollutants and flood risk in both England and Wales. The mapping focuses on rural areas and sources of diffuse pollution, avoiding urban areas due to the absence of appropriate soil and related datasets (urban areas are treated as a general constraint to planting in the context of this work).

The maps will assist the development and targeting of new funding schemes for environmental-based land management, including the next Rural Development Programme, as well as help inform revisions to river basin and flood management plans. They will also facilitate shared learning and development so that the contribution of forestry to mitigating flood risk and diffuse pollution – and the consequences for wider land use decisions - are considered in tandem.

3. Mapping Approach

The current project draws heavily on spatial datasets prepared by the EA under their WFD and FRM programmes. We were able to make use of national datasets of significant water management issues, created to update the river basin management plans, and the recently updated flood risk maps.

This report describes the methodology and datasets used to derive the national opportunity maps. Areas affected by existing woodland, open water, urban and deep peat are mapped as constraints to woodland creation. The mapping of woodland opportunities to address diffuse pollution is based on EA WFD datasets of modelled pollutant loads or pressure at a 1 km^2 scale for each of phosphate, sediment, nitrate, total pesticides and faecal indicator organisms (FIOs). The data sources are a range of models used by the EA which model diffuse pollution loadings to land and/or loss and delivery to watercourses from agriculture and rural land management. Pollutant thresholds are used to identify target areas for woodland planting to reduce diffuse pollution. Where available, published thresholds or those based on WFD water quality concentration standards are applied, but in their absence we have resorted to simple statistical values (e.g. top 10% in the case of FIOs) drawn from the combined datasets for England and Wales. Separate statistical distributions for each country were not used due to the problems this would pose for cross-border catchments. For flood risk management, we utilise EA spatial data for the risk of flooding from rivers and various datasets concerning the propensity of soils to generate rapid runoff. The latter is based on the Hydrology Of Soil Types (HOST) dataset and includes modifications for the vulnerability of soils to structural degradation by intensive agricultural practices and by soil poaching.

4. Spatial data sources

4.1 Constraints to woodland planting

The first step in determining the extent and scale of woodland creation opportunities was to identify core constraints to woodland planting. These are locations where the creation of sizeable areas of woodland is either not possible or very unlikely due to existing land use. While urban areas are included they should not be seen as an absolute barrier to planting as some will provide local opportunities, such as part of Sustainable Urban Drainage Systems. The core constraints were mapped as:

4.1.1 Existing woodland

Use was made of the Forestry Commission GB National Forest Inventory Woodland Map (Woodland Canopy - Interpreted Forest Type – selected), dated December 2013.

4.1.2 Open water

The OS Strategi 1:250 000 scale Inland water (lake, reservoir, pond) outer limit defined areas of open water.

4.1.3 Urban areas

The OS Strategi 1:250 000 scale Urban areas (large and small) outer limit defined the boundary of urban areas.

4.1.4 Deep peat (>40 cm depth)

In England, use was made of the Natural England (October 2008) Peat Map to identify deep peaty soils, while in Wales, areas of deep peat and eroded deep peat were selected from the FC_Peat Map created by Forest Research for FC Wales in 2011.

The four datasets were combined using the UNION tool to create a single dataset called CONSTRAINT. Map 1 shows the distribution of the core constraints to woodland creation across England and Wales.

4.2 Phosphorus and Sediment - PSYCHIC: Phosphorus and sediment yield characterisation in catchments

PSYCHIC is a process based model that is sensitive to land management practices which influence the mobilisation and delivery of sediment and phosphorus (P) to waters. A full description of the PSYCHIC model structure and its parameters is given in Davison et al. (2008). The model takes account of climate, landscape and land management factors, including crop type, livestock numbers and subsurface drainage. The PSYCHIC data used in this project draw on the 2010 agricultural census data for England and Wales.

The data was supplied as Microsoft Access database files from which spatial datasets were created. The attribute table provides estimated monthly and annual losses of sediment and P (kg/ha/y) for each cell of a 1 km grid across England and Wales. The distribution of annual total sediment and P losses are illustrated in Maps 2 and 3.

4.2.1 Sediment

There is no ecological in-river sediment standard and so there are no WFD compliance statistics. However, pressure from diffuse sediment pollution is cited as a reason for failure in 12% of water bodies in England and 6% in Wales that failed an element of good status. In addition, around 50 drinking water protected zones are at risk from sediment-related colour and turbidity problems. The Agriculture and Rural Land Management (ARLM) sector is the most significant source of diffuse sediment pollution. Map 2a shows the distribution of annual sediment losses in kg/ha/yr from all ARLM sources via all pathways to watercourses.

An annual sediment delivery rate of 50 t/km^2 is used by the EA to define river water bodies at risk from sediment pollution (EA, 2004). This equates to 500 kg/ha/y, which we selected as a threshold value to define the target area for woodland creation to reduce pressure from diffuse sediment pollution (Map 2b). Across England and Wales, 11,805 km^2 of land exceed this threshold, including 8,392 km^2 in England (6.5% of the land area) and 3,413 km^2 in Wales (16.9%).

4.2.2 Phosphorus

Excess P in freshwaters causes eutrophication, which is a widespread issue across England and Wales. In 2012, 45% of river water bodies in England and 7% in Wales failed WFD due to their P status. In England, 15% of the failing water bodies were more than 5 times in excess of the P standard. The greatest sources of P are the ARLM and water industry sectors. The relative contribution of P load from the ARLM sector varies around the country and is a significant reason for failure within the Anglian, Humber, Severn, South West and Thames river basins (EA, 2012a). Map 3a shows the distribution of modelled annual total P losses in kg/ha/yr from all ARLM sources via all pathways to watercourses (Collins and Zu, 2012).

The WFD standards for P in rivers have recently been strengthened to reflect improved understanding of the impact of this nutrient on freshwater ecology (EA, 2014). Existing P standards range between 40 - 120 ug/l mean annual Total Reactive P depending on river type (according to altitude and alkalinity). These have been revised based on the relationship between P concentration and site ecological quality index, and now range from 28 to 69 μg/l mean annual Total Reactive P according to river type.

In previous regional mapping projects a threshold of 1.0 kg/ha/y was used to define the target area for woodland creation to reduce diffuse P pollution, based on a generalised 100 μg/l target concentration and 1,000 mm annual runoff. This appeared appropriate for wetter parts of the country but is thought to be too high for drier areas, where low annual runoff volumes result in higher pollutant concentrations in water. Thus the method was changed for the national assessment and the P concentration draining to watercourses estimated using the PSYCHIC modelled P load and the mean hydrologically effective rainfall for each 1 km grid cell. This also allowed use of the revised P standards to define the target area, rather than P loads as before.

In the absence of available data on river water body typology, the higher 69 μg/l P standard that applies to lowland, high alkalinity rivers was selected to define the target area for woodland creation to reduce diffuse P pollution, while the lower 28 μg/l P standard set for upland, low alkalinity rivers, was used to separate areas subject to low and medium pollution. Map 3b shows the distribution of the target area across England and Wales, comprising 66,916 km^2 of land where modelled P concentrations in drainage waters exceed the 69 μg/l P standard for rivers. This includes 60,252 km^2 in England (46.3%) and 6,664 km^2 in Wales (32.7%). It is important to note that land draining to the more sensitive river types within the area classed as having medium P concentrations would also greatly benefit from woodland planting aimed at reducing diffuse P pollution.

4.3 Nitrate – NeapN

Mapping of diffuse pollution from nitrate used NeapN, a soil leaching model developed by ADAS to predict the concentration of nitrate leaving the base of the soil zone from agriculture across England and Wales (Anthony *et al*., 1996; Lord and Anthony, 2000). The model takes into account climate, soil type, animal number and type, crop type and agricultural practice, and has been validated against detailed monitoring on commercial farms across England and Wales. Model predictions provide input concentrations of nitrate from agriculture to surface water and groundwater resources.

The NeapN dataset is supplied as a .csv text file from which a spatial dataset was created to represent the estimated nitrogen (N) losses (kg N/ha) from 5 land covers (arable, grass, rough grazing, woodland and open water) and the concentration (mg N/l) of N leached to aquifers or watercourses on a 1 km^2 grid across England and Wales.

Several standard/threshold values for nitrate and or TON_N (TON = Total Oxidised Nitrogen) are applied to protect water resources and avoid the eutrophication of specific habitats; these are summarised in Table 1 and the range of modelled nitrate-N losses to water displayed in Figure 1.

EU Directive	Notes	Standard/thresholds (mg N/l)				
		River	Lake	Groundwater	Estuary	Coastal
Drinking Water	Max [tap]	11.295 mg N/l *(≡ 50 mg NO_3/l)*				
Nitrates	Trigger = freshwater with elevated [nitrate]					
Urban Waste Water	Trigger = drinking water with elevated [nitrate]					
Groundwater Daughter	New trigger (cycle 2) to reverse upward trend			8.471 *(37.5)*		
Water Framework	Thresholds used to assess risk of eutrophication - dependent on typology		0.99–1.99	0.90 - 5.87 *(4 - 26)*	0.25 *(1.12)*	0.42 *(1.86)*

Table 1 Threshold values for nitrogen (NO_3 or TON-N) in water bodies for resource protection and to reduce the risk of eutrophication

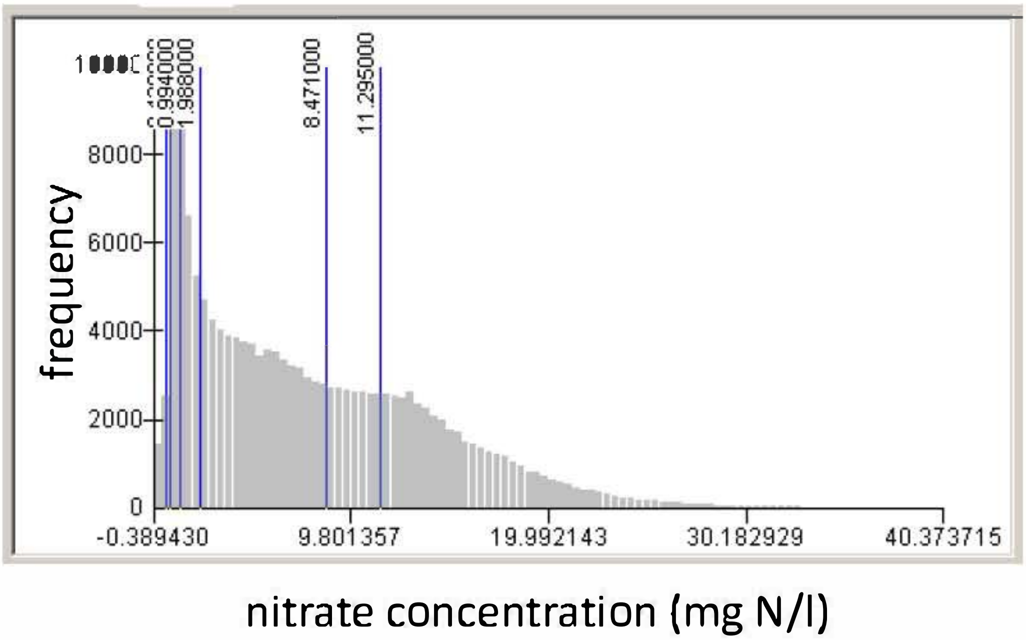

Figure 1 The distribution and range of modelled concentration values for leached nitrate-N (mg N/l) across England and Wales.

The spatial distribution of the nitrate-N concentration data is shown in Map 4a. The problem of excess nitrate in surface water and groundwater is widespread across England but less of an issue in Wales. Currently, diffuse nitrate pollution is implicated as a cause in 76 of the 122 failing groundwater water bodies in England and Wales and may become worse in the future due to continued rising trends in nitrate concentrations in some aquifers (EA, 2012b). The agricultural sector is the largest source of nitrate reaching surface and groundwater in both England (49%) and Wales (60%), and land use change to woodland is recognised to be a highly effective means of reducing nitrate inputs and subsequent losses to water (EA, 2012b).

Map 4b shows that nitrate-N concentrations in soil waters draining around 28.0% of land in England and Wales exceed the Drinking Water Standard of 11.295 mg N/l (50 mg NO_3/l), while 40% of land exceeds the recently revised, lower, groundwater standard of 8.471 mg N/l (37.5 mg NO_3/l) being applied under the second cycle of River Basin Management Plans (DEFRA, 2014). The lower threshold is used to define the target area for woodland planting to help tackle the nitrate issue (i.e. comprising the medium and high classes in Map 4b). Based on this, the separate target areas for England and Wales are 59,689 km^2 (46%) and 528 km^2 (2.6%), respectively.

4.4 Pesticides - Pesticides Usage Data

The 2012 pesticide usage (PU) data is derived from land cover statistics, drawing on the June 2010 agricultural census and estimates of pesticide usage supplied by GfK Kynetec for 2009 (grassland) and 2011 (arable) crop years. Usage is based on typical application rates (kg/km^2) of 12 key pesticides across England and Wales to a range of crop types, including cereals, potatoes, sugar beet, fodder crops, beans, peas, maize, oil seed rape, linseed, permanent grass and grass ley. Pesticide applications to forestry, horticulture and rough grazing are very small in comparison and not included in the estimates.

The PU dataset was supplied as 1 km grid with values for each of the 12 pesticides and a final column of total pesticide use. There is no consideration of the fate of the pesticides in the soil or their relative toxicity to the freshwater environment. The spatial distribution of pesticide use is illustrated in Map 5a and reflects the pattern of agricultural use across England and Wales, rather than actual losses to or concentrations in water. Areas of heaviest pesticide use are in central and eastern England. The range of values is illustrated in Figure 2 and the top third (>26.438 kg/km^2) was selected to define the target area for woodland creation to address diffuse pesticide pollution from agricultural sources (Map 5b). A total area of 50,494 km^2 exceeds this threshold, with almost all (50,396 km^2) lying in England (39% of England) and just 98 km^2 in Wales (0.5% of Wales).

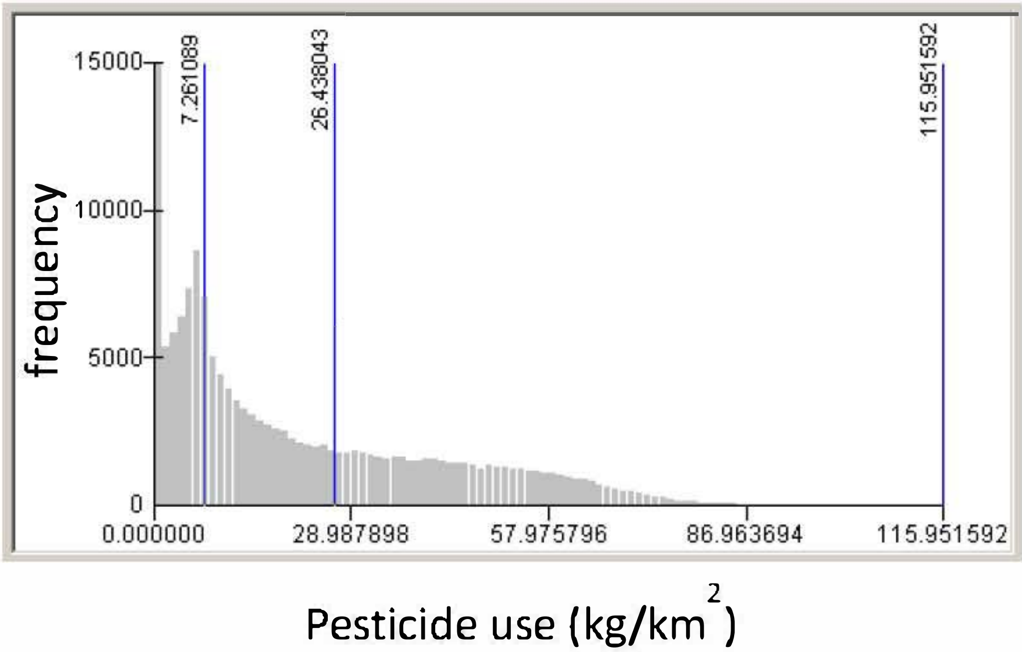

Figure 2 Distribution of total pesticide use across England and Wales in 2012. The blue bars indicate class thresholds for the three quantile ranges. The spatial distribution of this data is illustrated in Map 5a.

4.5 Faecal Indicator Organisms (FIO) – Catchment Sensitive Farming (CSF) FIO risk used for 2013/14 New Environmental Land Management Scheme (NELMS) targeting for water quality

While Nisbet at al (2011) found little evidence to support the use of wooded buffers to remove/reduce FIO numbers from applications of wastewater, it is expected that woodland creation is likely to be generally effective at reducing FIO loads to watercourses. Benefits could arise from the ability of woodland to reduce rapid surface runoff, when much contamination occurs, and by helping to exclude livestock from directly accessing and contaminating watercourses.

There is no national dataset of FIO losses/risk equivalent to the other nutrient and sediment risk models. The best available source of information is the statistical model developed by the Centre for Research in Environment and Health (CREH) to predict relative FIO risk to support the Catchment Sensitive Farming Initiative (Crowther, 2010). The CREH model predicts FIO pressure based on a multiple regression model of the observed FIO concentrations in 14 catchments (153 monitored sub-catchments) with catchment variables such as livestock density, human population, rates of FIO excretion, land use and other hydrological variables. The land use data is based on the ADAS 2010 land use database. This was applied to a 1 km gridded dataset by the EA in order to estimate relative risk of pollution from agriculture.

Two datasets were supplied for England, comprising the relative FIO pressure from agriculture to Bathing Waters and Shellfish Waters derived using the CREH regression model at a 1 km grid scale. Data for Wales are not currently available. The dataset contains values for the estimated FIO load from agriculture and a Yes/No field that indicates whether the 1 km grid drains to one of the priority Bathing or Shellfish water priority catchments assessed in the 2013/14 NELMS targeting work. Two different models are used; Bathing Water pressure relates to summer farming practices while Shellfish Waters are subject to agricultural pressure all year round. The EA NELMS targeting map only includes land draining to failing Bathing or Shellfish waters. FIO losses to water are mainly associated with high flows/storm events.

For this project, the entire national modelled dataset for each of Bathing and Shellfish Waters was used (Maps 6-8). Maps 6a, 7a and 8a show the distribution of annual FIO loads from agriculture to Shellfish and/or Bathing Waters. A threshold equating to the top 10% of FIO values was selected for both receptors to define the target area for woodland creation to reduce this diffuse pollutant (Map 6b for Shellfish Waters, Map 7b for Bathing Waters and Map 8b for the combined area). The combined area of land in England exceeding this threshold amounts to 20,062 km^2 (13% of England).

4.6 Multiple pollutants

The individual pollutant maps were combined to determine the extent of opportunities for woodland creation to tackle multiple diffuse pollutants in the absence of any pollutant-specific screening or prioritisation. Map 9a shows the distribution of the target areas for the different diffuse pollutants using the higher threshold values for nitrate and phosphate applied in previous regional mapping projects, while Map 9b displays areas of overlap between the pollutants (note that no data are available for FIO's in Wales, the FIO area in England represents the combined area for Bathing and Shellfish Waters, and no areas overlap for all five diffuse pollutants in England). These maps are replicated in Maps 10a and 10b using the recently revised, lower thresholds for nitrate and phosphate (note that a very small area in England now overlaps for all five diffuse pollutants). The respective areas and % of land in England and Wales identified for targeting one or more of the diffuse pollutants are given in Table 2.

Number of diffuse pollutant pressures	Use of lower pollutant threshold values for N & P to define target areas		Use of previous pollutant threshold values for N & P to define target areas	
	Nitrate >8.471 mg/l Phosphorus >69 μg/l		Nitrate >11.295 mg/l Phosphorus >1.0 kg/ha/y	
0	28,149	18.66%	65,786	43.4%
1	43,447	28.80%	38,071	25.1%
2	41,472	27.49%	41,931	27.7%
3	35,401	23.46%	4,964	3.3%
4	2,392	1.59%	732	0.5%
5	19	0.01%	0	0%

Table 2 Extent of opportunities to use woodland creation to tackle multiple diffuse pollution pressures in England and Wales.

4.7 Fluvial flood risk – EA Flood Maps January 2014

The recently updated EA flood maps show risk of flooding from rivers, sea, reservoirs, surface water and groundwater. For the purpose of this project, attention was restricted to identifying where woodland creation could help to reduce flooding from rivers. There is scope to use the surface water flood maps at a local level but the dataset is too large to utilise in national mapping.

The Flood Map (Jan 2014), Flood Zone 2 represents land assessed as having between a 1% and 0.1% probability of fluvial flooding and a 0.5% and 0.1% probability of tidal flooding in any year, ignoring flood defences. The floodplain is classified according to the information source; the flood zone being a composite of detailed modelling of fluvial, tidal and fluvial/tidal hydrological responses and the recorded extent of fluvial, tidal and coastal flood events. The floodplain TYPE field was used to select areas representing the fluvial floodplain [‘Fluvial Model’, ‘Fluvial Event’, ‘Fluvial Model and Fluvial Event’, ‘Undefined Event’, ‘Fluvial/Undefined Event’, ‘Fluvial Model and Fluvial /Undefined Event’, ‘Fluvial Model and Undefined Event’].

The selected features were exported to create a new dataset of the fluvial flood zone. Areas of constraints to woodland creation (see Section 4.1), where tree planting would not be possible or appropriate, were removed; these include open water, urban areas, existing woodland and areas of deep peat soil. The final dataset represents areas suitable for potential floodplain woodland (Map 11). Also shown are ‘Areas Benefitting from Flood Protection’ and ‘Flood Storage Areas’. These do not represent constraints to planting but will influence the ability of woodland to affect flood flows and therefore need to be considered at a local level.

4.8 Soils data, HOST classification and modifications for structural degradation

Woodland in the wider catchment can be most effective at reducing flood flows when targeted to soils that are prone to generating rapid runoff or the pathways along which water flows to streams. Such areas include naturally wet soils subject to seasonal waterlogging or surface ponding, and sensitive soils at risk of surface compaction, sealing or poaching. The identification of target locations for planting was based on an assessment of the hydrological properties of soils and their susceptibility to structural degradation from agricultural use.

This drew on the following spatial datasets and published reports:
- National soil map - NSRI
- The Hydrology Of Soil Types (HOST) (Boorman *et al*., 1995)
- Standard Percentage Runoff (SPR) based on the HOST classification
- Revised SPR values derived from the study 'Impact of land use and management on flooding (Packman *et al*., 2004)'
- Poach Class, Harrod (1998)

HOST: The HOST system was developed to classify soils according to their hydrological behaviour. HOST is a conceptual representation of the hydrological processes in the soil zone. All soil series (map units) in the UK have been grouped into one of 29 hydrological response models or 'HOST classes'. Allocation to a HOST class is by a hierarchical classification. Soils are first allocated to one of three physical settings:

- a soil on a permeable substrate in which there is a deep aquifer or groundwater (i.e. at >2 m depth)
- a soil on permeable substrate in which there is normally a shallow water table (i.e. at <2 m depth)
- a soil (or soil and substrate) which contains an impermeable or semi-permeable layer <1 m from the surface.

Each physical setting is sub-divided into response models, which describe flow mechanisms and identify groups of soils that are expected to respond in the same way to rainfall. Finally there are sub-divisions of some of these models according to the rate of response and water storage within the soil profile. The spatial distribution of HOST classes is displayed in Map 12.

SPR: Calibrated values of SPR for each HOST class have been derived from multiple regressions between the proportion of each response model within a number of UK river catchments and the SPR values derived from river gauging data. The SPR represents the percentage of rainfall that contributes to quick response runoff. HOST classes with a SPR

>25% represent seasonally waterlogged and flashy soils that are likely to make a significant contribution to the generation of flood flows. The distribution of SPR values is shown in Map 13.

Revised SPR values: A joint DEFRA/EA funded research programme reviewed the impacts of rural land use and management on flood generation. One output was a refinement of the Flood Estimation Handbook (FEH) rainfall-runoff model to account for the effects of soil degradation due to intensive agricultural practices. The authors identified the HOST classes at risk and assigned an appropriate analogue HOST class with a higher SPR value to represent the hydrological properties of the degraded soil (Packman *et al*., 2004). The distribution of the vulnerable soils is shown in Map 14.

Poach Class: HOST classes with naturally high (60%) SPR values (e.g. due to an impermeable substrate within 1 m of the soil surface or on flat ground) were not adjusted by Packman *et al*. (2004) because intensive agricultural practices were thought unlikely to result in a further increase in quick-response runoff. However, we believe this underestimates the impact of structural degradation from livestock poaching on the hydrological properties of these and other soils and therefore we made a further adjustment. To avoid double accounting, we revised upwards the SPR values for all soils with no Analogue HOST class to reflect the risk of structural damage by poaching. This drew on the classification of Harrod (1998) and is illustrated in Figure 3; Map 15 shows the distribution of soil poach class across England and Wales.

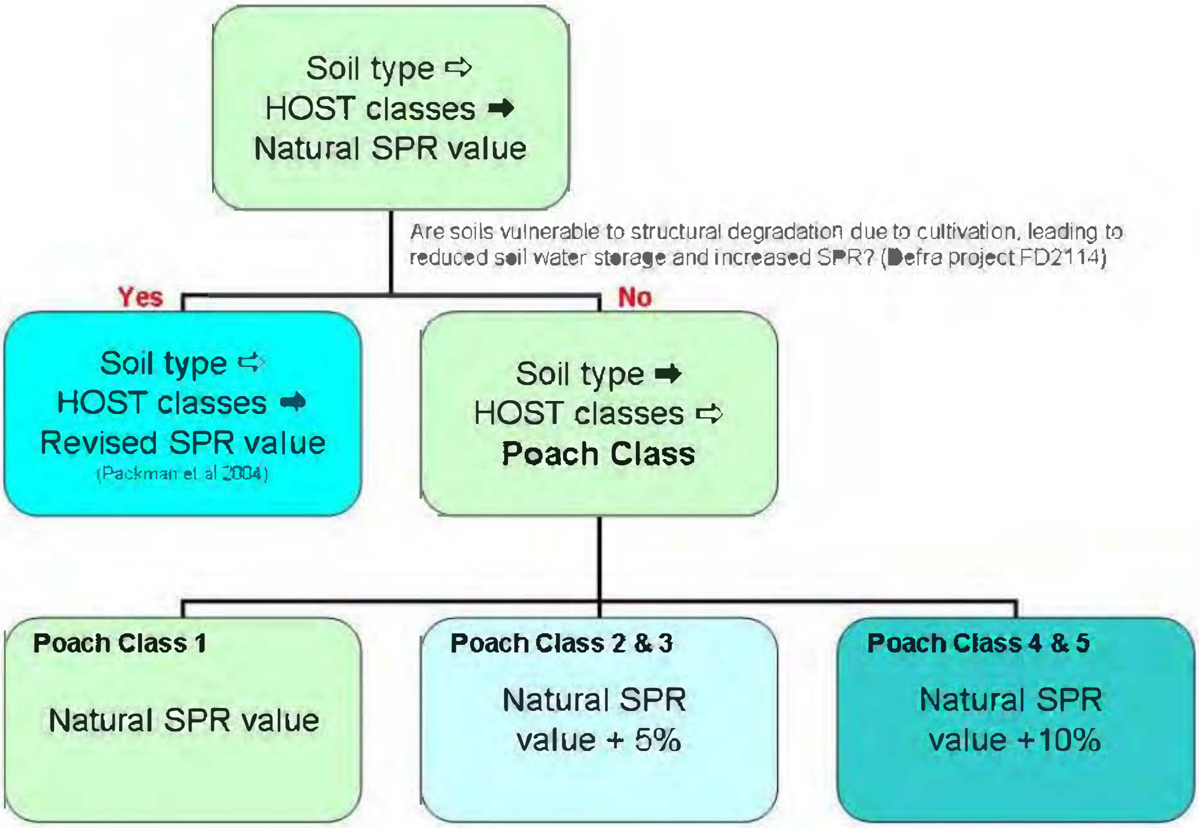

Figure 3 Method used to amend standard percentage runoff values to account for the potential impact of agricultural land management.

The above process generated an SPR value for each HOST class that reflected soil hydrological properties and their susceptibility to structural degradation from agricultural use. The final step was to integrate the values based on the relative presence of different HOST classes within each mapped soil association. Soil associations are composed of one or more soil series that are assigned to an individual HOST class. For example, the Claverley soil association (711) consists of four soil series belonging to two HOST classes. The approach is illustrated in Table 3, while Map 16 shows the spatial distribution of final SPR values. Target areas for woodland creation were defined as soil associations with >50% SPR, reflecting the threshold used in previous regional and catchment opportunity mapping work. A total area of 35,050 km^2 exceeds this threshold in England (26.8%) and 5,206 km^2 in Wales (25.1%).

Component soil series forming the Claverley soil association (subgroup)	Percentage composition	**HOST class** and natural SPR value	Analogue **HOST class** & SPR value	Poach risk class	Revised SPR value
Claverley, Clifton & Salop (7.11)	75%	**24** – SPR 39.7%	**25** - SPR 49.6%	Very High	49.6%
Ivesheah (6.11)	25%	**19** - SPR 60%	**22** - SPR 60%	Extreme	70%
Soil association natural SPR value		44.8%	Soil association degraded SPR value		53%

Table 3 Example of method used to derive a weighted SPR value for individual soil associations to reflect the nature and vulnerability of individual soil series to structural degradation by agricultural practices.

4.9 Riparian zone – EA Detailed river network

The close proximity between woodland and water in the riparian zone makes this a very effective location for woodland planting to aid FRM, as well as to deliver other significant water benefits. A key attribute is the formation of large woody debris (LWD) dams from fallen trees and the input and collection of dead wood. These dams impede water flow and promote out of bank flows, increasing flood storage and delaying flood flows. Additionally, riparian woodland can buffer/reduce sediment delivery from the adjacent land and protect riverbanks, reducing downstream siltation and helping to maintain the flood storage capacity of river channels.

The EA Detailed River Network was used to create a 50 m grid dataset to represent the riparian zone across England and Wales. This is slightly narrower than the standard 60 m zone that is most likely to interact with and provide woody debris to the river channel but was selected for ease of application at the national scale. The riparian raster was merged with that created for the target areas for woodland creation to reduce rapid runoff, based on the soil degraded SPR classification, to identify target areas for riparian woodland creation to benefit flood risk management. The small size of the zone prevents it being displayed on an A4 sized map.

5. Combined opportunities

5.1 Combined opportunities for woodland creation to reduce flood risk

The final target area for woodland creation to reduce flood risk is shown in Map 17. This comprises potentially suitable areas for planting on the fluvial floodplain, soils on the adjacent land with a high propensity to generate rapid runoff (SPR >50%), and along a 50 m wide riparian zone abutting the latter. A 'local' example of this approach is displayed in Map 18. These areas are favoured either in view of their proximity to sources of flood generation or their ability to reduce the conveyance of flood flows downstream.

5.2 Combined opportunities for woodland creation to reduce diffuse pollution and flood risk

Map 19 shows the distribution of the target areas for woodland creation for FRM in relation to those for reducing one or more diffuse pollutants, defined using the revised lower thresholds for N & P.

6. Recommendations

It is recommended that partners use the maps and supporting spatial datasets to help deliver future woodland creation within the identified target areas. This would be aided by partners agreeing on a subset of priority areas to increase the scope for planting to make a difference for FRM and/or diffuse pollution at the catchment scale.

7. Derived Spatial datasets

1. PNW_RR - Potential new woodland to reduce rainfall runoff. Reclassification of NATMAP vector soil data to identity areas where woodland creation can best protect and improve soil texture and reduce downstream flood risk.

The column GRIDCODE in the attribute table
Value 1: Soils with a PD_SPR value greater then 50% are target areas for woodland creation to reduce rainfall runoff and downstream flood risk.
Value 2: 50 m riparian zone within the target area for woodland creation to reduce rainfall runoff

2a. PNFW_Anglia; 2b. PNFW_Dee; 2c. PNFW_Humber; 2d. PNFW_NE; 2e. PNFW_NW; 2f. PNFW_SE; 2g. PNFW_Severn; 2h.PNFW_SW; 2i. PNFW_Thames; 2j. PNFW_Tweed; 2k. PNFW_W_Wales - Potential new floodplain woodland within each river basin. Derived from the updated Flood Map' land within the Fluvial Flood Zone 2. To enable the constraints to woodland planting to be removed from the dataset, the Fluvial Flood Zone had to be split before processing was possible, using the EA WFD River Basin boundaries.

3. DP_ARLM - Target area for woodland planting to reduce Diffuse Pollution pressure from Agriculture and Rural Land Management. 1 km^2 grid covering England and Wales with columns for each individual pollutants with 0/1 label to define target area and an additional column of the potential number of diffuse pollutant pressures targeted within each grid cell.

DP_Pest: Diffuse pollution pressure from pesticides
DP_SED: Diffuse pollution pressure from sediment
DP_PHOS: Diffuse pollution pressure from phosphorus
DP_Nit: Diffuse pollution pressure from nitrate
DP_FIO_BW: Diffuse pollution pressure from Faecal Indicator Organisms (FIO) to Bathing waters
DP_FIO_SfW: Diffuse pollution pressure from FIO to Shellfish waters
DP_FIO; Diffuse pollution pressure from FIO
Value 1 – modelled pollution loss rate greater than pollution specific threshold – opportunity to use woodland creation to reduce diffuse pollution pressure
Value 0 – modelled pollution loss rate less than pollution specific threshold value
DP_NUM - Value = number of diffuse pollutants

4. Constraints - Combined area of land subject to constraints to woodland planting including: Urban areas, Open water, Existing woodland, and Deep peat. The four datasets were combined using the UNION tool to create a single dataset from which all the attributes have been removed.

5. PNW - Potential New Woodland. The constraints dataset was converted to a 50 m raster grid and reclassed using the OS national coastline as an analysis mask. The area free from constraints (no data) was then exported as the area of potential new woodland.

8. References

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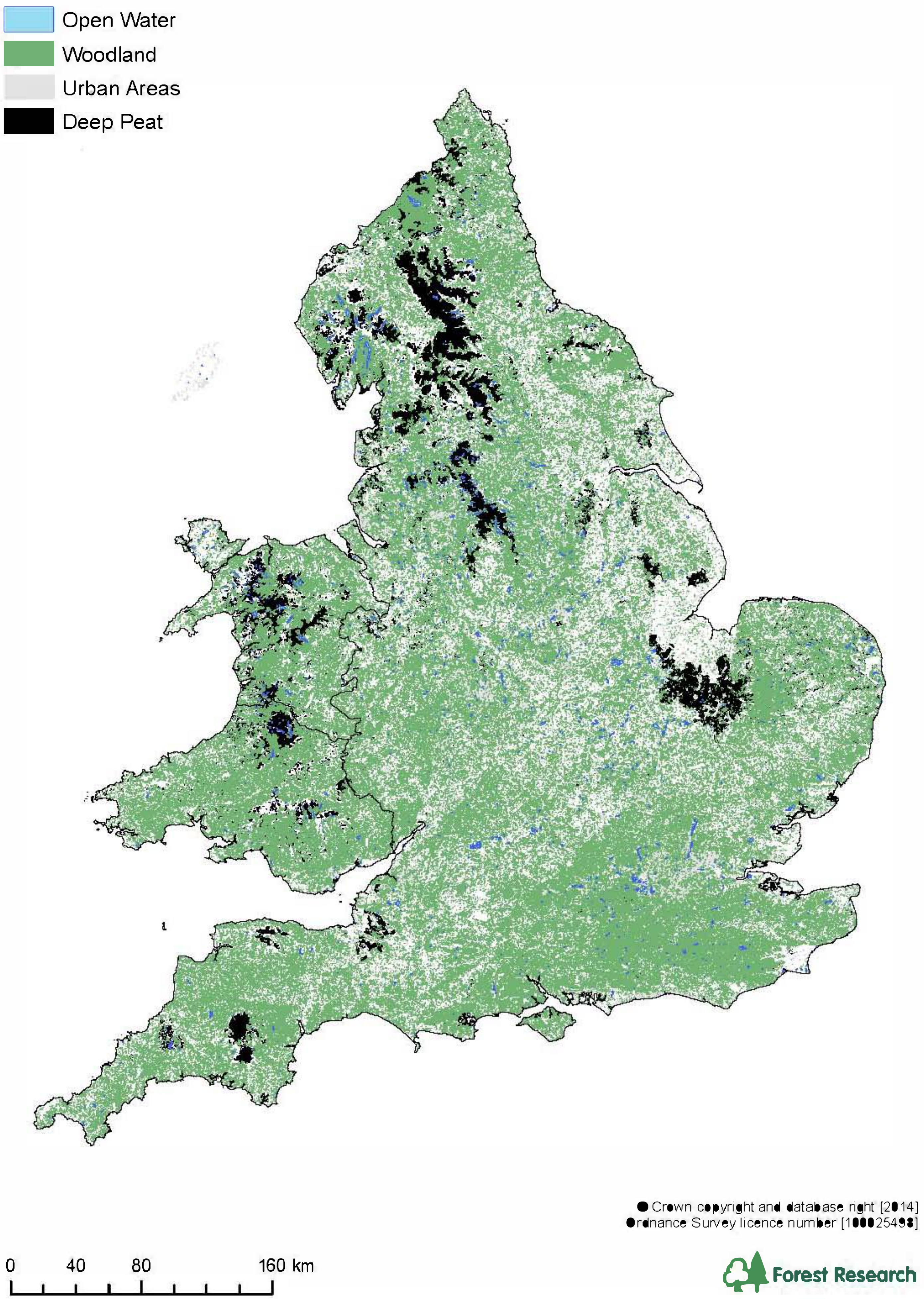
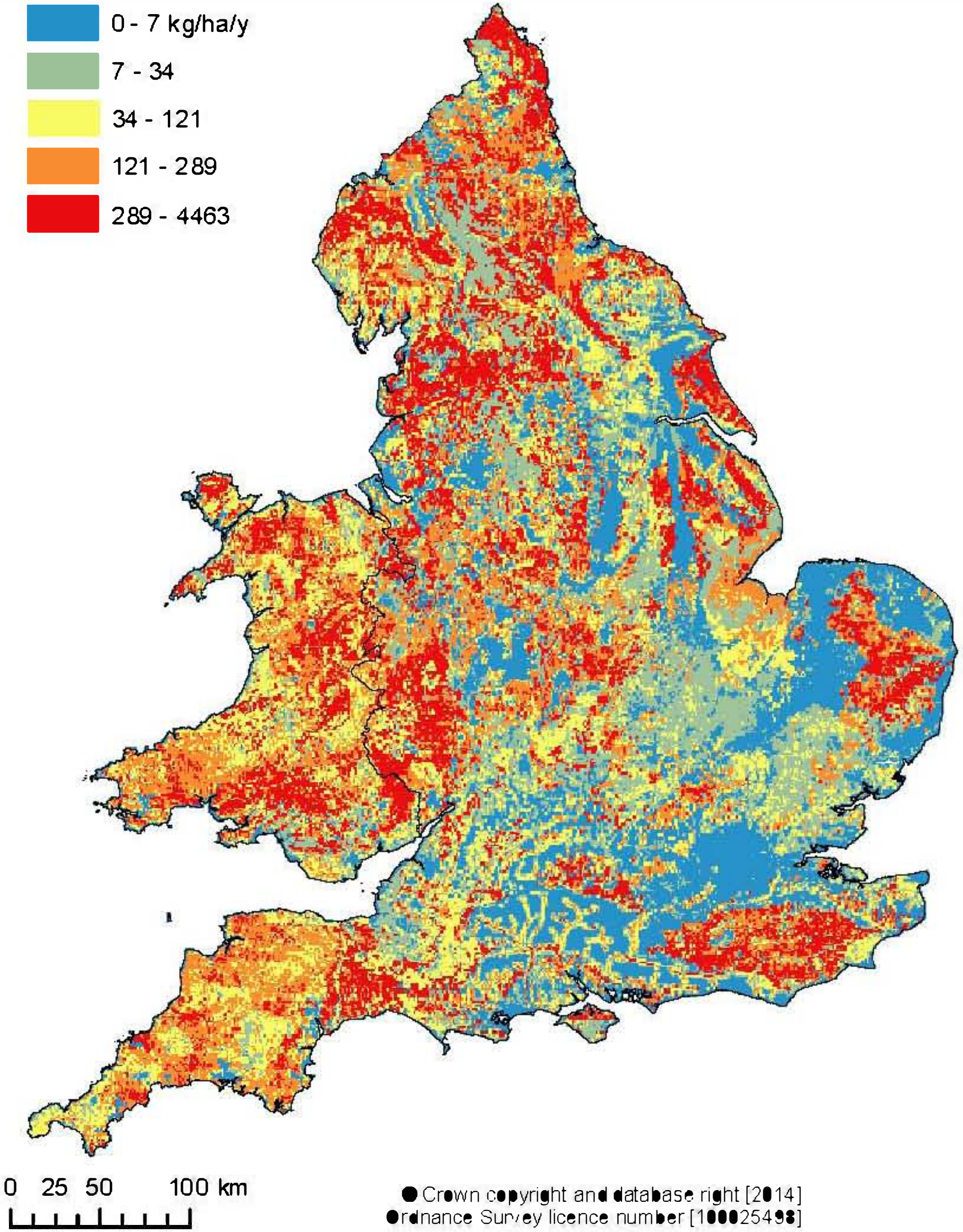
Appendix: Licence document for derived spatial datasets

Special licence – Co deliver: word document (Draft sent to Dan Haigh 27th March 2014)

Map 1 Distribution of constraints to woodland creation



Map 2a Annual total sediment reaching watercourses from all diffuse sources via all pathways



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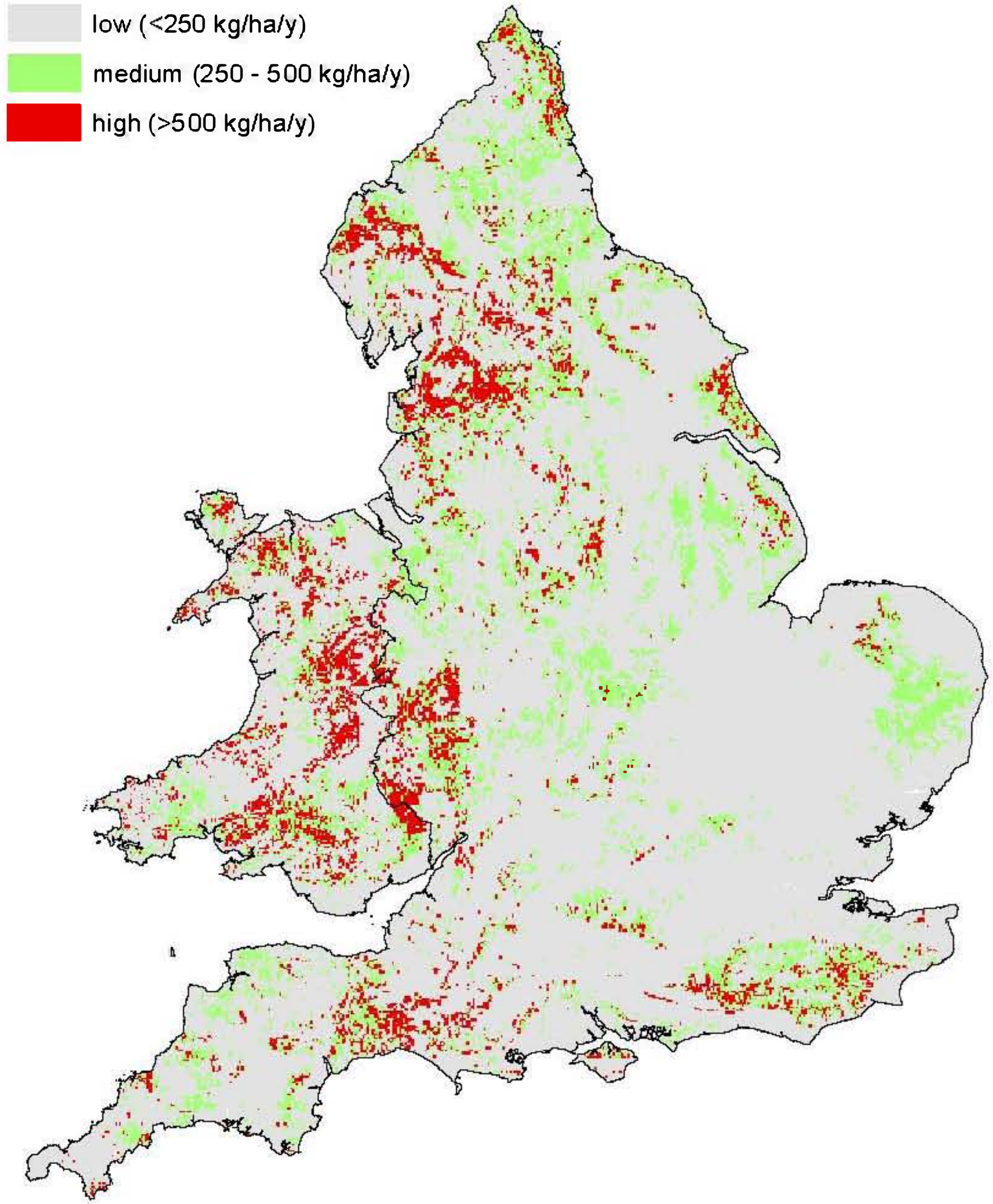
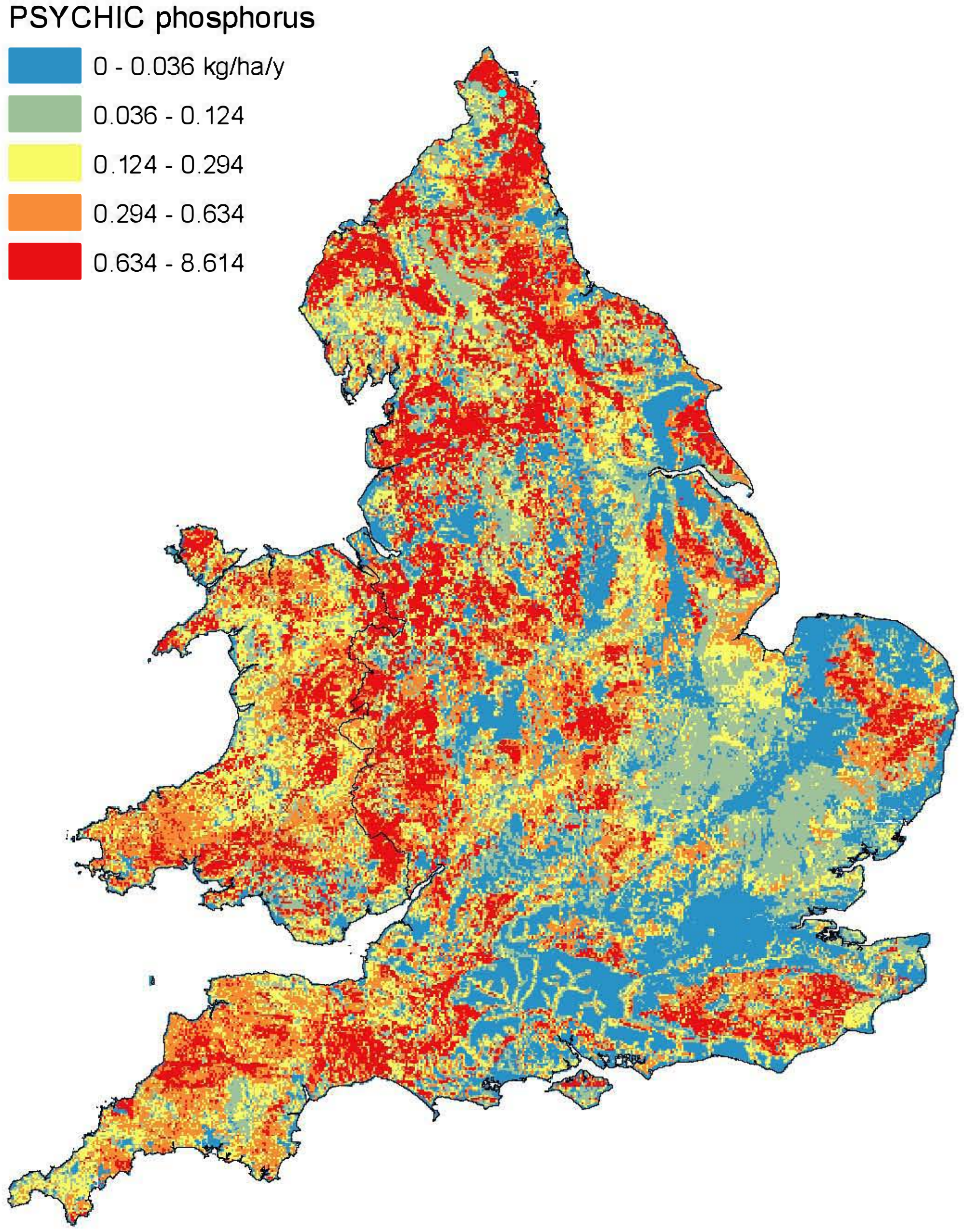
Map 2b Relative loads of total sediment from diffuse agricultural sources



Data source PSYCHIC model [Collins & Zhang, 2012. ADAS] Phosphorus and sediment yield characterisation in catchments using 2010 agricultural cencus data

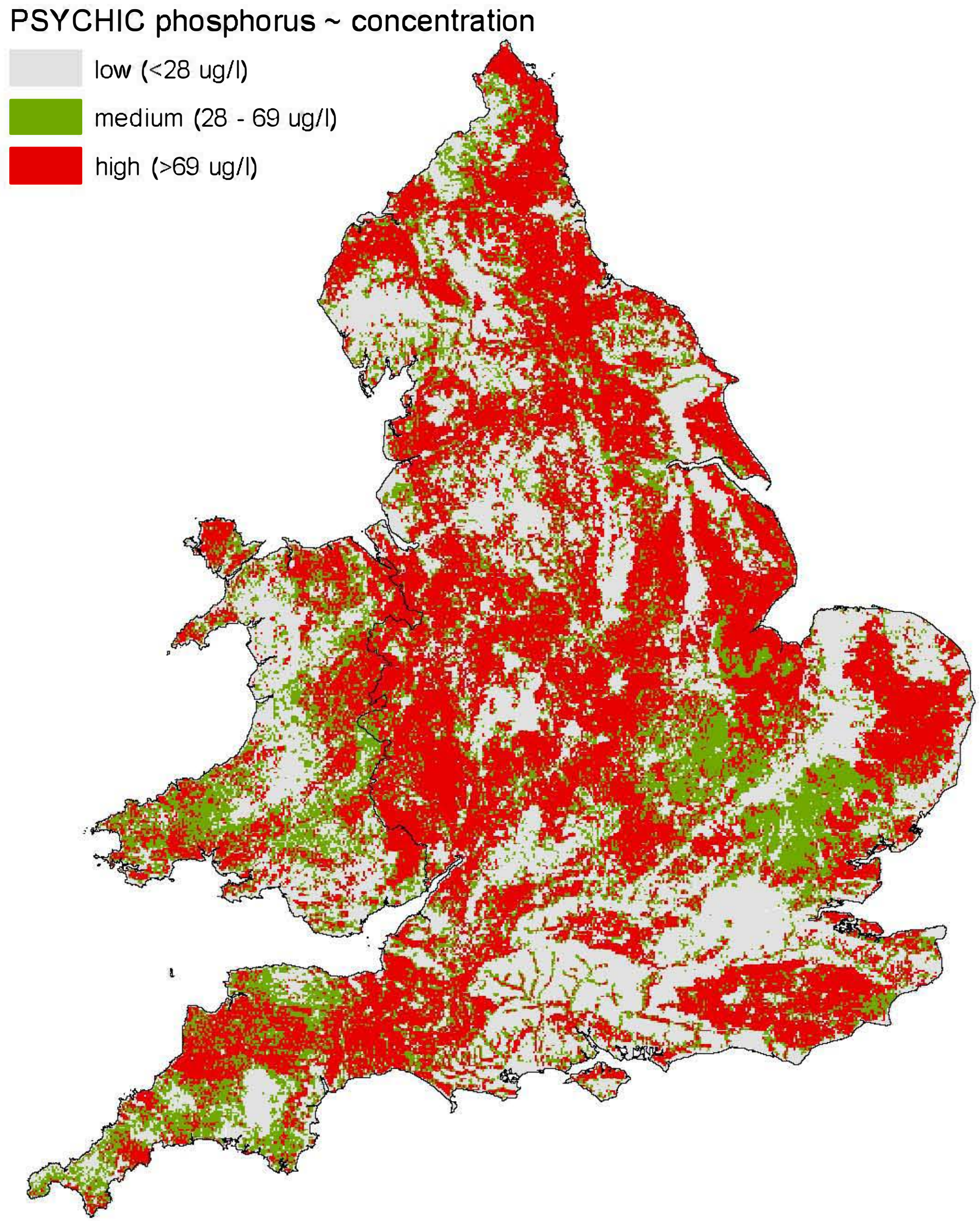
Forest Research

Map 3a Annual total P reaching watercourses from all diffuse sources via all pathways



0 25 50 100 km

Map 3b Relative annual mean leached total P concentration from diffuse agricultural sources



Data source PSYCHIC model [Collins & Zhang, 2012. ADAS] Phosphorus and sediment yield characterisation in catchments using 2010 agricultural cencus data

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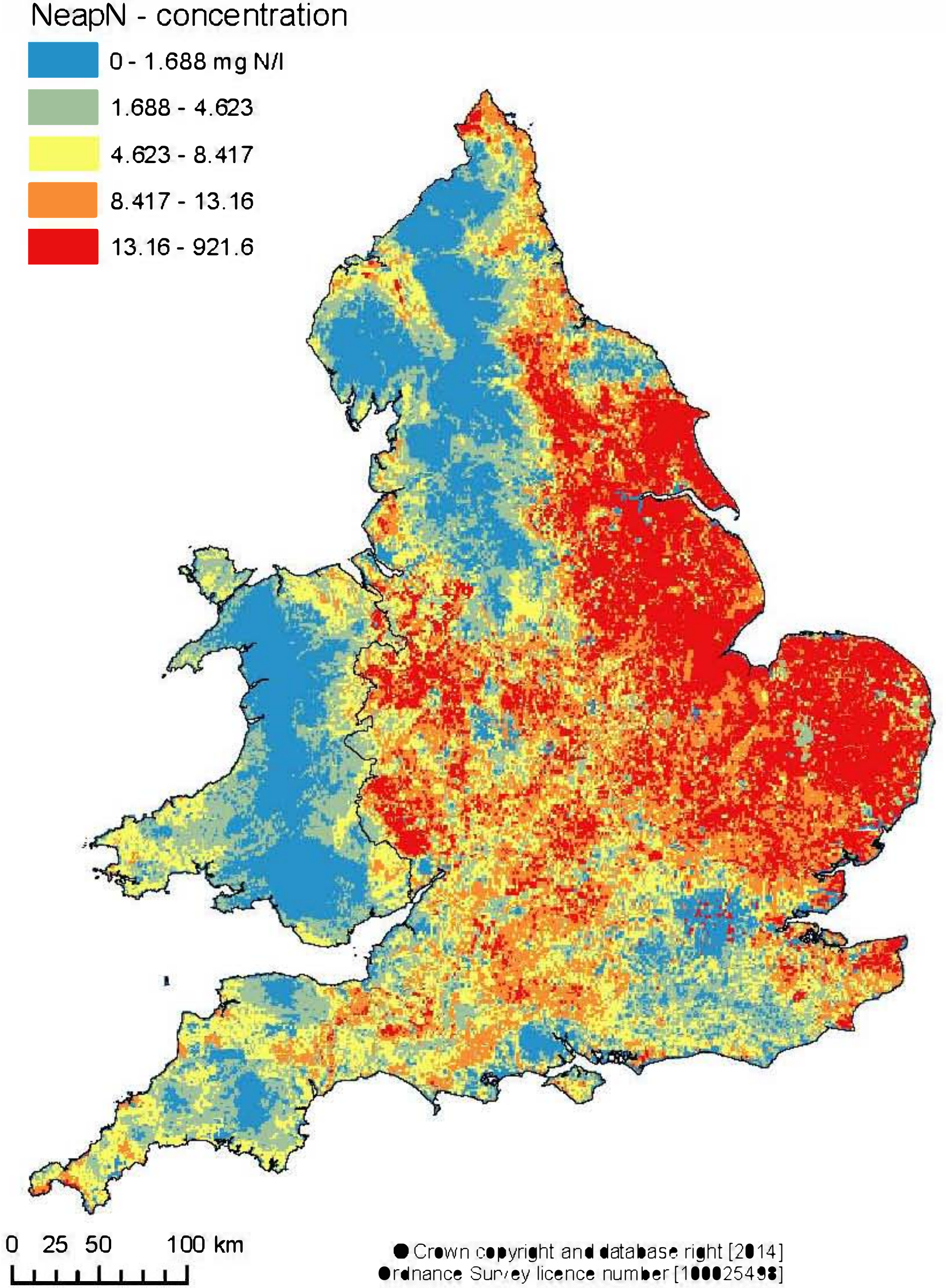
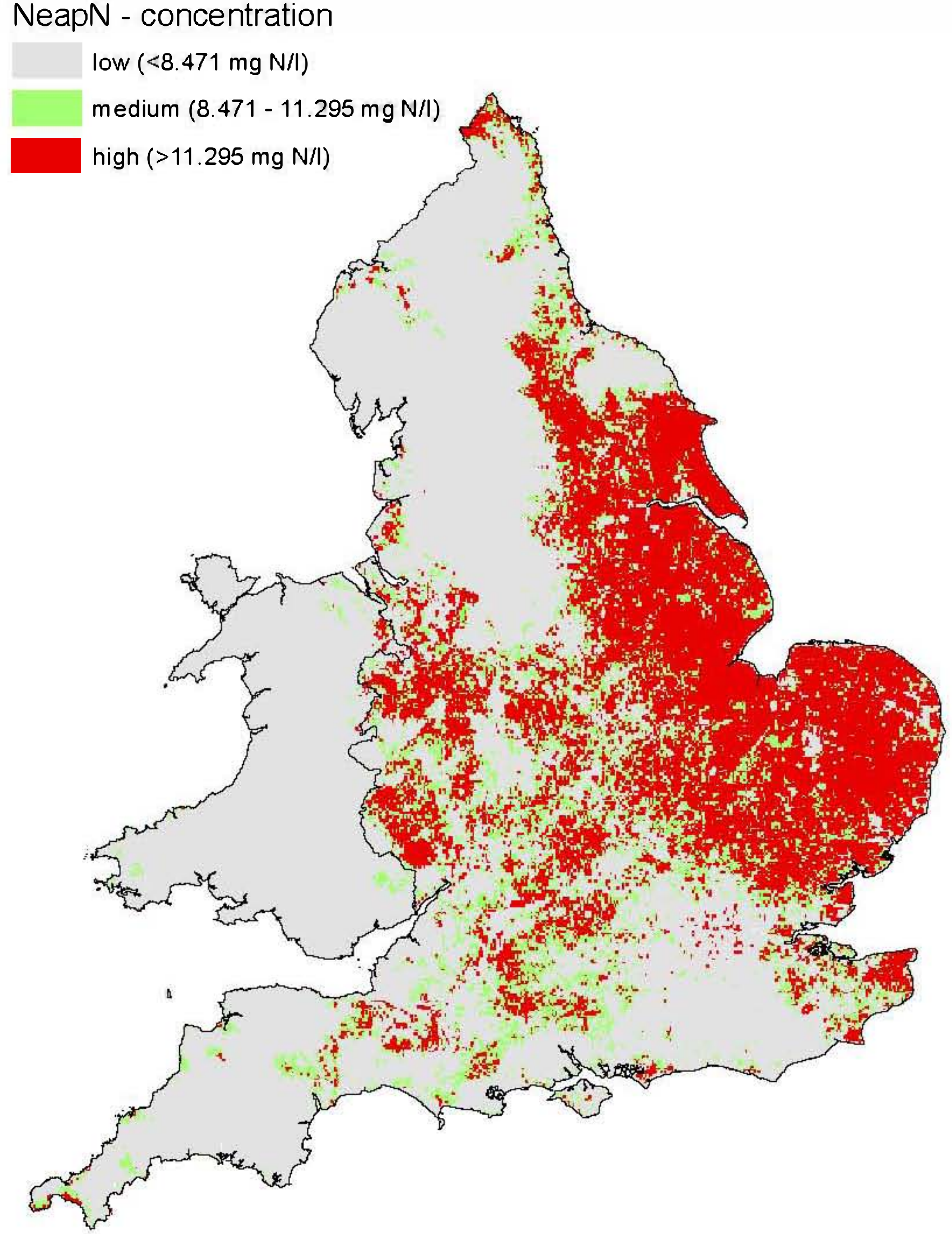
Map 4a Annual mean leached nitrate concentration



Map 4b Relative annual mean leached nitrate concentration

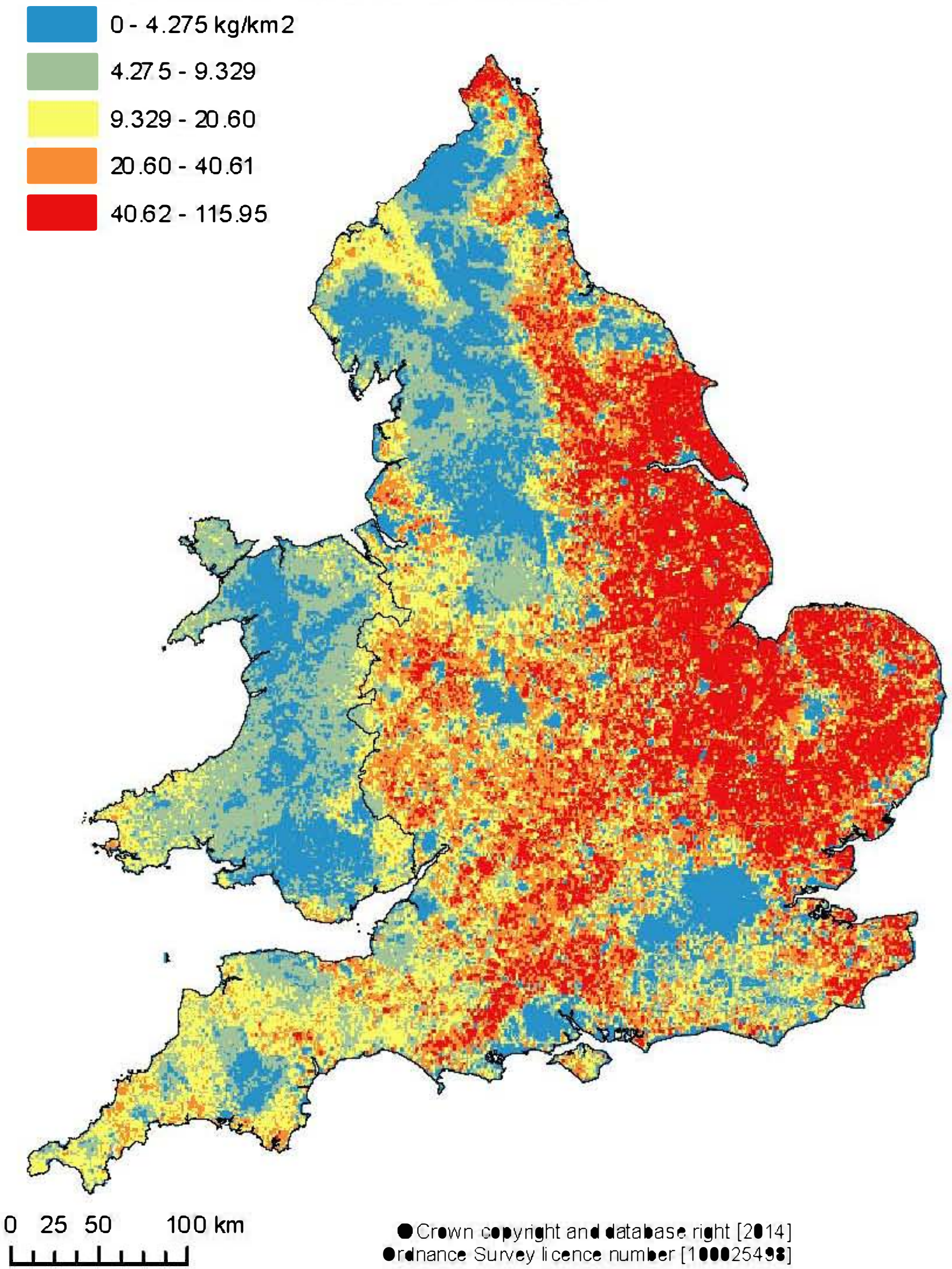


Data source ADAS NeapN soil leaching model

Forest Research

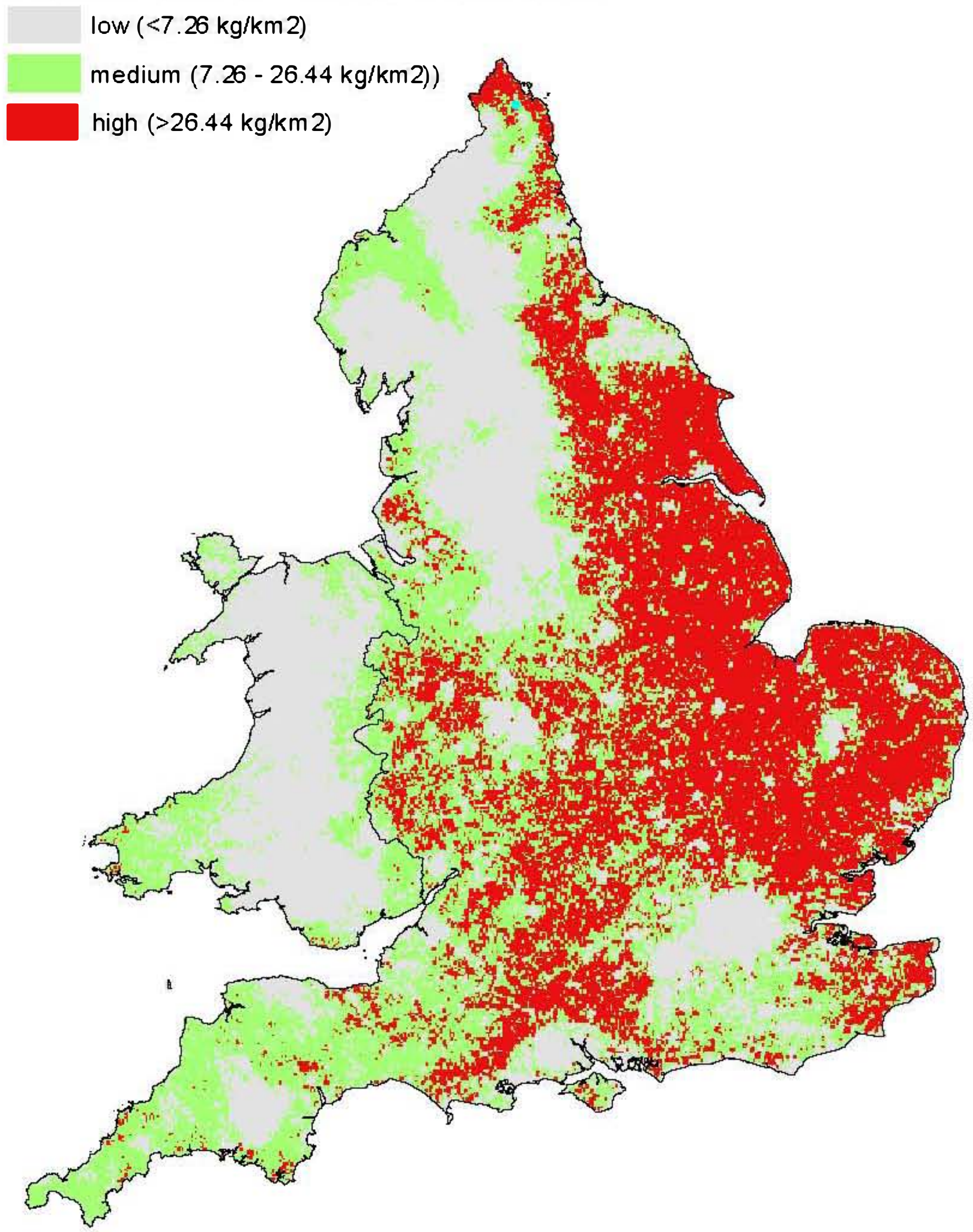
Map 5a Annual pesticide usage

Pesticide useage - total (n=12 pesticides)



Map 5b Relative annual pesticide usage

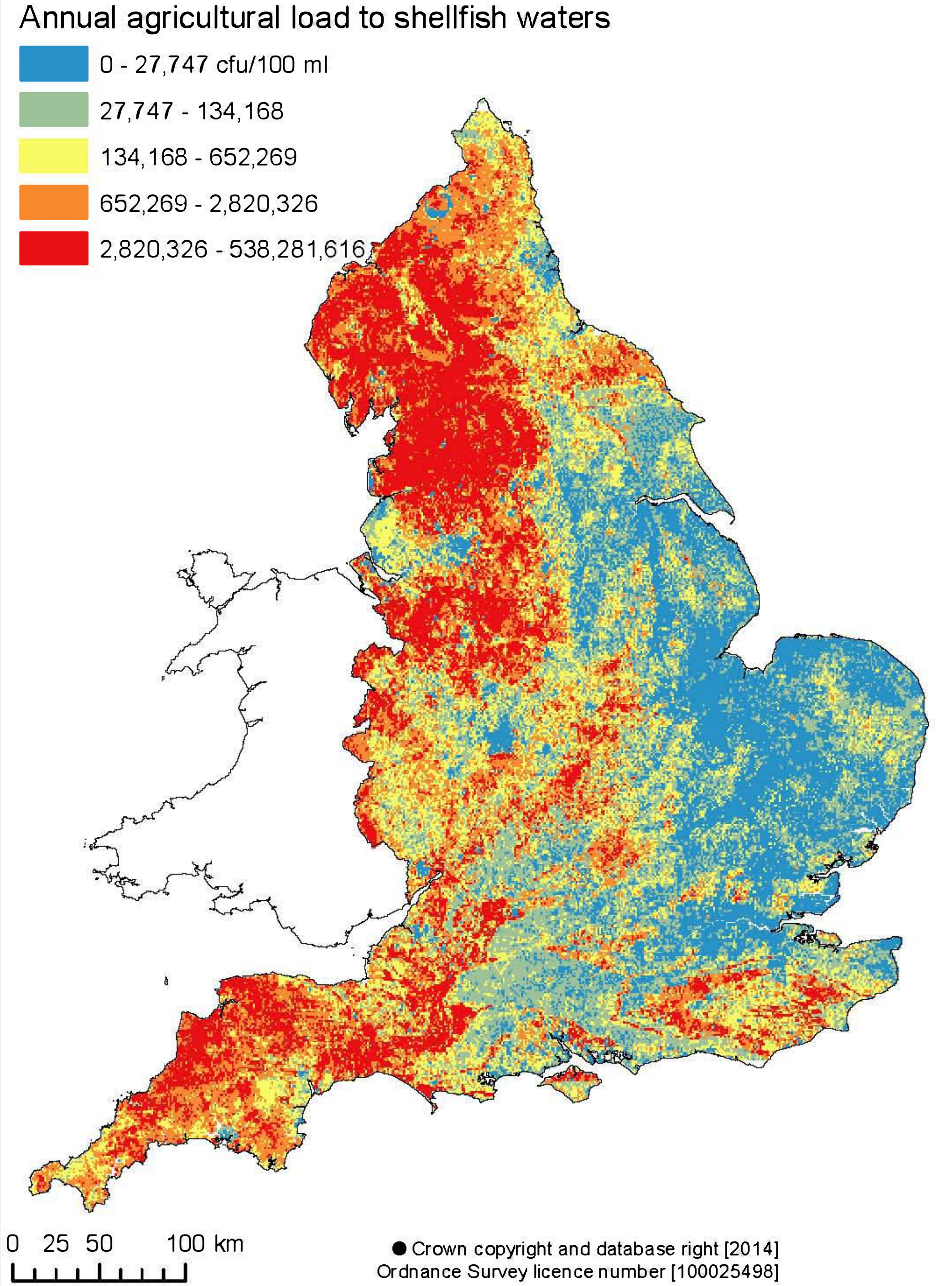
Pesticide useage - total (n=12 pesticides)



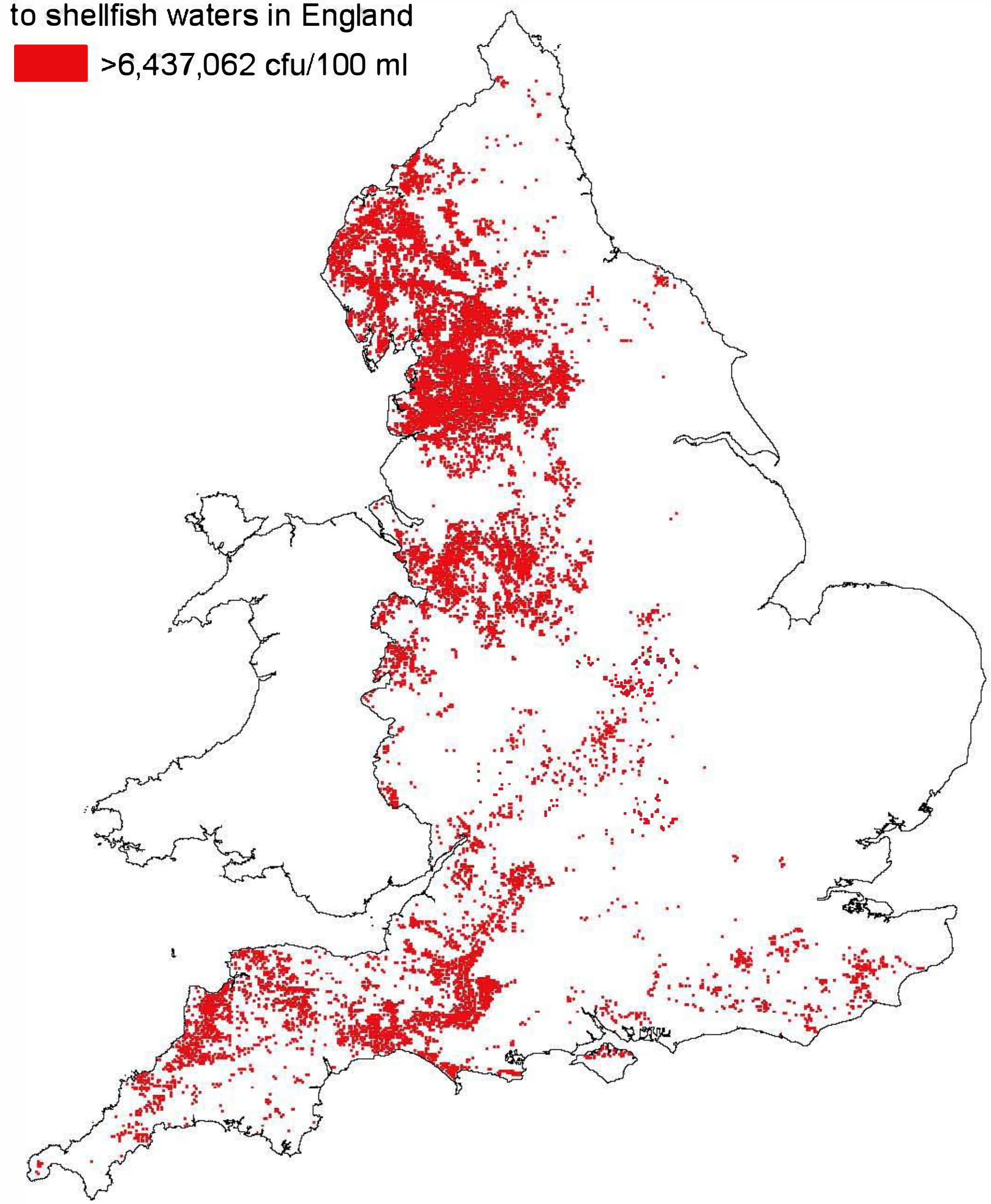
Data source GfK Kynetec, Pesticide Usage Data 2012

Forest Research

Map 6a FIO pressure from agriculture to shellfish waters



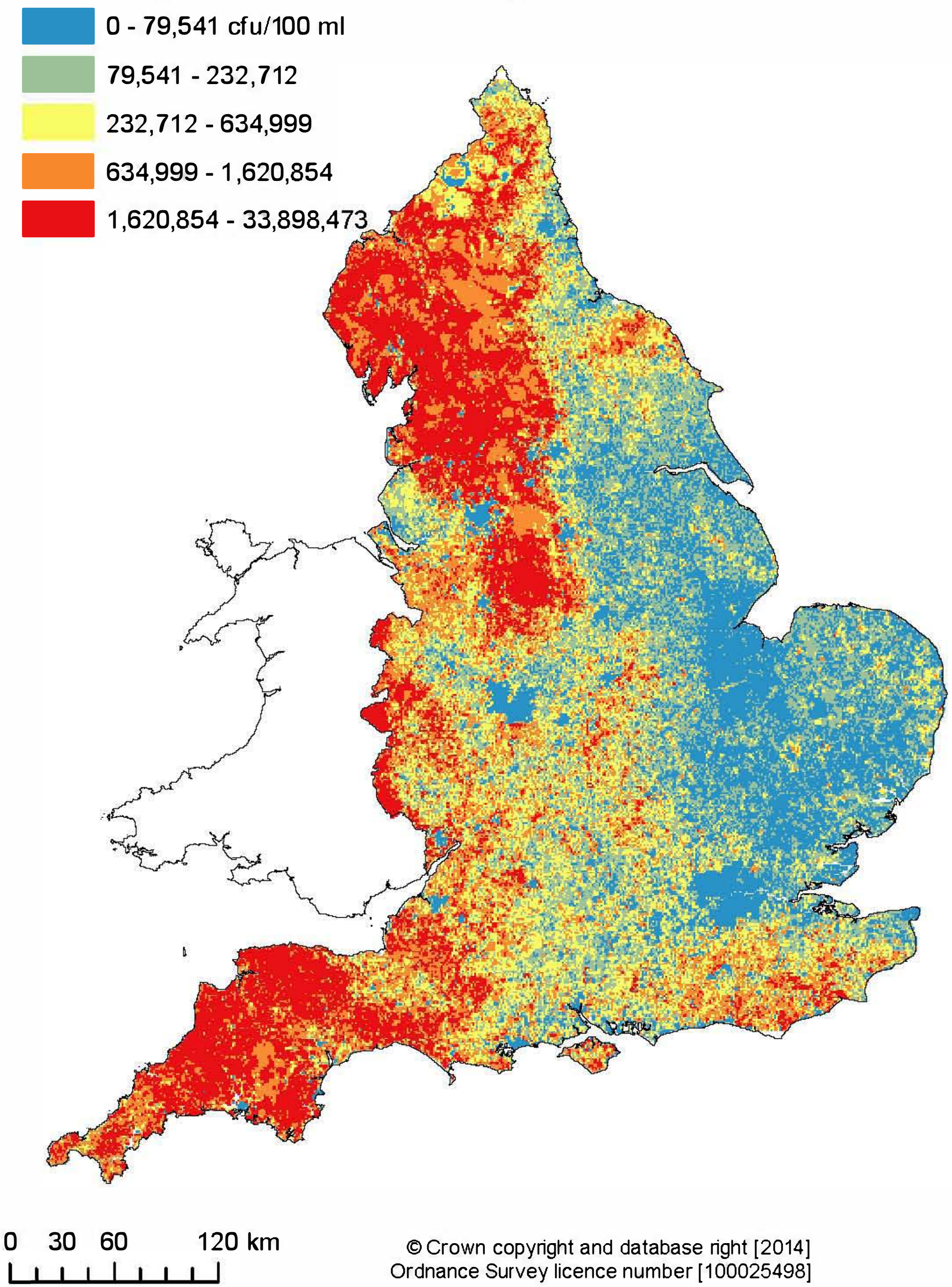
Map 6b Relative FIO pressure from agriculture to shellfish waters



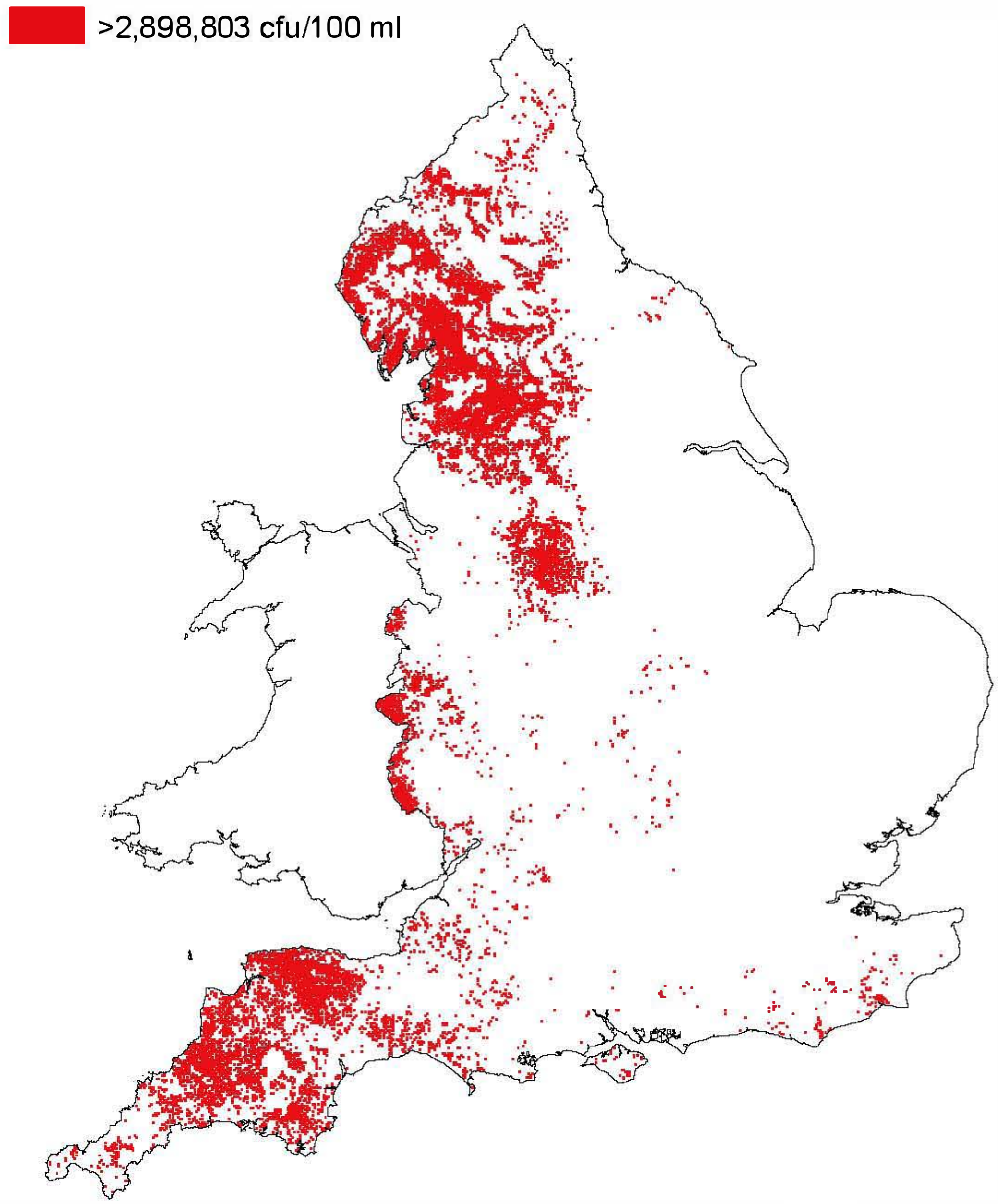
Data source EA: CSF evaluation using CREH data
2013/14 NELMS targetting datasets

Forest Research

Map 7a FIO pressure from agriculture to bathing waters

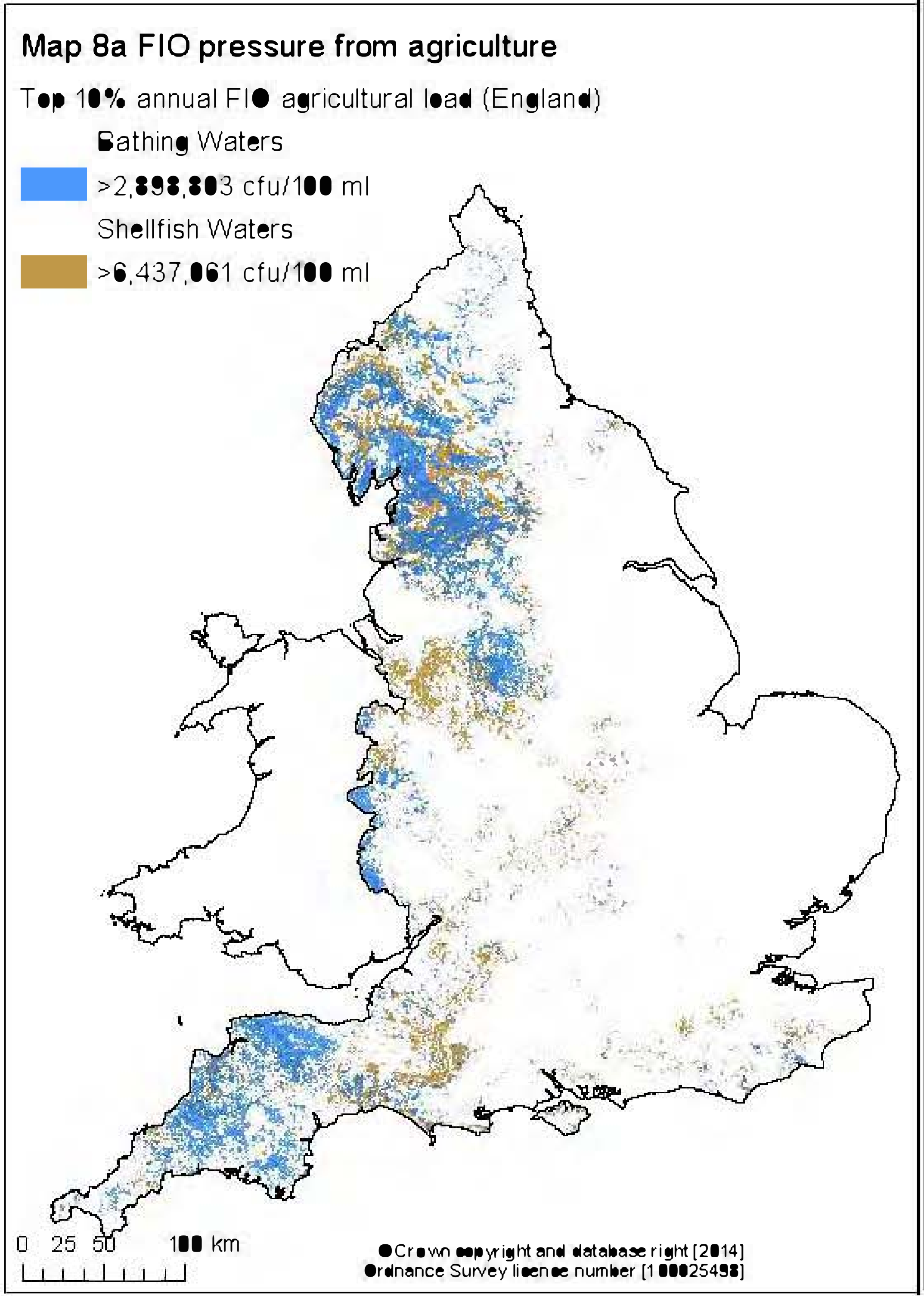


Map 7b Relative FIO pressure from agriculture to bathing waters



Data source EA: CSF evaluation using CREH data
2013/14 NELMS targetting datasets

Forest Research


Map 8a FIO pressure from agriculture
Top 10% annual FIO agricultural load (England)
Bathing Waters
>2,898,803 cfu/100 ml
Shellfish Waters
>6,437,061 cfu/100 ml
0 25 50 100 km
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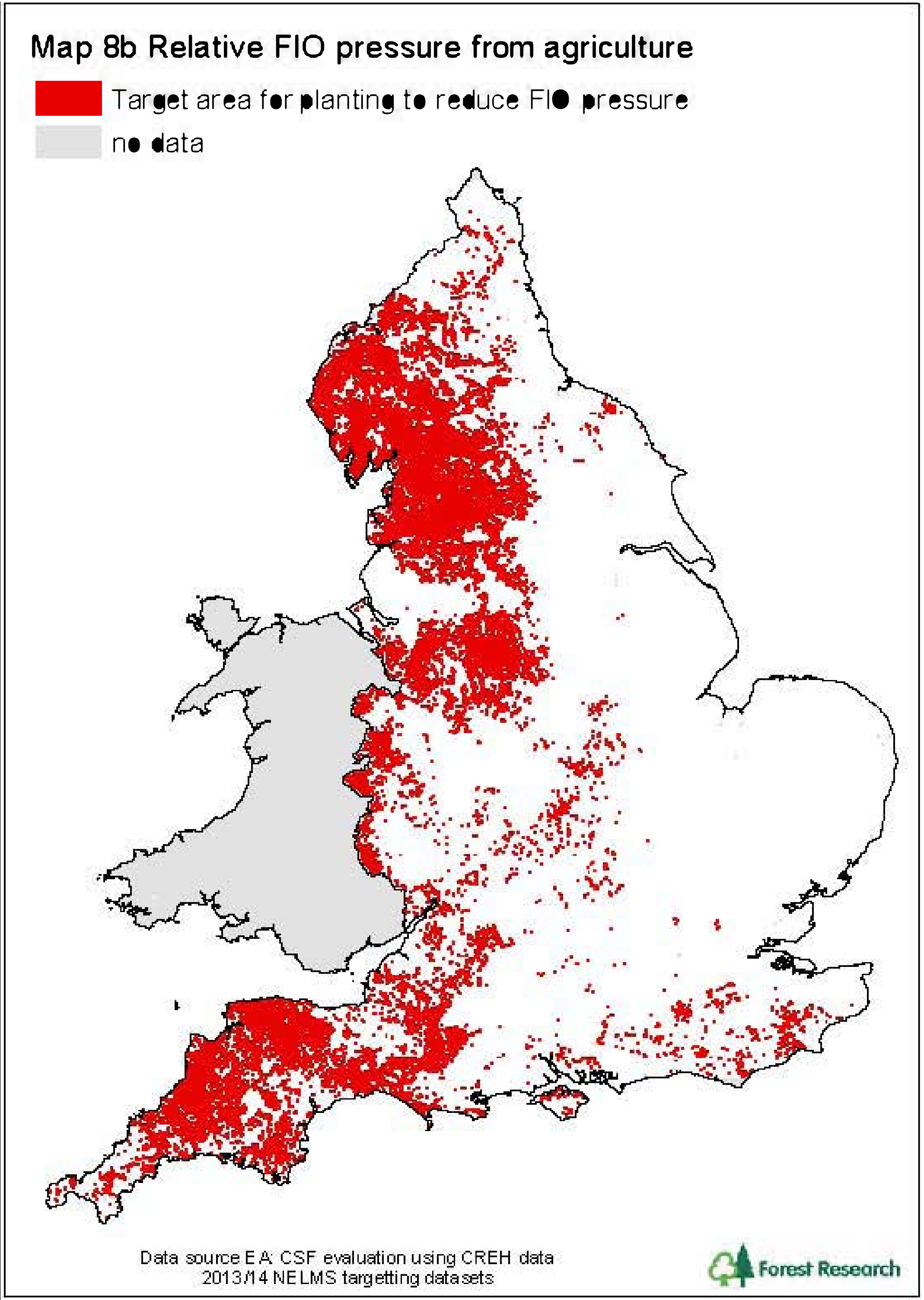
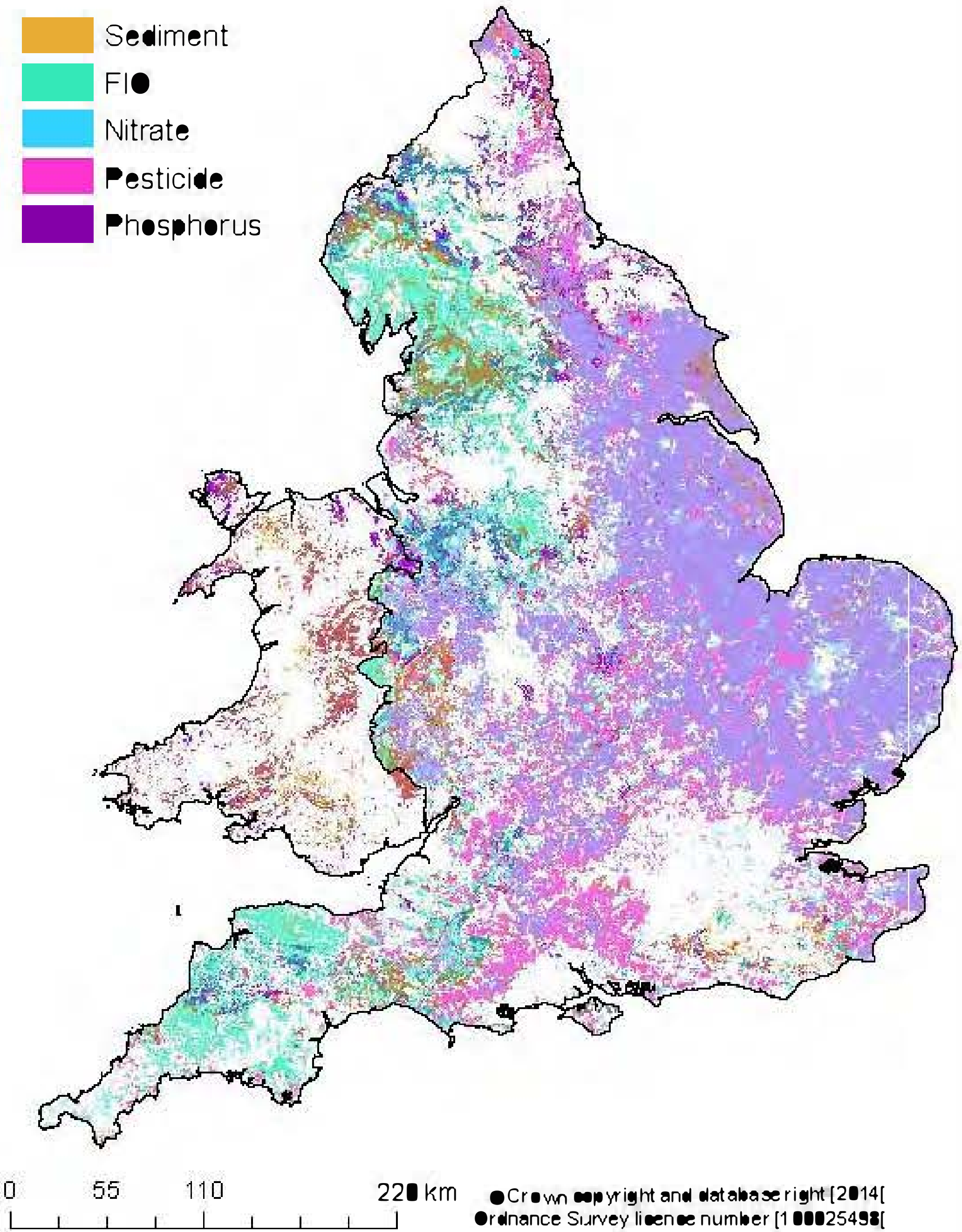
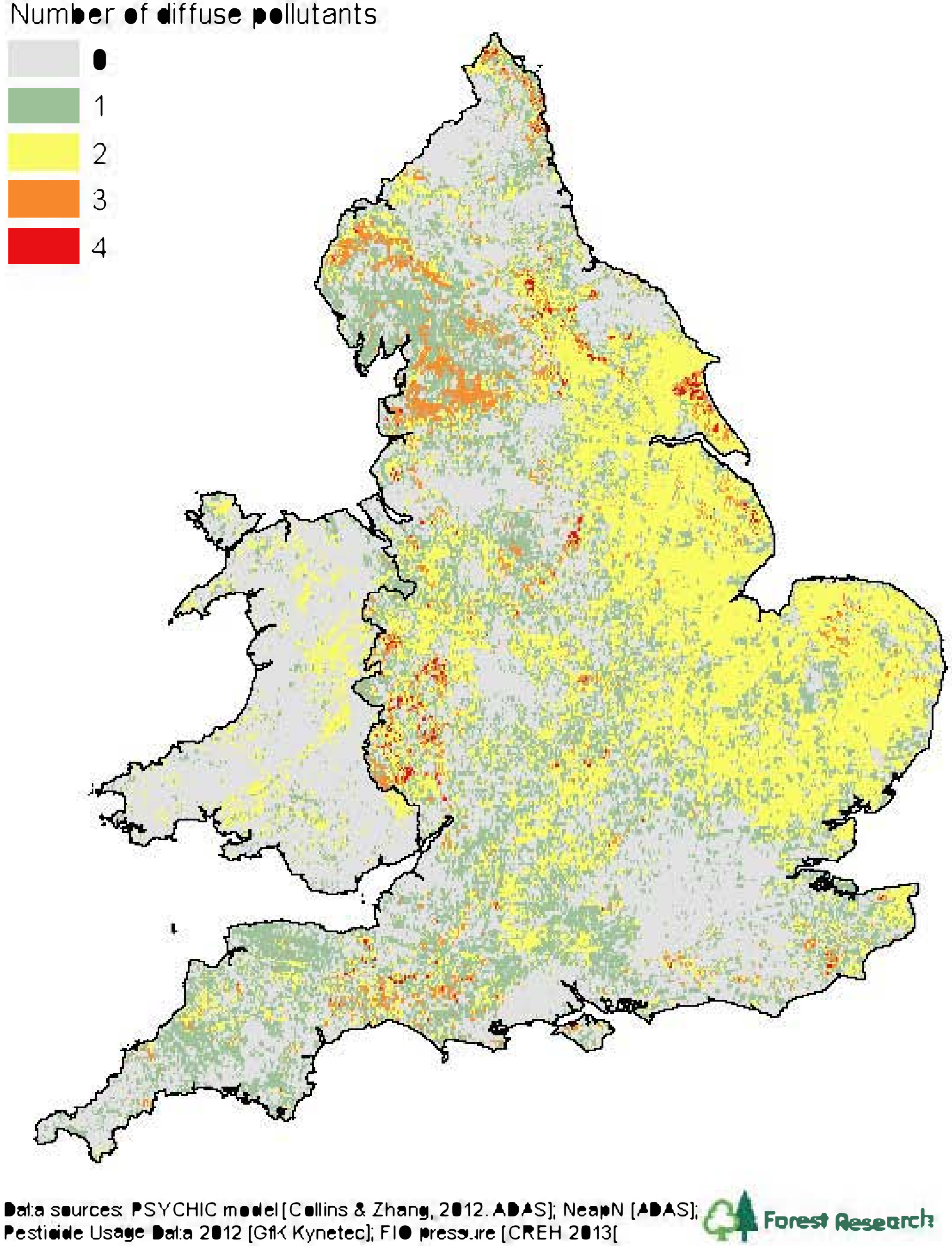
Ordnance Survey licence number [100025498]


Map 8b Relative FIO pressure from agriculture
Target area for planting to reduce FIO pressure
no data
Data source EA: CSF evaluation using CREH data
2013/14 NELMS targetting datasets
Forest Research

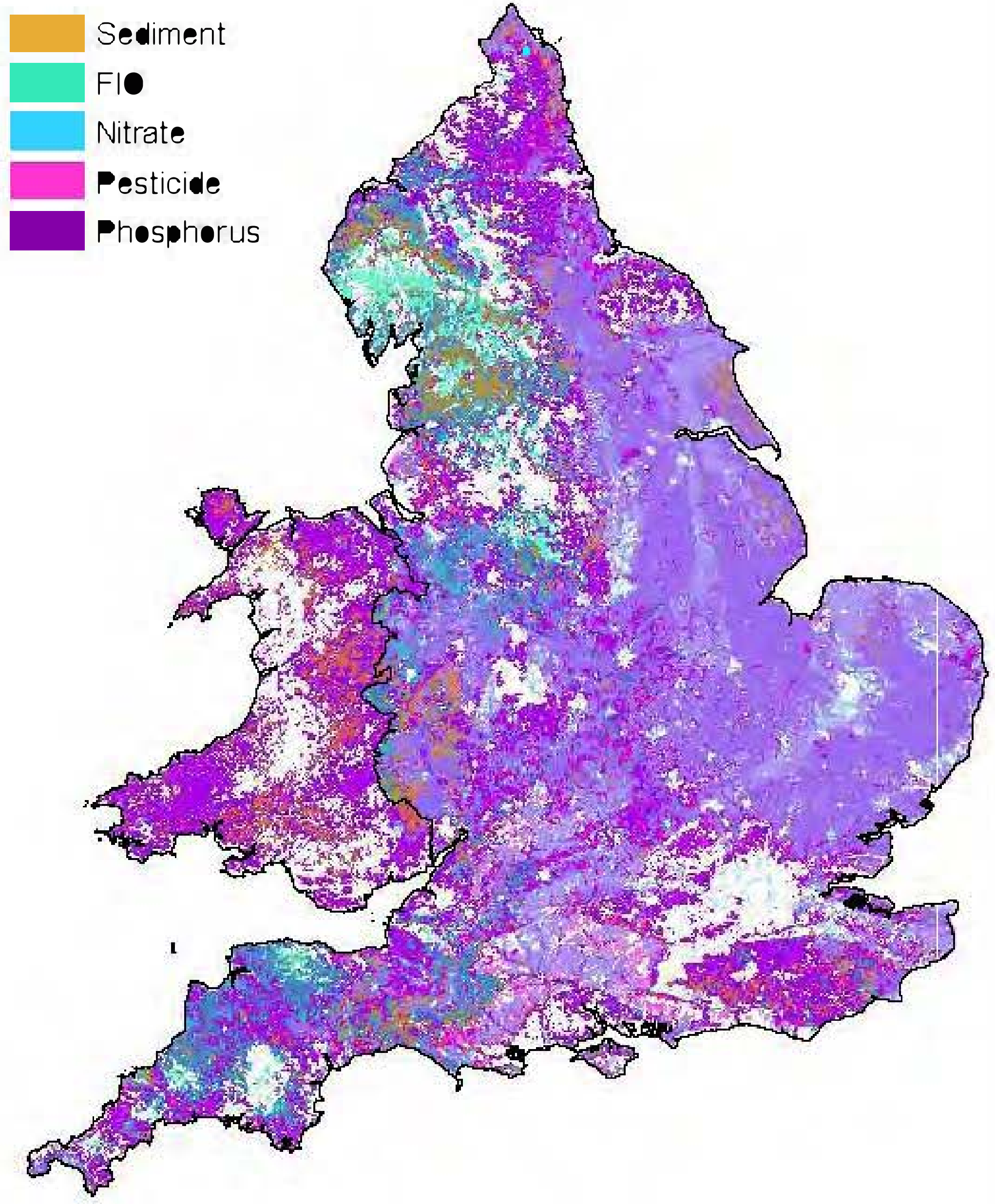
Map 9a Target areas for woodland creation to tackle different diffuse pollutants based on higher thresholds for N and P



Map 9b Woodland opportunities to tackle multiple diffuse pollutants based on higher thresholds for N and P

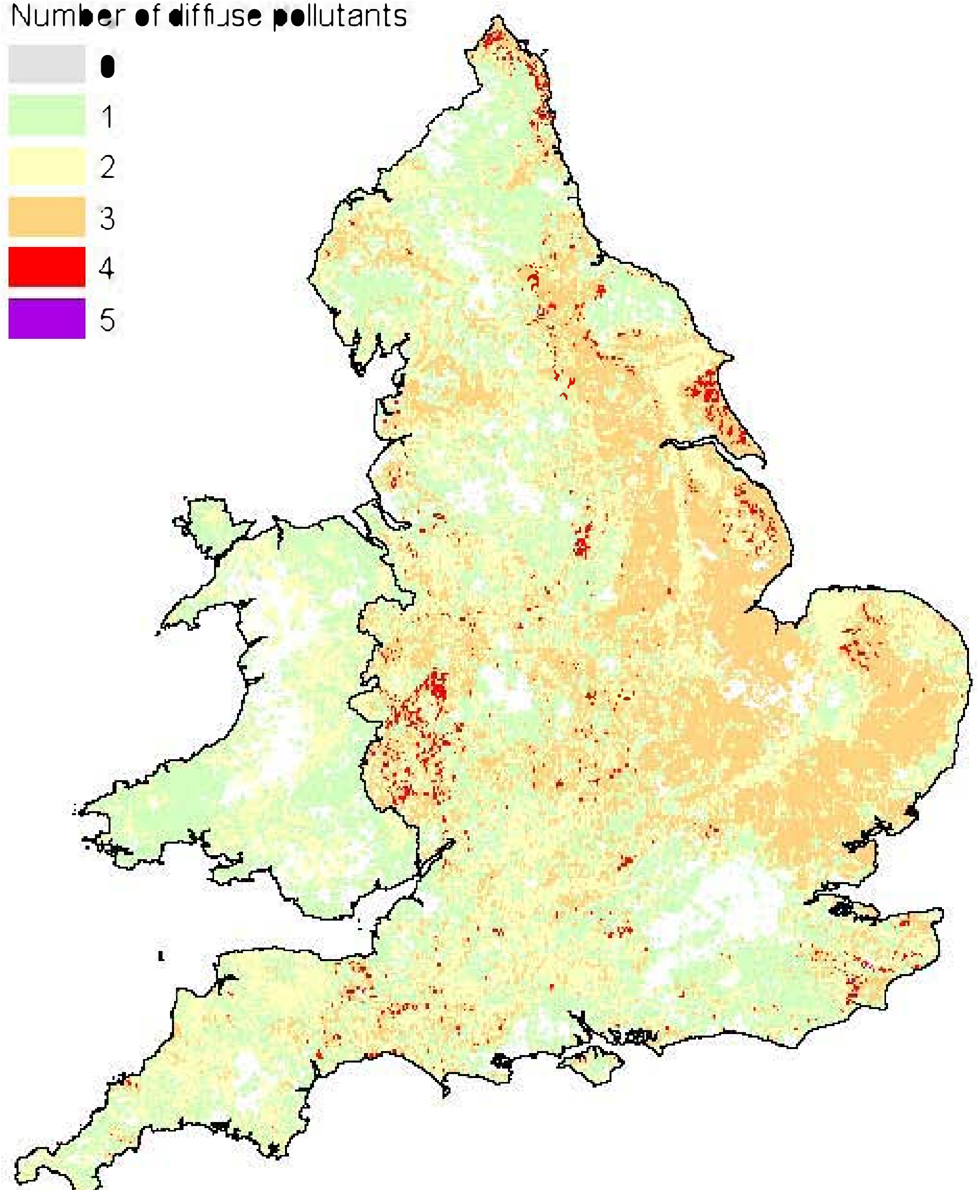


Map 10a Target areas for woodland creation to tackle different diffuse pollutants based on lower thresholds for N & P



0 55 110 220 km

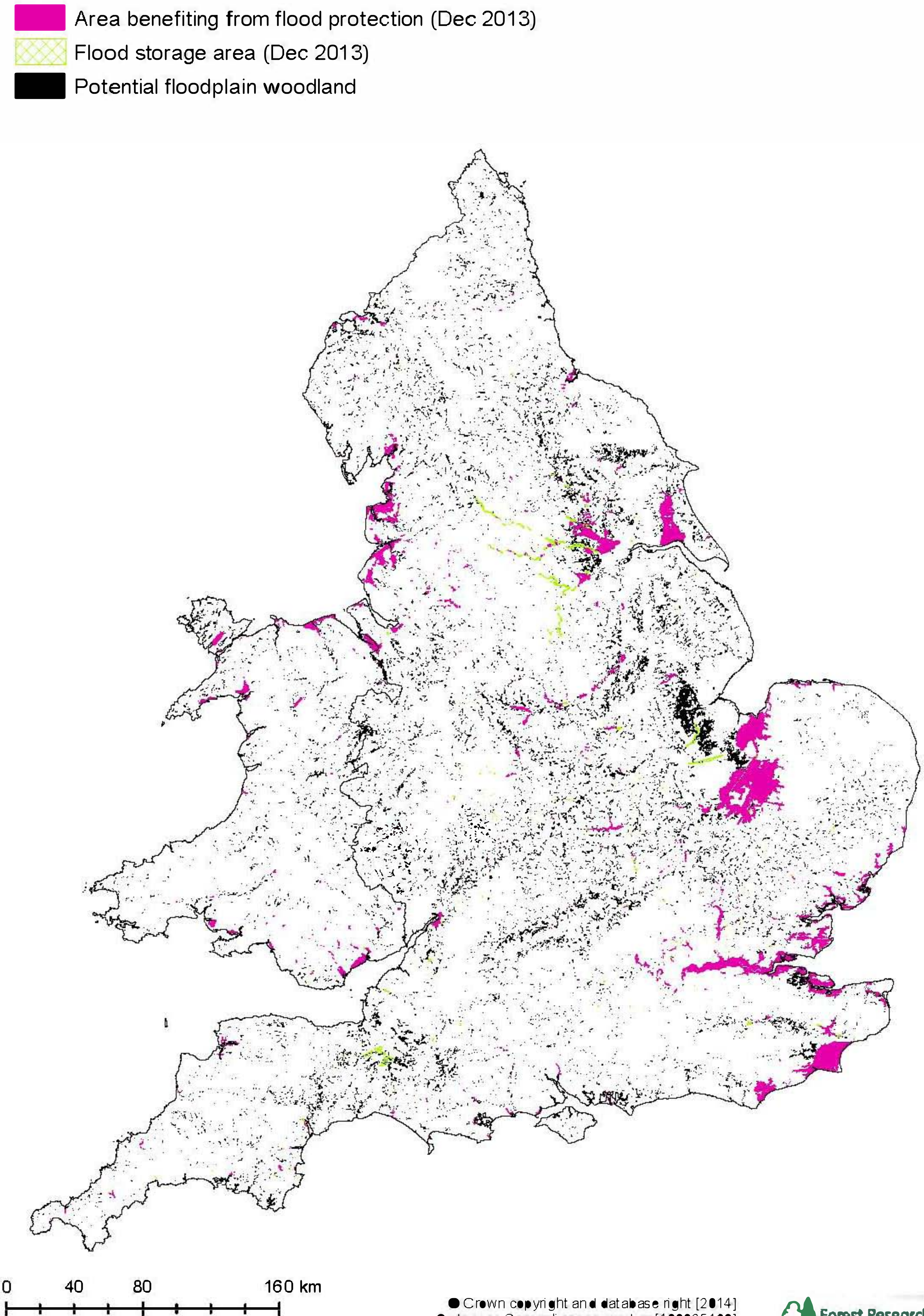
Map 10b Woodland opportunities to tackle multiple diffuse pollutants based on lower thresholds for N & P



Data sources: PSYCHIC model [Collins & Zhang, 2012. ADAS]; NeapN [ADAS];
Pesticide Usage Data 2012 [GfK Kynetec]; FIO pressure [CREH 2013]

Forest Research

Map 11 Areas suitable for planting floodplain woodland



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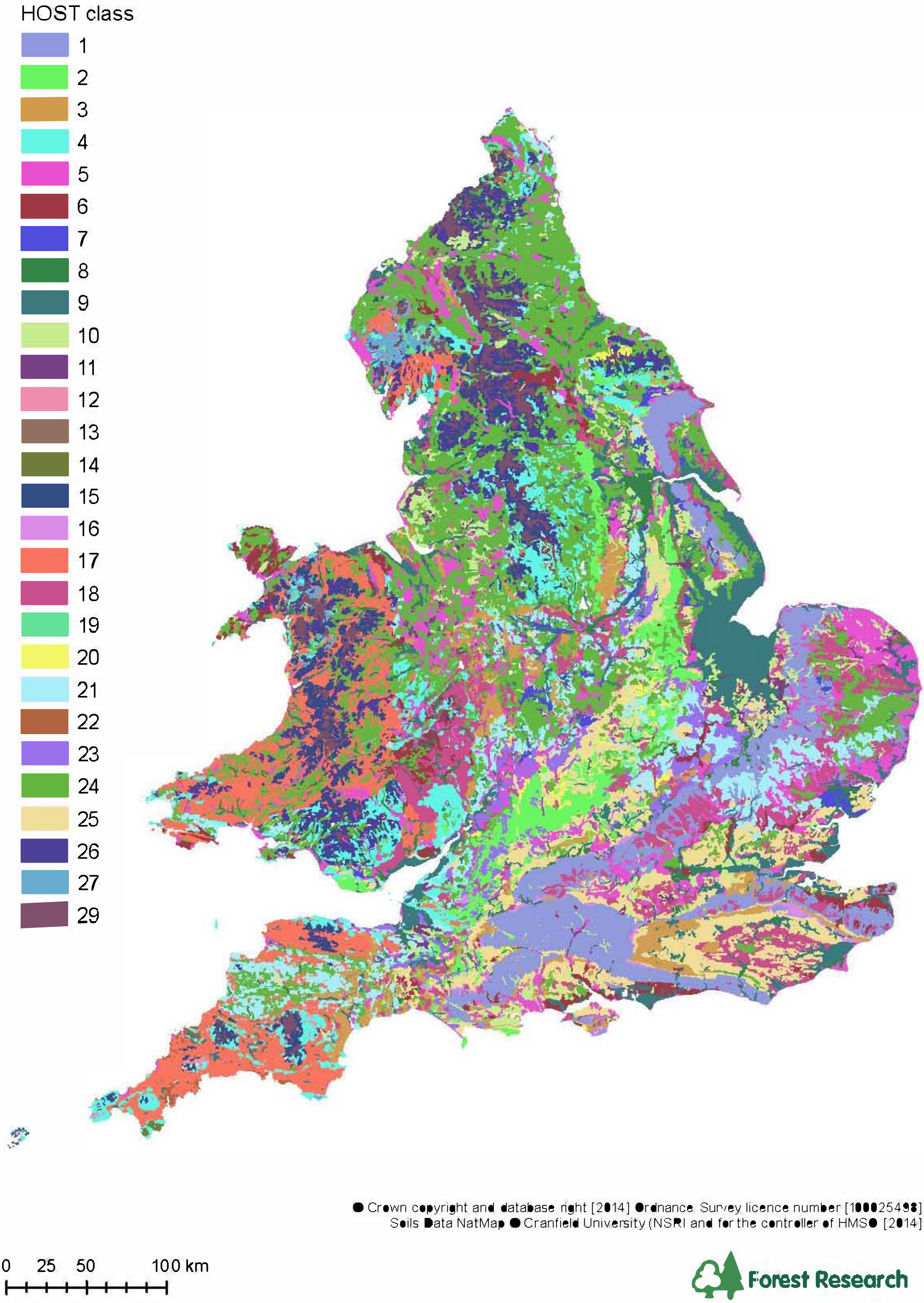
Map 12 Hydrology of Soil Types (HOST) Classification of soils



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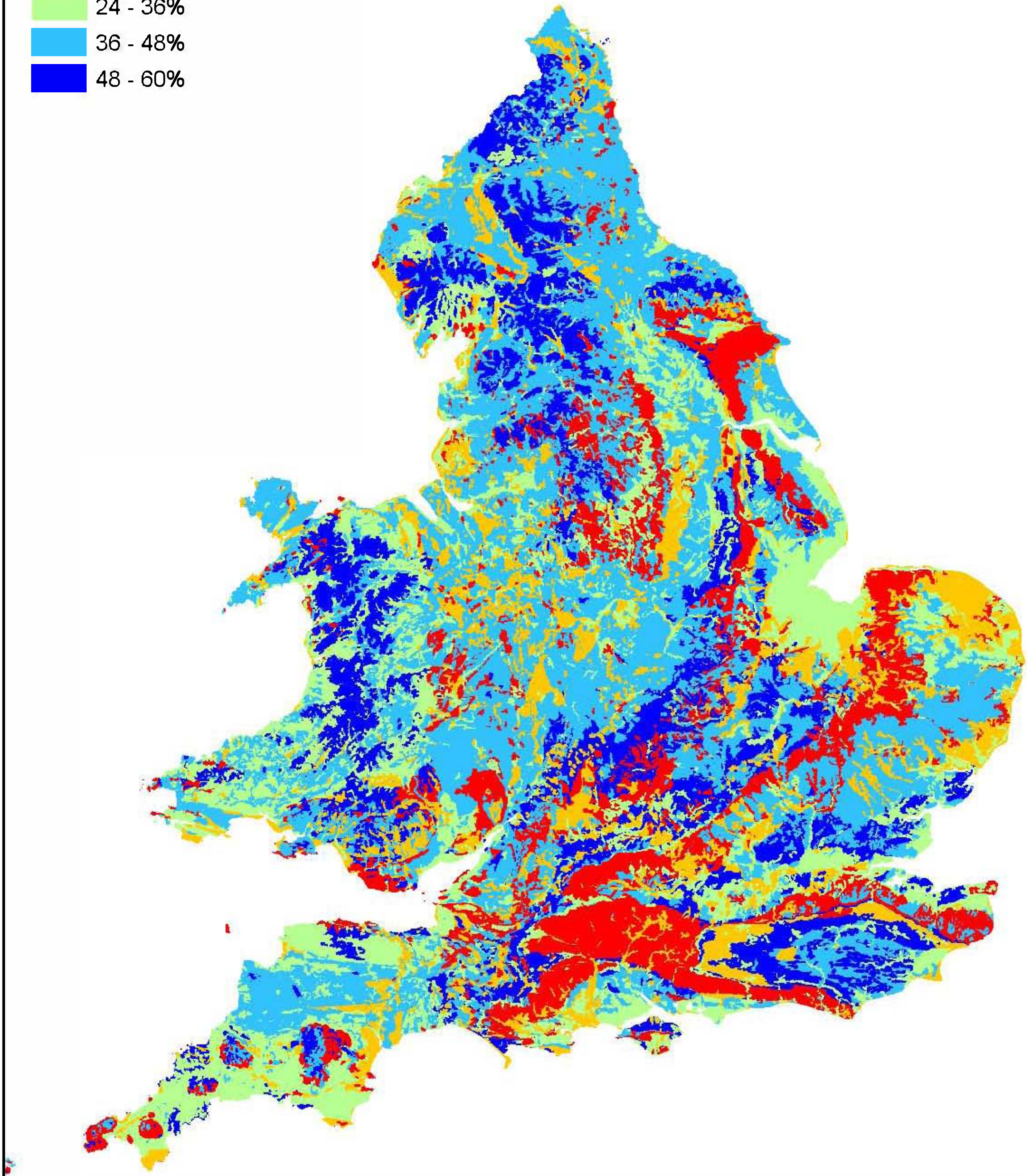
Map 13 Percentage of rainfall contributing to quick response runoff

NATMAP HOST natural SPR%

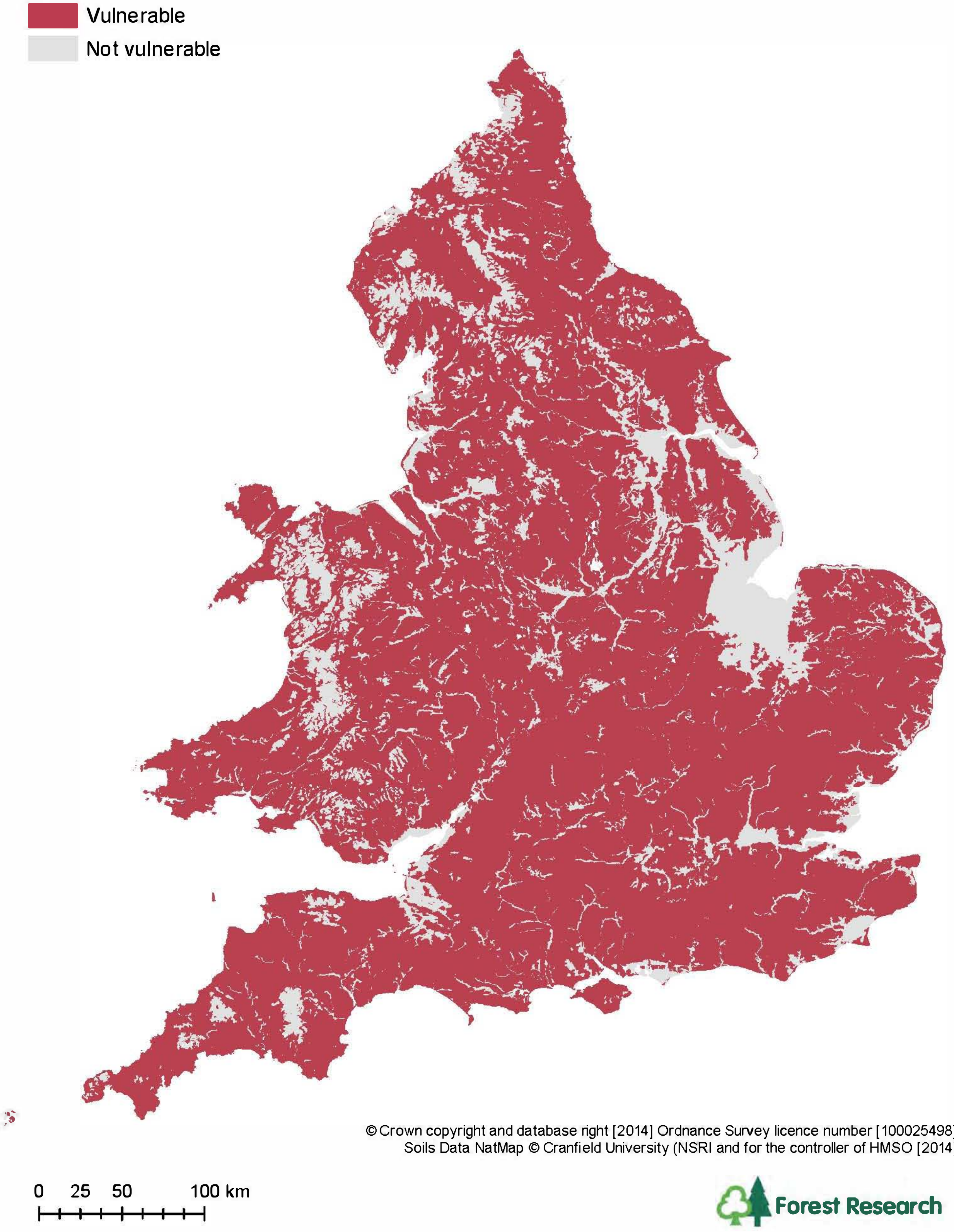
- 0 - 12%
- 12 - 24%
- 24 - 36%
- 36 - 48%
- 48 - 60%



0 25 50 100 km

Forest Research

Map 14 Disribution of soils vulnerable to increased rapid runoff due to structural degradation by intensive agricultural practices



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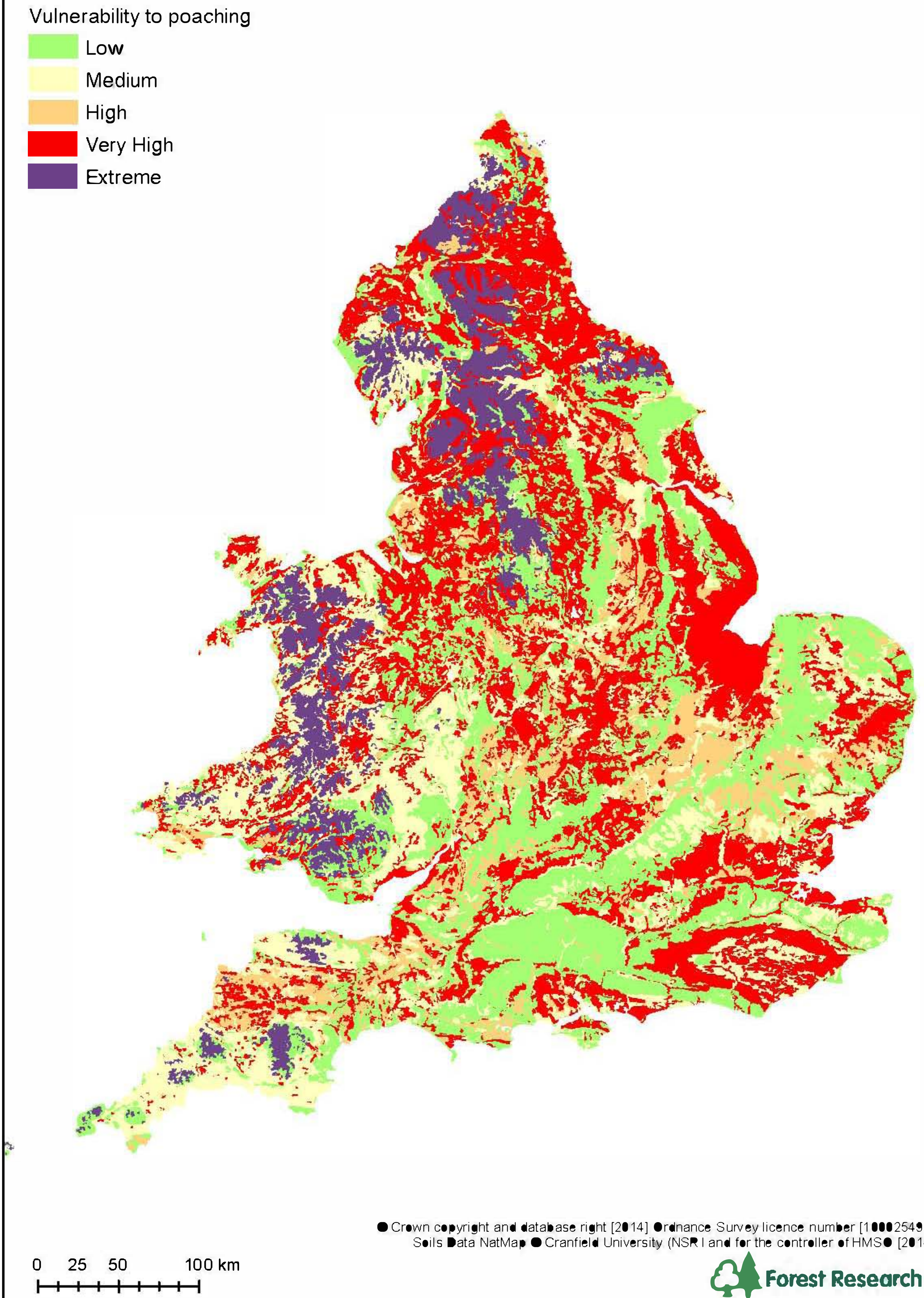
Map 15 Vulnerability of soils to damage by livestock poaching



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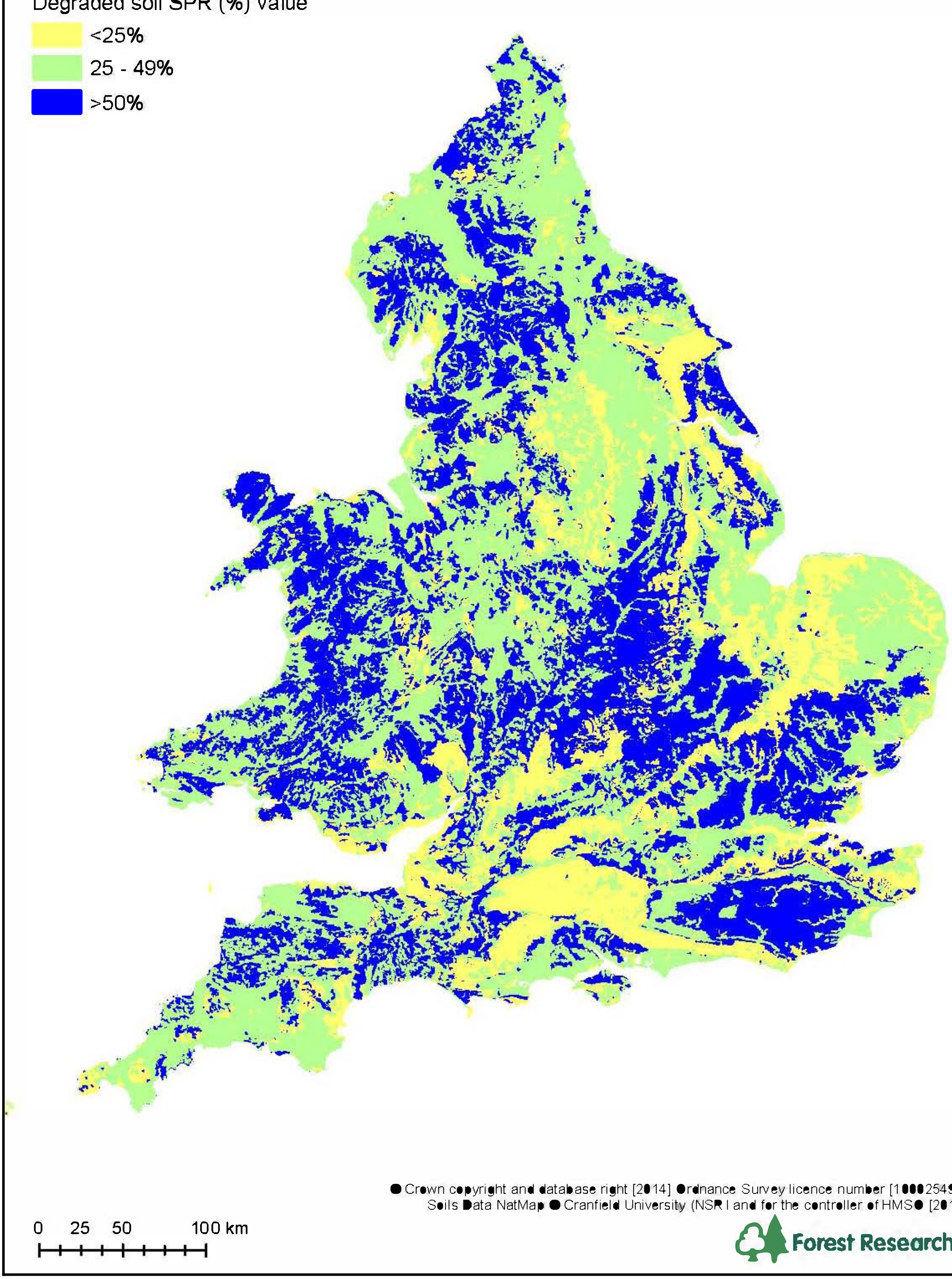
Map 16 Propensity of soils to generate rapid runoff



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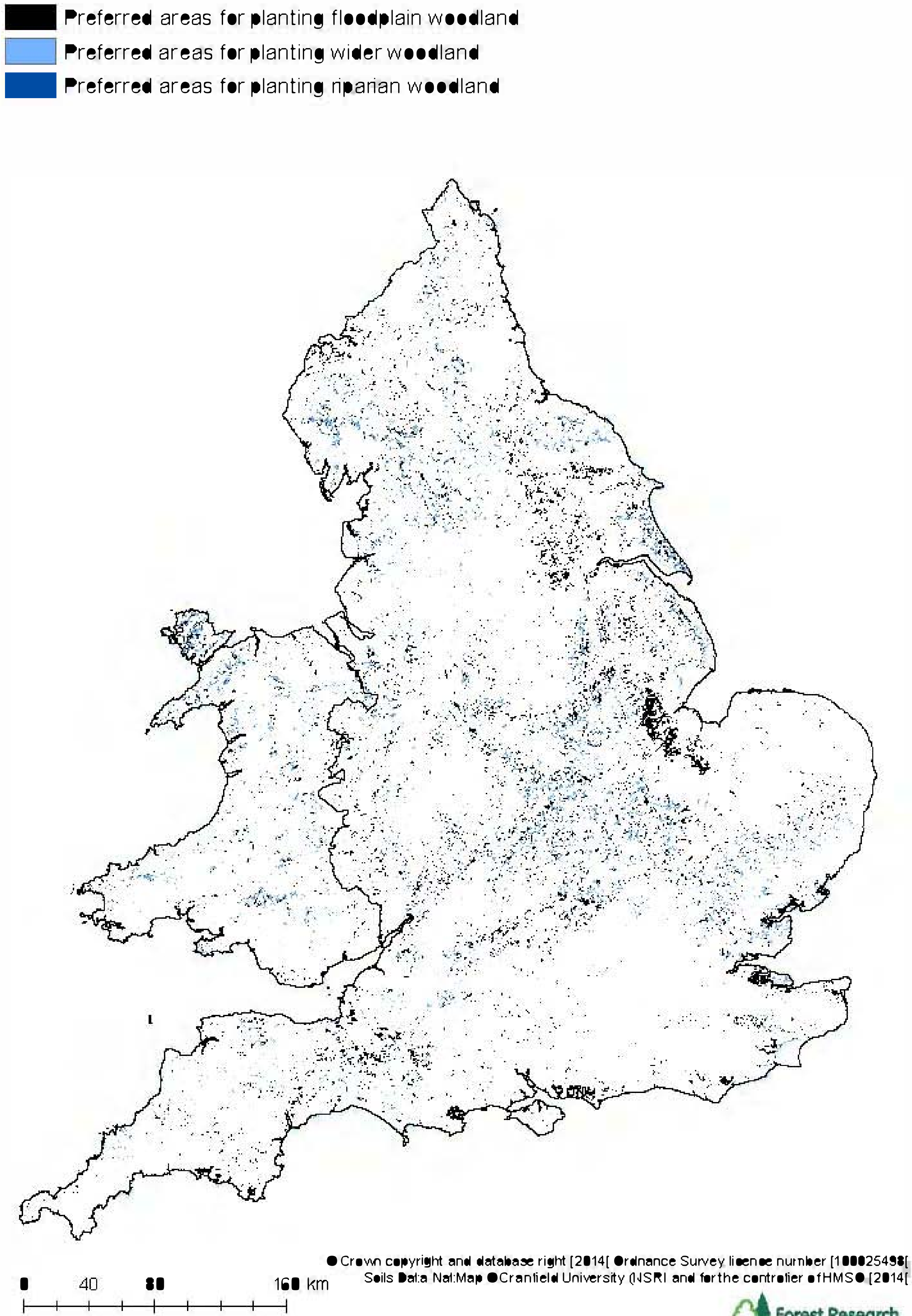
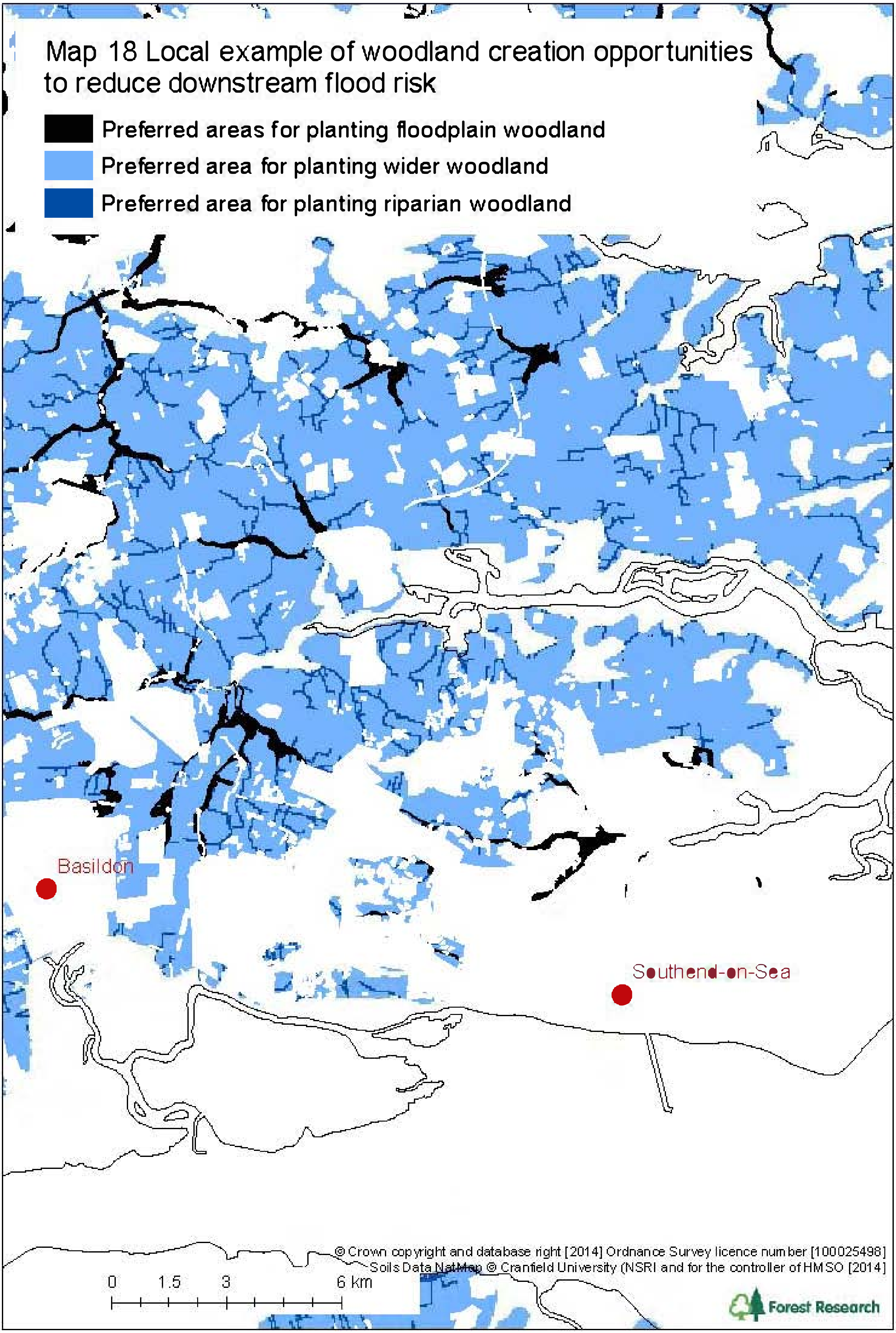
Map 17 Opportunities for woodland creation to reduce downstream flood risk



Forest Research


Map 18 Local example of woodland creation opportunities to reduce downstream flood risk
Preferred areas for planting floodplain woodland
Preferred area for planting wider woodland
Preferred area for planting riparian woodland
Basildon
Southend-on-Sea
0
1.5
3
6 km
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Soils Data NatMap © Cranfield University (NSRI and for the controller of HMSO [2014]
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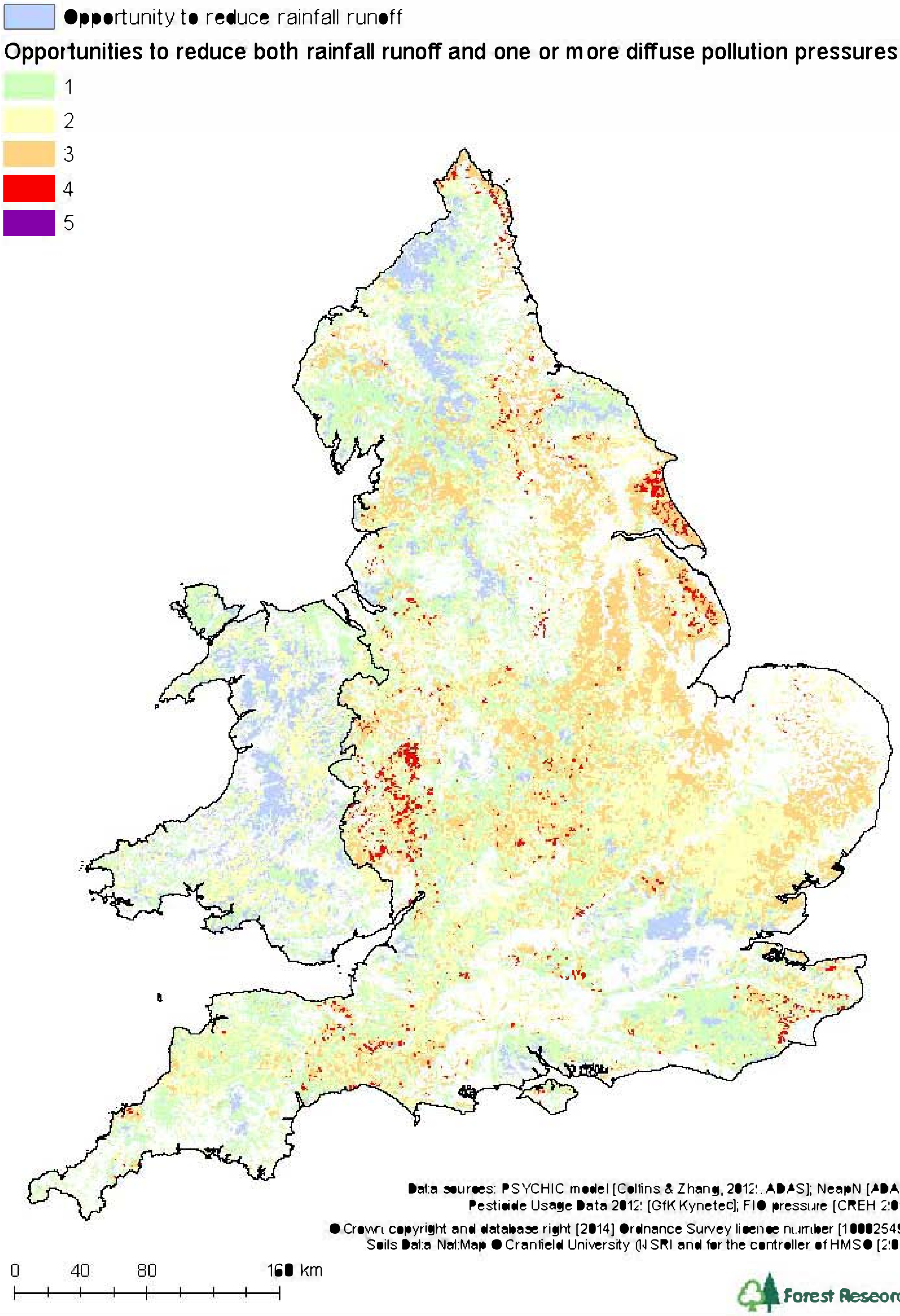
Map 19 Opportunities for woodland creation to reduce downstream flood risk and one or more diffuse pollutants



Data sources: PSYCHIC model [Collins & Zhang, 2012; ADAS]; NeapN [ADAS]; Pesticide Usage Data 2012 [GfK Kynetec]; FIO pressure [CREH 2013]

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