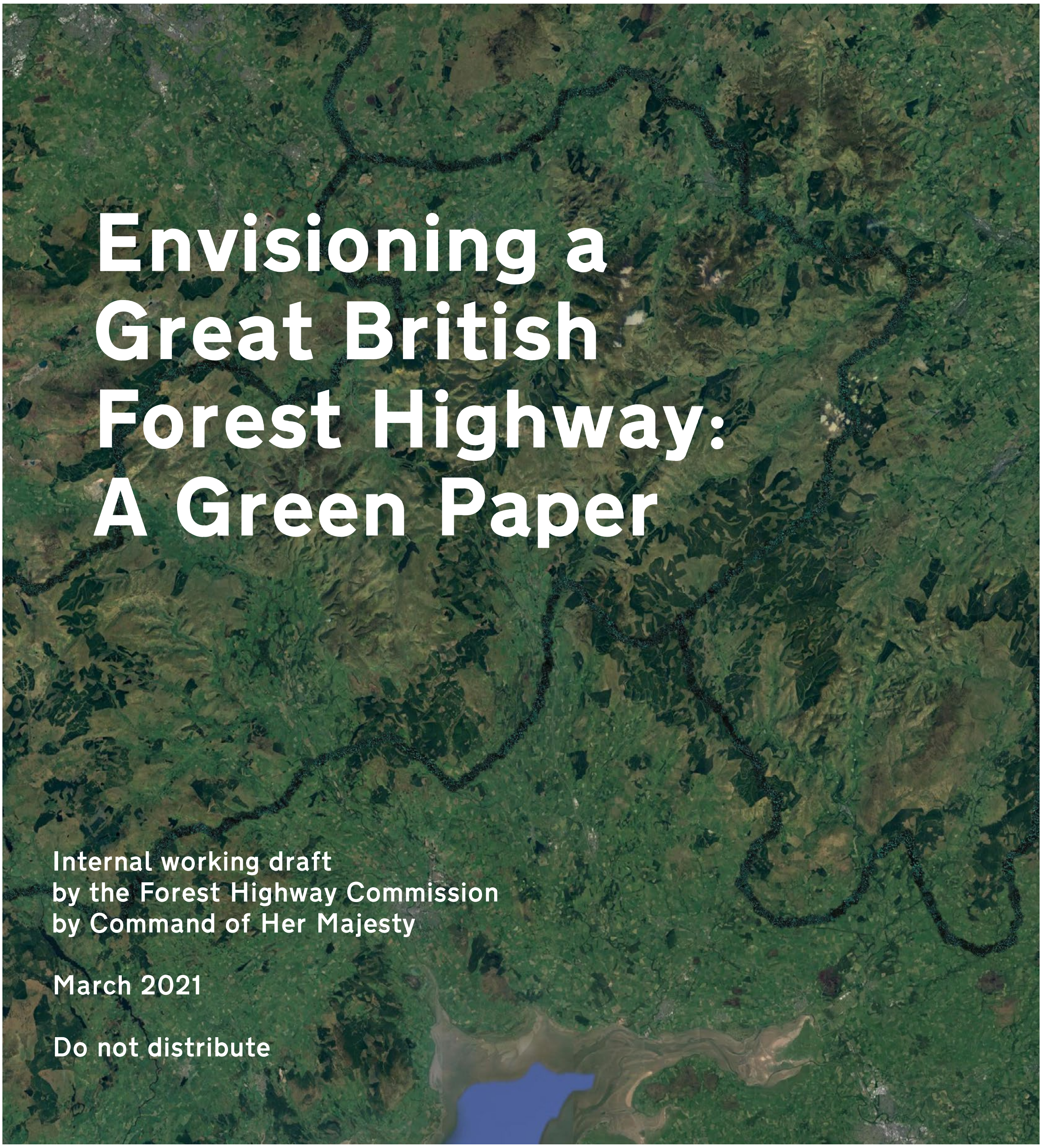
Forest Highway
Commission



# Envisioning a Great British Forest Highway: A Green Paper

Internal working draft
by the Forest Highway Commission
by Command of Her Majesty

March 2021

Do not distribute

## Contents

## Green paper authors

**The PLANNER**

*Forest Highway Commission*

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**The Rt Hon POLITICIAN**

*Ecosystem Infrastructure*
*Committee Chair*

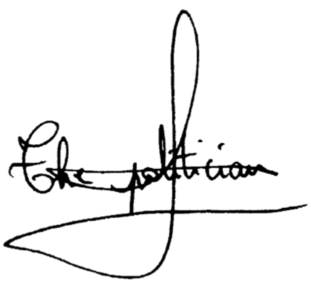
## Ministerial foreword

The British Government's ambitious tree planting goals provides an historic opportunity to design world-leading, innovative woodland creation projects. Through our flagship project, the **Great British Forest Highway**, we have designed something that delivers for our communities, our businesses and our ecosystems. This project is a dividend to everybody in Great Britain, no matter their political alignment, locality or species.

The primary role of any government is to keep its citizens safe and free, and advances in ecological research have shown how important environmental health is in the long term, holistic achievement of this endeavour. A resilient, diverse national biome is an ideal to which governments across the globe should aspire.

In preparing these proposals, the **Forest Highway Commission** and the **Ecosystem Infrastructure Committee** have engaged with a number of theoretical perspectives, design methodologies, and geospatial datasets. We now look forward to the beginning of the consultation process, which will open the opportunity for each and every stakeholder to have their say.

Delivering the ambitious aims of this Green Paper will require a huge effort. Indeed, the **Great British Forest Highway** is the potentially most ambitious environment connectivity project in history. We look forward to working with you in making these proposals a reality.



The Rt Hon POLITICIAN

*Ecosystem Infrastructure*
*Committee Chair*


*The proposed route for the Great British Forest Highway.*

*Basemap from ESRI.*

# Executive summary

## The challenge

The UK Government has committed to the transformation of the nation's landscapes in order to offset greenhouse gas emissions and adapt to the pressures of climate change.

Afforestation and reforestation are key strategies in this process due to the ability of forests to remove carbon from the atmosphere and sequester it as biomass (primarily in the wood and roots of trees) and in the soil. Forests also provide a multitude of secondary environmental, societal, and economic benefits.

To achieve net zero emissions by 2050, the UK needs to convert at least 9,750 km2 of land into forests. This would increase the percentage of forested land in the UK from its current level of 13% to 17%.

We believe that the scale of these proposed land cover changes makes how they are designed a matter of national importance.

## Our response

Understanding that the way a forest is defined has significant impacts on the design and management of new forests, we undertake a historical review of forest definitions from the Middle Ages to the twenty-first century. We find that the way forests are conceptualised is a reflection of human needs within a specific historical and geographic context. Today, dominant forest definitions focus on the carbon sequestration potential of forests and the provision of ecosystem services to local communities.

We challenge these conceptions through the development of a non-human-centred definition of a forest. For this, we draw inspiration from the work of contemporary biologists and social scientists working in the field of multispecies studies. Through our definition, we understand a successful forest to be highly connected and embedded in its host environment.

Building on this definition, we present a work-in-progress methodology for forest-centred afforestation. Using this methodology, we create an indicative design for the Great British Forest Highway, a national-scale infrastructure project which aims to link together the core forests of Great Britain.

## Key principles

The design of the Great British Forest Highway is guided by the following key principles:

- that the wellbeing of non-humans is of equal importance to the wellbeing of humans;
- that forests should be designed from a non-human-centred perspective;
- that the design should operate at the national level, leaving scope for future research and development at the regional and local levels;
- and that proposals should support the achievement of existing governmental goals and commitments.

## Scope

The project focuses on Great Britain as a site for an ecosystem infrastructural project.

In this document, ‘Great Britain’ refers to the largest island in the British Isles which constitutes the mainlands of England, Scotland, and Wales. It is understood in terms of physical geography and does not include any of the smaller English, Scottish and Welsh islands that are often understood as part of ‘Great Britain’ as a political entity (e.g. the Hebrides, the Northern Isles, Anglesey, Isle of Wight).

While the rationale for this project could be applicable for the island of Ireland (which constitutes the mainlands of Northern Ireland and the Republic of Ireland), such a project would require coordination between the UK Government, the Government of Ireland and the 26 other member states of the European Union. Currently, no plan to create a forest highway on this site is being considered.

## Areas of consultation

We welcome feedback on all aspects of this proposal. However, we seek specific feedback on a number of key questions:

- In centring the needs of the forest, which stakeholders have been overlooked in the design of the forest highway?
- How might communities connect their local forests to the infrastructure of the forest highway?
- And, how might the Great British Forest Highway be actively managed in a forest-centred manner after planting?

## How to respond to the consultation

This is a public consultation to which anyone with an interest may respond. The UK Government invites the contribution of evidence, ideas and recommendations in response to the plans described in this document.

Responses should be sent to <add email address here> by 19th March 2022.

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# The Great British Forest Highway

In this document, we present a proposal to link together the forests of Great Britain using a network of inter-regional ‘forest highways’.

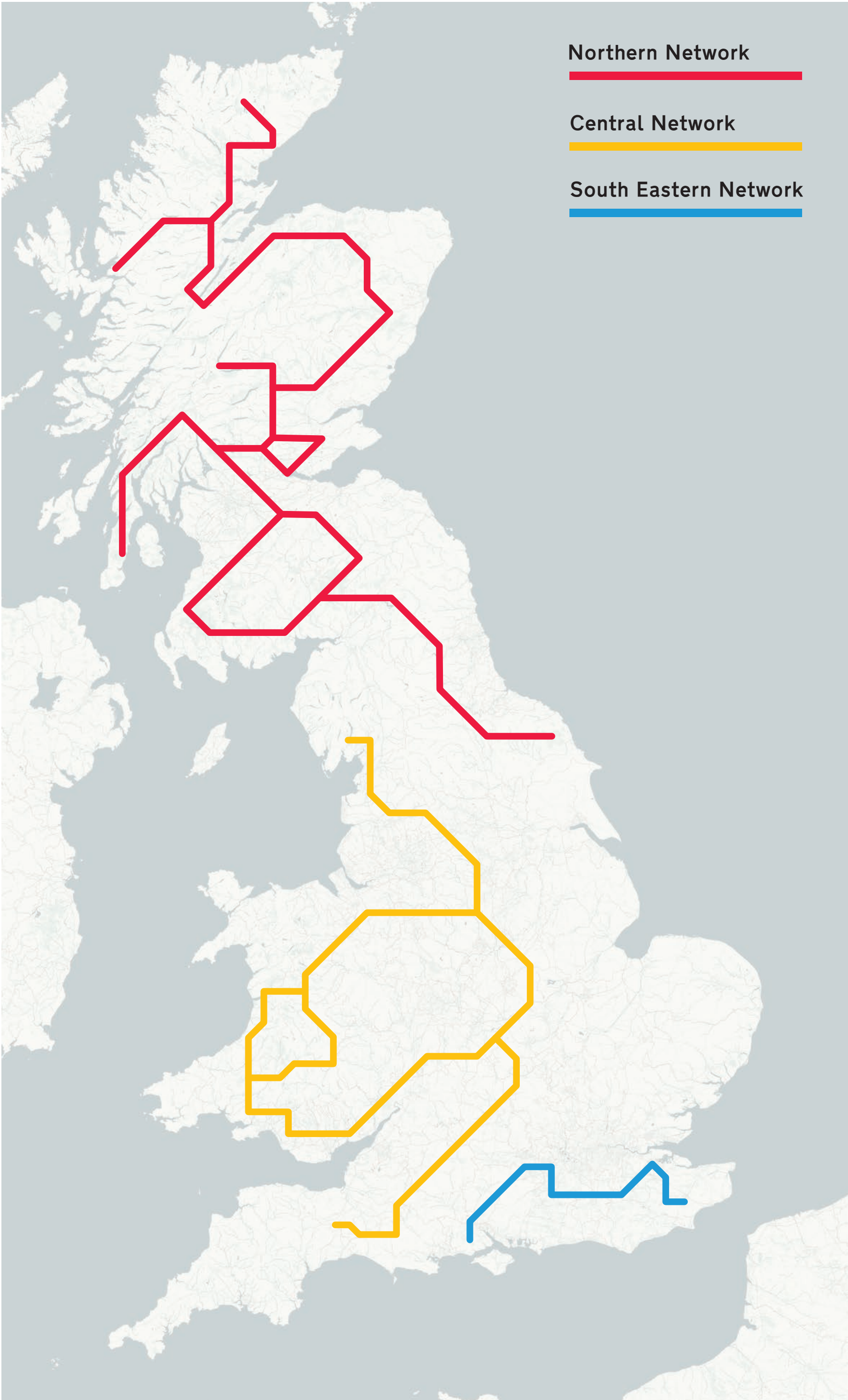
This design proposal challenges the dominant human-centred methods of afforestation which focus only carbon sequestration and the provision of ecosystem services at the local level. Instead, we consider connectedness, embeddedness and complexity as additional metrics by which to judge the holistic success of a forest.

To this end, we have developed a forest-centred methodology for afforestation, drawing upon avant-garde research from the fields of biological, social and data sciences. We took particular inspiration from mycorrhizal networks of plants and fungi; multispecies studies theory; and geospatial data analysis.

Using our methodology, we identified three inter-regional network service zones which we call the ‘Northern Network’, ‘Central Network’, and ‘South-Eastern Network’. We then plotted forest highway paths to link together the keystone areas of mature forests within these service zones.

We propose to spend 60% of the UK’s total tree budget for the next 30 years to implement this project. Our indicative network design has a cumulative length of ~3,970 km and an average width of 1.5 km, for a total area of ~5,955 km2. This is almost four times the size of greater London. We can only imagine the positive impacts that such an ambitious project would have on our collective national identity.

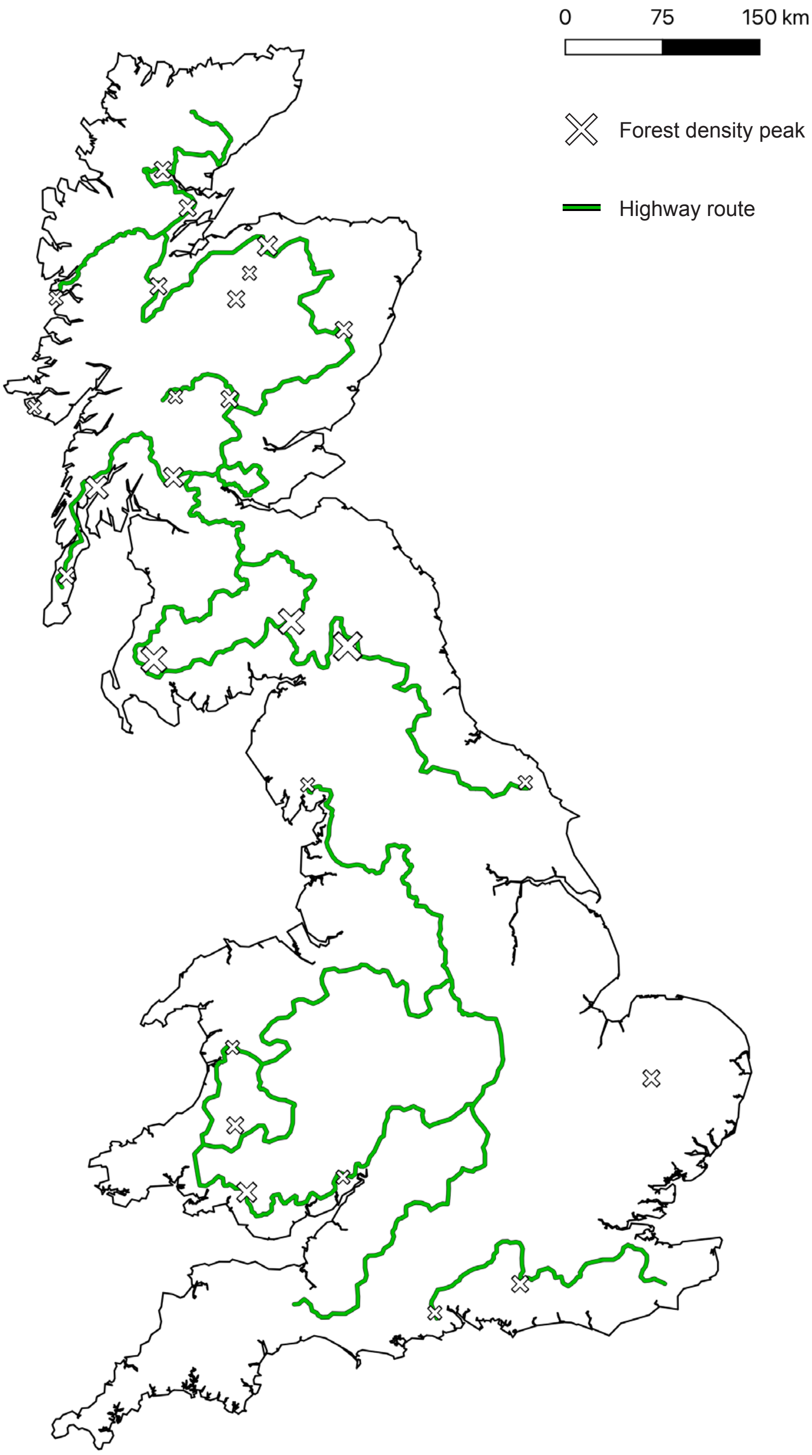
To our knowledge, this is the first project from a national government to draw explicit inspiration from the idea of non-human-centred design. We hope that it can not only be made a reality, but that it can also serve as an illustration of how such ideas can meaningfully enter the realm of policy development.




*A network map of the Great British Forest Highway.*

*The highway is split into three networks: the **Northern Network**, connecting the forests of Scotland, North East England, and Yorkshire; the **Central Network**, connecting the forests of North West England, the Midlands, South West England and Wales; and the **South Eastern Network**, connecting the forests of South East England.*

*Basemap from CartoDB.*




*The proposed route for the Great British Forest Highway.*


*Composite render of the Forest Highway as seen by satellite.*

*Basemap from Google Earth.*


*Detail: The proposed route for the Northern Network.*

*Basemap from Google Earth.*


*Detail: Composite render of the Northern Network as seen by satellite.*

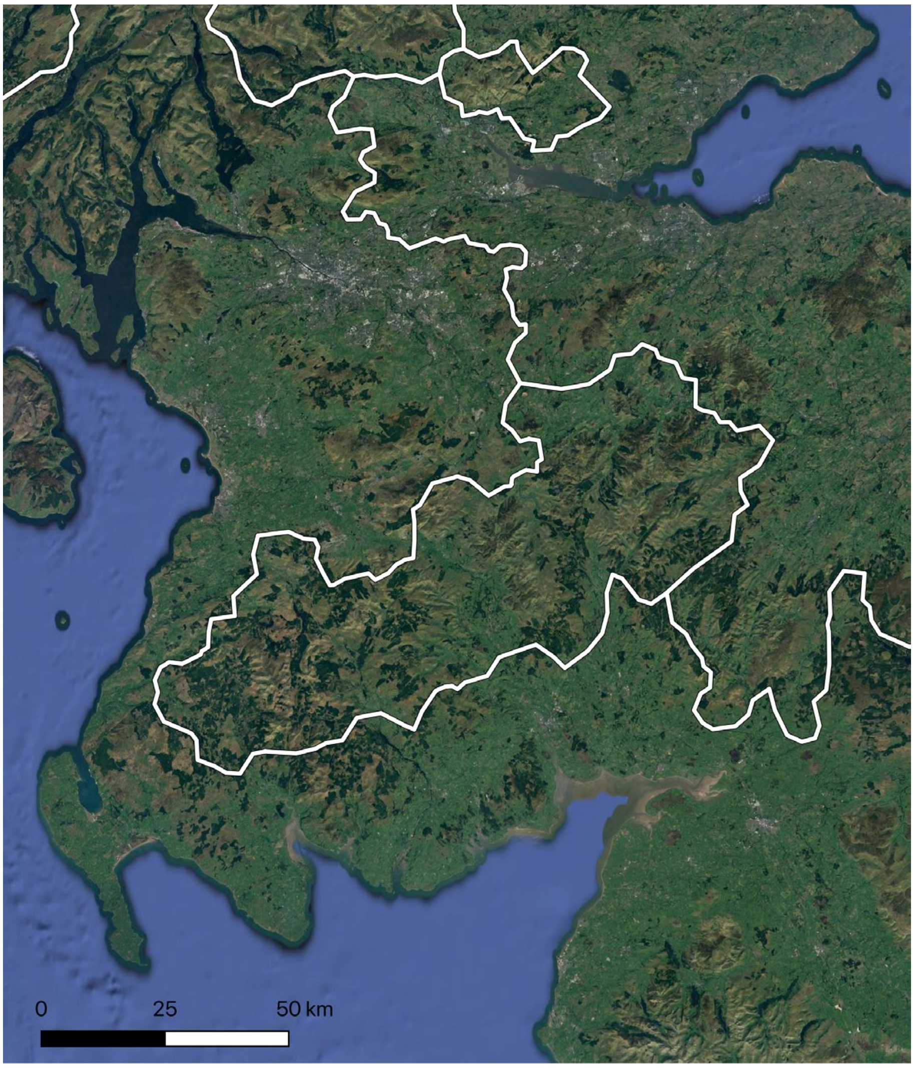
*Basemap from Google Earth.*


*Detail: The proposed route for the Central Network and South Eastern Network.*

*Basemap from Google Earth.*


*Detail: Composite render of the Central Network and South Eastern Network as seen by satellite.*

*Basemap from Google Earth.*

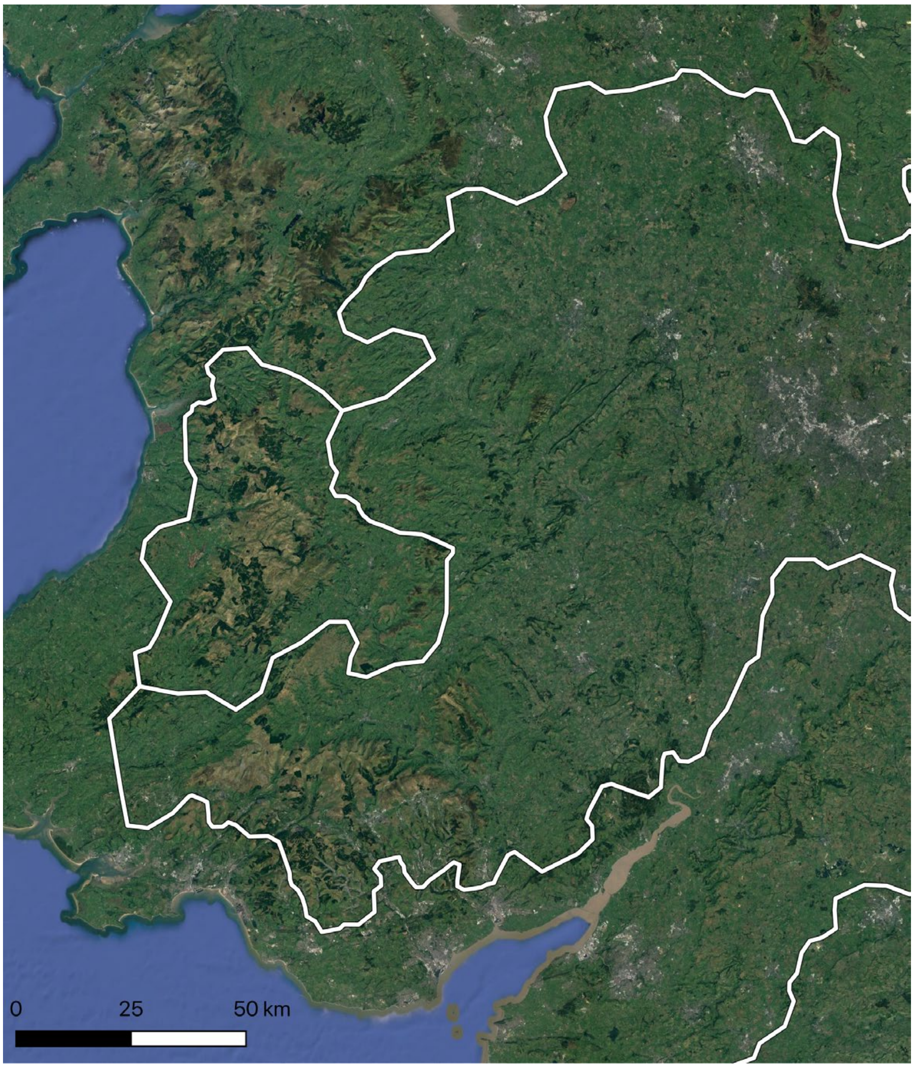



*Detail: The Strathclyde-Galloway Ringway and connecting highways, part of the Northern Network.*

*Basemap from Google Earth.*


*Detail: Composite render of the Strathclyde-Galloway Ringway and connecting highways as seen by satellite.*

*Basemap from Google Earth.*




*Detail: The Dyfed Ringway and connecting highways, part of the Central Network.*

*Basemap from Google Earth.*


*Detail: Composite render of the Dyfed Ringway and connecting highways as seen by satellite.*

*Basemap from Google Earth.*


*Detail: The South-Eastern Network.*

*Basemap from Google Earth.*


*Detail: Composite render of the South-Eastern Network as seen by satellite.*

*Basemap from Google Earth.*

# Chapter 1 - Case for action

The landscapes of Great Britain are not prepared to survive the growing pressures of climate change, ecosystem fragmentation and environmental degradation (UKRI 2020). Therefore, our landscapes need to change.

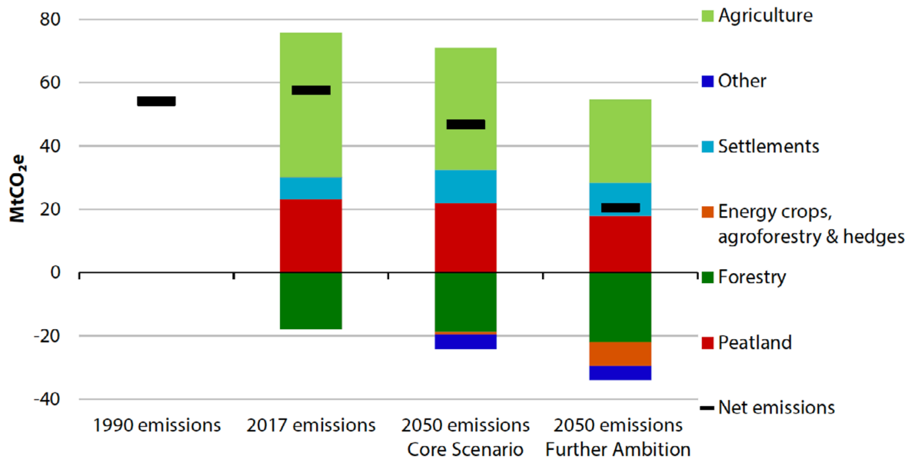
Afforestation and reforestation are two key strategies to adapt landscapes to a changing climate. Expansion of tree cover can also offset greenhouse gas emissions, as growing trees capture carbon dioxide from the atmosphere and store it as carbon in their biomass and in the soil (IPCC 2019). This process is called carbon sequestration. In fact, afforestation and reforestation are expected to play a key role in delivering the UK Government's commitment to achieve net zero greenhouse gas emissions by 2050 (CCC 2019). This of course must be achieved in conjunction with a massive reduction in the amount of anthropogenic greenhouse gases emitted into the atmosphere.

In addition to their carbon sequestration potential, forests provide numerous ecosystem services: they provide habitats for the most of Earth's terrestrial biodiversity (FAO 2020); they stabilise soil and prevent erosion (Blanco-Canqui and Lal 2010); they retain water, buffering the effects of floods and droughts (EEA, 2020). They also provide social value as recreation spaces for humans, and economic value as tourist destinations and through the extraction of timber (Forestry Commission 2004).

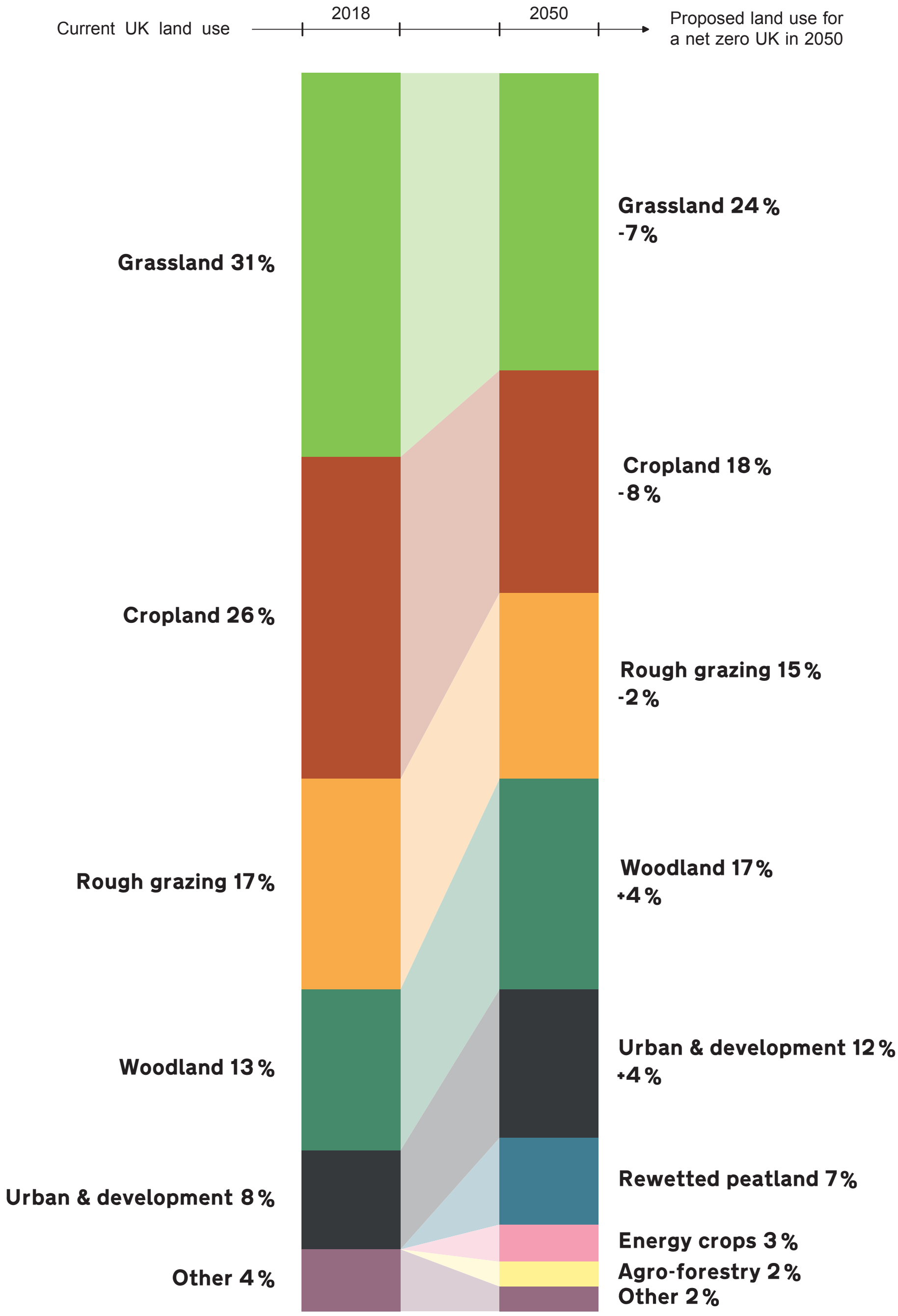
Temperate forests currently cover 13% of land in the UK. To achieve net zero by 2050, this coverage will have to increase to at least 17%. It equates to around 975,000 hectares, or 9,750 km2, of new woodland that needs to be planted across the UK over the next 30 years (CCC 2020). That is six and a half times the area of Greater London (~1,500 km2).

This is an ambitious and vitally important goal. However, it raises some big questions: How should these new forests be designed? Where should they be located? And whose needs should they serve?

However, to answer these questions we must start by asking ourselves a seemingly simple question - what do we mean when we say the word 'forest'?

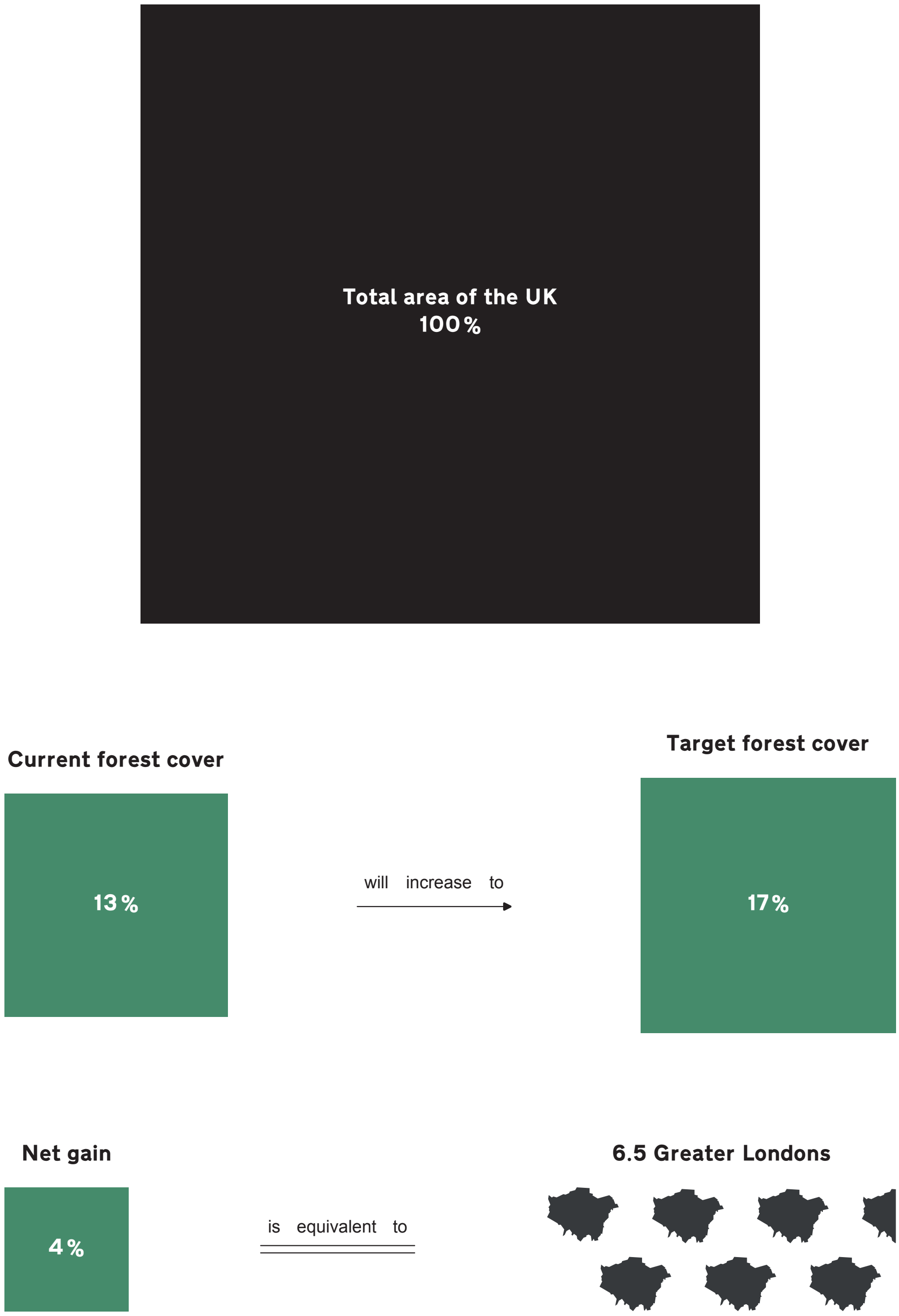



*Scenarios for very deep emissions reduction from the agriculture and land use, land-use change and forestry sectors Image: (CCC 2020). We use the 'Core Scenario' in our calculations.*



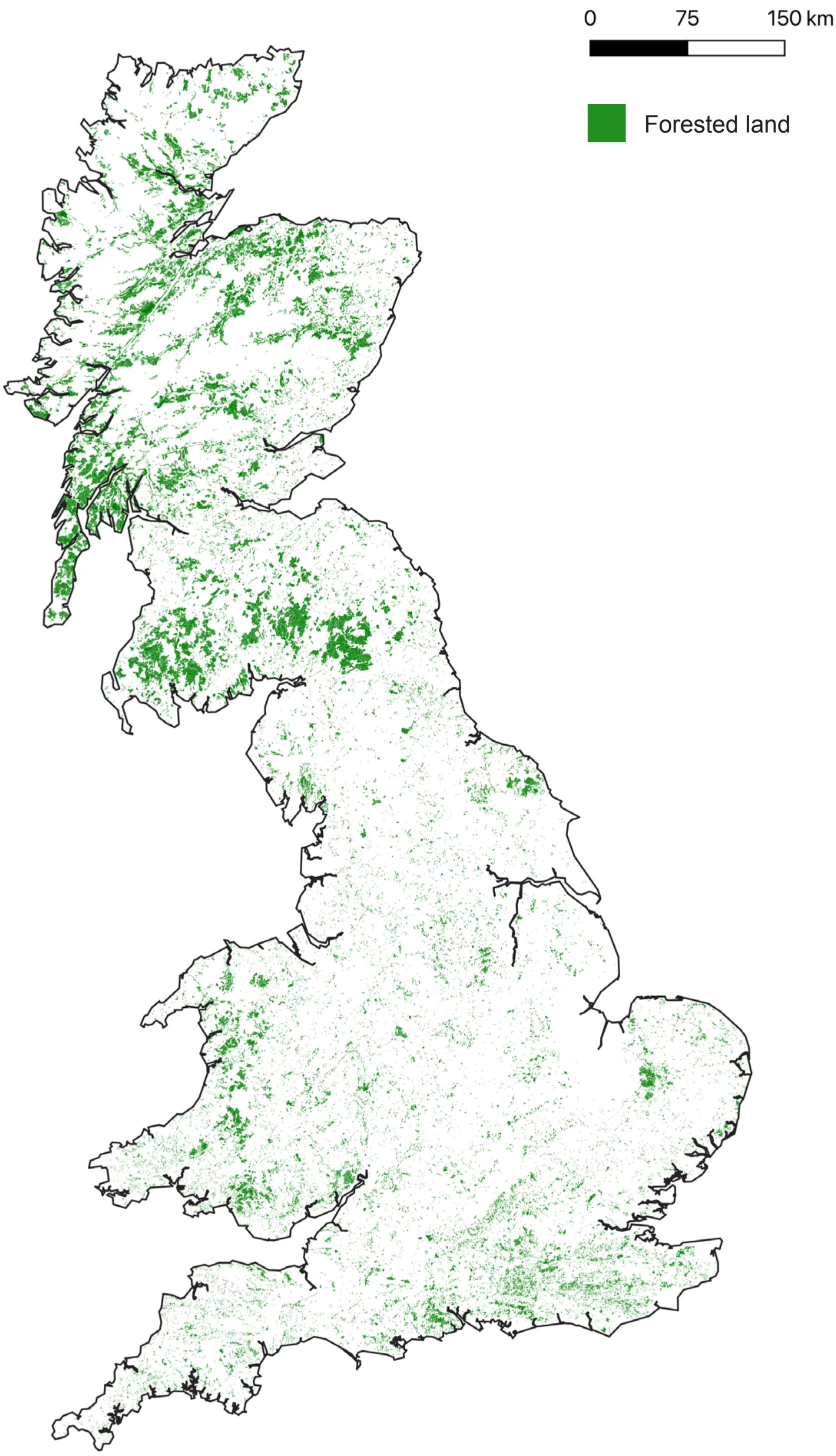

*Land use changes required to meet the UK Government's net zero greenhouse gas emissions target by 2050.*

*Data: (CCC 2018; CCC 2020).*




*A proportional representation of the net increase of forest cover required to achieve carbon neutrality by 2050 in comparison to the area of Greater London.*

*Data: (CCC 2018; CCC 2020).*




*Forest cover on Great Britain (NFI 2018).*

*The NFI covers any forest or woodland in Great Britain of at least 0.5 hectares in area with a minimum width of 20 m, and that have at least 20% tree canopy cover or the potential to achieve this (Forest Research 2019).*

# Chapter 2 - What is a forest?

## Envisioning a forest

While perhaps not conventional within a policy document such as this, I would like to invite you to take part in a creative exercise.

Stop for a moment and imagine a forest. Give yourself a moment to build a picture in your mind. Perhaps down a couple of sentences describing your forest.

What image came into your mind? For me it was the following:

**I'm walking in a landscape dominated by trees. Leaves crunch underfoot as I meander my way forward. The light is golden and dappled. Occasionally, I stop to study an interesting mushroom or fallen tree trunk that I meet along my path. I breathe deeply; the air smells fresh and earthy. The faint sounds of a dog barking and a child laughing floats on the breeze. I'm walking by myself but I don't feel alone here; I share this place with many others. All is calm, and slow, and beautiful.**

So, how does your forest compare to mine?

My forest is a place of relaxation, far away from the pressures of my life in London. It is a reminder of the wild spaces I am trying to protect in my job from a Westminster office.

Now, how does it compare to the definition of a forest by the UN Food and Agriculture Organization (FAO)?

**"[A forest is] land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use" (FAO 2020).**

This is the most widely used definition of a forest within policy contexts and has been agreed upon by every member state of the UN. Yet, somehow, it fails to describe anything about forests other than their size and density of trees (or potential density). The ecological complexity of forests is lost, and so is their social and cultural importance. Under this definition, an ancient woodland could be replaced with a monoculture plantation of exotic trees and no deforestation would have occurred (Putz & Redford 2010).

This exercise seeks to highlight the importance of how forests are defined within afforestation and reforestation projects. Each definition provides a lens through which forests are viewed, valued, managed and assessed in different ways. No single definition can embody all dimensions of a forest, and with each definition the needs of select stakeholders are foregrounded (and others pushed to the fringes). Therefore, choosing a definition is both a functional and political decision (Chazdon et al. 2016).

## Forests through the ages

The practical and political importance of defining a 'forest' can be illustrated with a brief overview of its historical definitions.

We start in England during the Middle Ages (500-1500), where the term 'forest' had little to do with trees. Instead, it was a legal term used to describe royal hunting grounds (Langton & Jones 2009). The metric of success for a medieval forest was its population of game animals (deer, boar, birds, etc.).

**"A forest must always have beasts of venery abiding in it, otherwise it is no forest. [...] The sovereign alone can make a forest, and by a sovereign alone can a forest be held" (Manwood 1598).**

The next major development happened in early modern Germany during the 1700s, where 'forest' came to mean a site of timber extraction. New concepts were developed to help understand forests through their long-term yield. Forests were abstracted in terms of how many 'stands of timber' they represented and the length of their grow-harvest 'rotation'.

**“[A forest is land used for] the conservation and cultivation of timber in a way that guarantees a continuous, durable and sustainable utilisation, because timber is an essential thing, indispensable for the essence of the country” (von Carlowitz 1713, quoted in Zemanek 2018).**

This ‘forest as timber’ definition can be seen as an ancestor to the FAO definition encountered earlier in this chapter, which was developed in 1948 as a tool to assess the global timber harvesting potential after shortages following World War II.

The next key development in defining forests happened during the 1960s, when the idea of environmental conversation entered mainstream discourse. ‘Forest’ began to describe a type of ecosystem in which trees are a key component. Biodiversity emerged as a metric to measure the success of forests.

**“[A forest is] a dynamic complex of plant, animal and micro-organism communities and their abiotic environment interacting as a functional unit, where trees are a key component of the system” (CBD 2006).**

Interestingly, this new definition did not replace ‘forest as timber’; instead, the two ideas existed simultaneously and were contextually applied by various stakeholders to achieve specific goals. From this point forward, defining forests became an additive process, with each new concept diversifying what ‘forest’ can mean.

In the 1980s, climate change and the dangers it posed began to break into public conversation. With this, ‘forests’ started to be defined as carbon stocks and new metaphors about forests being “the lungs of the earth” appeared. Biomass and carbon density became the metrics used to measure the success of a forest in the face of climate change.

**“[A forest is] a minimum area of land of 0.05–1.0 ha with tree crown cover (or equivalent stocking level) of more than 10–30% with trees with the potential to reach a minimum height of 2–5 m at maturity in situ. Young natural stands and all plantations which**

**have yet to reach a crown cover of 10–30 % or tree height of 2–5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest" (UNFCCC 2002).**

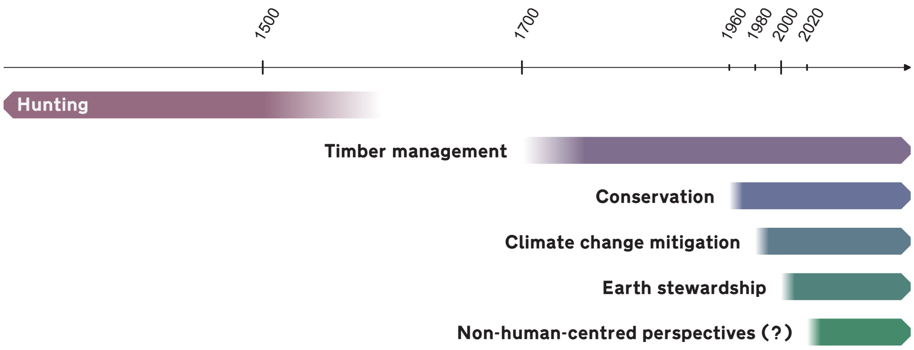
Most recently, twenty-first-century academics have developed a new perspective of 'forests' inspired by concepts of resilience and earth stewardship. In this way of thinking, 'forests' are considered components within dynamic socio-ecological systems (Chapin et al. 2010). In practice, this blurs the boundaries between the definitions we have previously introduced.

**"[A forest is] a complex system composed of heterogeneous assemblages of individual agents (e.g., trees, animals, humans) closely interacting through flows involving markets, goods and various other ecosystem services" (Messier et al. 2014).**

The influence of this socio-ecological thinking can be seen in the prevalence of 'placemaking' within contemporary afforestation projects (Sen & Nagendra 2020). In projects like the Northern Forest and the Heart of England Forest, the creation of forests is presented as a method of fostering local identity, resilience and prosperity. The success of these projects is assessed in terms of the ecosystem services they provide, such as increasing property value, reducing air pollution, provision of recreational spaces, habitat creation, carbon sequestration and so on.

Looking at the diverse range of forest definitions we have encountered, we can see that the way forests are conceptualised is a reflection of human concerns and needs within a specific historical and geographical context. In addition, we can also see how these definitions underpin the ways in which forests are monitored and managed.

Because the aim of this project is to design forests from a non-anthropocentric, we must redefine 'forests' from the point of view of a forest.




Hunting: Forest lands should be managed primarily to sustain game animal populations.

Timber management: Forest lands should be managed primarily to sustain timber production.

Conservation: Intact forests should be protected to conserve biological diversity. Forest management should minimise ecological impact and maximise ecosystem functions and species interactions.

Climate change mitigation: Forest conservation, reforestation, and afforestion can reduce global warming through carbon sequestration.

Earth stewardship: Forests are complex, adaptive systems whose resilience is intimately linked with society. Ecosystem services of forests are important for poverty alleviation and sustainable development.

Non-human-centred perspectives (?): Forests should be understood through non-anthropocentric means.

*"Forest definitions emerge from prevailing objectives of use and management. Since the mid-twentieth century, forest management objectives and definitions have diversified, with new ones being added to earlier more entrenched and legitimised ones"*

*Quote and image adapted from (Chazdon et al. 2016).*

# Chapter 3 - A forest's forest

## What are non-human-centred perspectives?

The study of non-human-centred perspectives has been pioneered by anthropologists and philosophers working in the field of multispecies studies. Researchers working in this field seek to understand reality beyond the limited capabilities of human perception (Bueno-Guerra 2018). They do so by studying material and social phenomena through the perceptual worlds of non-human species, also known as 'umwelts' (von Uexküll 2010). These species can be animal, vegetal, or fungal (and, in the work of the most mind-bending researchers, even technological or mineral).

To think outside of the human perspective is a fundamentally impossible task, but a productive one. It allows us to come to terms with the limits of human understanding and raises the question of human responsibility in a world we share with other life forms (Aisher & Damodaran 2016). This productive impossibility is why we must "stay with the trouble" (Haraway 2016).

## How does a forest understand itself?

It is easy to fall into the trap of thinking that a forest is a place with a lot of trees and many of the forest definitions presented in Chapter 2 are built upon this foundation. However, ecologists remind us that structural habitat features as perceived by humans (such as large groups of trees) do not correspond to functional habitat units for other organisms (Van Dyck 2011). So, how might we avoid this anthropocentric trap?

One way would be define forests in the following way:

**Forests are the result of an ongoing and open collaboration between a community of trees, insects, birds, fungi, soil, water, etc., which creates the conditions for the community to continue to flourish (Basden 2015).**

With this definition we can understand the fundamental difference between a holistically healthy forest that maintains the conditions for life and a monoculture plantation of trees that degrades its environment (FOEI et al. 1997).

Mycorrhizal networks through which plants and fungi communicate and distribute resources to one-another are a key example of a successful collaboration that sustains forests. These networks are commonly called ‘wood-wide webs’. Linked together in this way, the vegetal and fungal inhabitants of forests look less like individuals and more like collective superorganisms (Gabbatis 2020).

And so, where a human-centred approach might determine the success of a forest through its carbon sequestration potential or the provision of ecosystem services to the local community, a forest-centred approach would determine success by looking at the overall complexity of its connections. A thriving forest is one that exhibits connectedness internally and externally, and is highly embedded in its host environment.

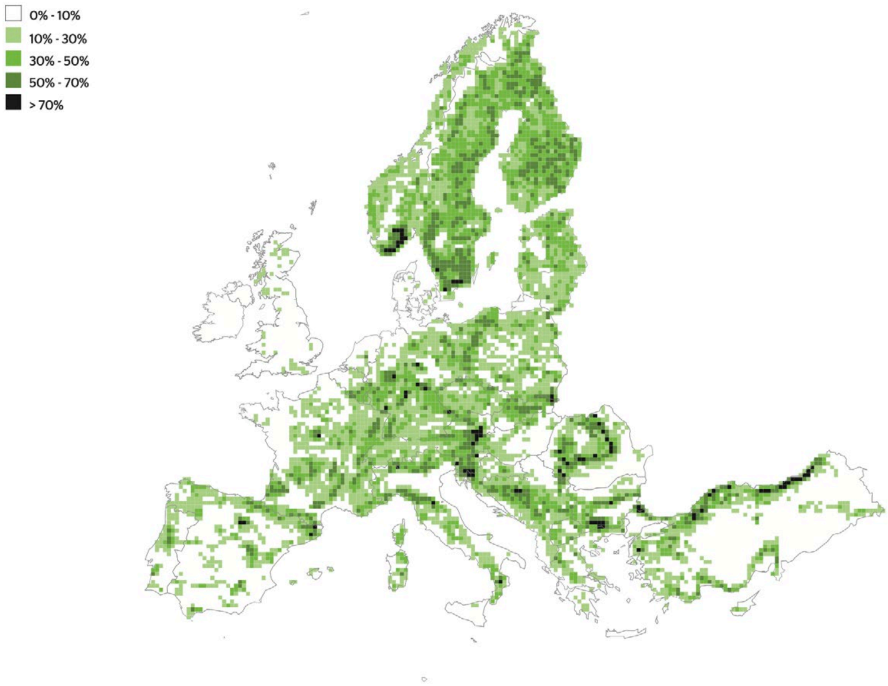
When thinking this way, the presence of large numbers of trees in a certain location becomes a clue that a forest may be present, rather than a defining trait.

## How are our forests doing ?

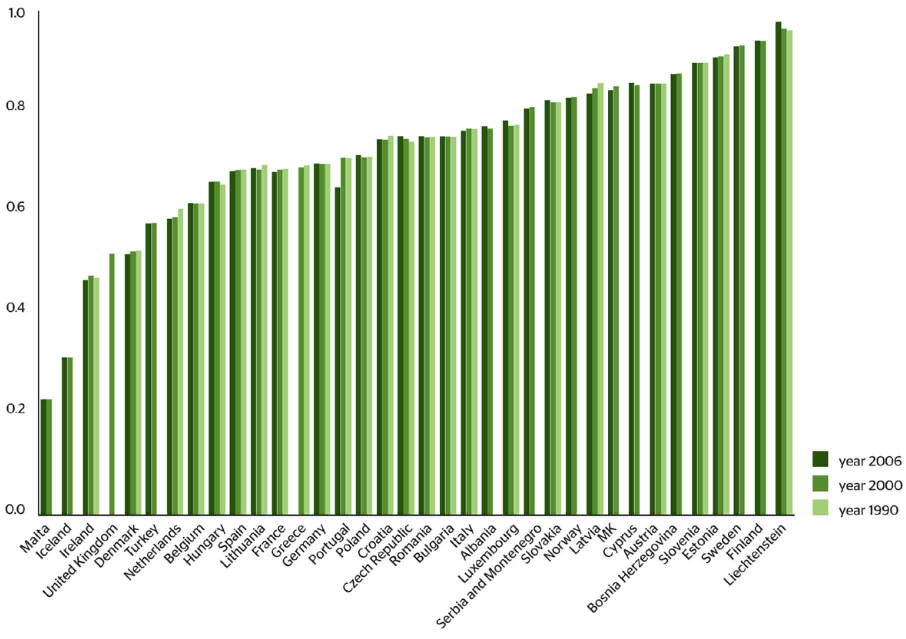
In light of this forest-centred perspective, it is disheartening to find that the UK has one of the lowest levels of forest connectivity in Europe (Forest Europe 2006). It is also troubling to discover that the most recent national-scale study into the connectivity of the UK’s forests was published in 2012 (Estreguil et al.). We believe that there is a critical need to significantly increase the amount of research being done on this topic.

*Some mycorrhizal species cover the roots of plants and form networks (1), other species actually penetrate the cells of the plant roots, but also form networks (2). Orchids are intriguing as they can only germinate with the help of mycorrhizal fungi (3). Image: (Science Focus 2020).*

*Fungal mycorhizae. Image: (Oregon Caves National Monument n.d.)*




*2006 landscape level forest connectivity for selected European countries. The index varies between 0%, where forests are maximally fragmented, and 100%, where forest maximally connected (Forest Europe 2011).*




*Country average of normalized connectivity per landscape unit for 1990, 2000, 2006 (low scale based on Corine Land Cover, ranked per increasing connectivity) (Forest Europe 2011).*

# Chapter 4 - Designing the Forest Highway

## An infrastructural approach

This chapter outlines an afforestation methodology for the maximisation of forest connectivity, embeddedness and complexity, inspired by our forest-centred definition of 'forest' (see Chapter 3). This methodology is then applied to create an indicative design for the Great British Forest Highway. It is important to note that this methodology is a work-in-progress and is still subject to change. We welcome feedback on it as part of our public consultation process.

Current forest creation projects focus on 'placemaking' and the delivery of ecosystem services at the local level. We seek to challenge this approach: instead, we propose to spend the UK's tree planting budget through the creation of forest highways that link together existing keystone forests.

In this endeavour, we take specific inspiration from landscape connectivity features, such as wildlife corridors, that are used to reconnect habitats fragmented by human activities (English Nature 1991). Such corridors can take several forms: unbroken strips of rewilded land, stepping stone patches of rewilded land, or linear landscape features (e.g. hedgerows, ditches, tree rows).

Additionally, there is growing interest in the construction of wildlife bridges (or ecoducts) to allow animals to safely traverse roads, trainlines, dams, and other obstructions. Well-known wildlife bridges include those in Banff National Park spanning the Trans Canadian Highway and those in Christmas Island, Australia, built over several roads specifically to facilitate the annual red crab migration. However, the Netherlands lead the construction of wildlife bridges globally, with a total of 30 completed bridges and a further 20 in development (Wageningen University 2020). Wildlife bridges are currently rare in the UK with the only notable examples being Scotney Bridge in Kent and Mile End Bridge in London (Natural England 2015). While the design of site-specific structures is outside the scope of our methodology, we do foresee wildlife bridges playing a key role in delivering the Great British Forest Highway.

Our methodology aims to extend the concept of wildlife corridors and bridges by applying their underlying logics at the scale of national infrastructure. Therefore, we seek to connect our forests in a similar way to how we connect our towns and cities: using a strategic network of inter-regional 'trunk highways' (DfT 2020) to which smaller 'roads' can be connected at the local level. To design this network, we took a data-driven approach through the analysis of a number of geospatial datasets. This took the form of four key steps:

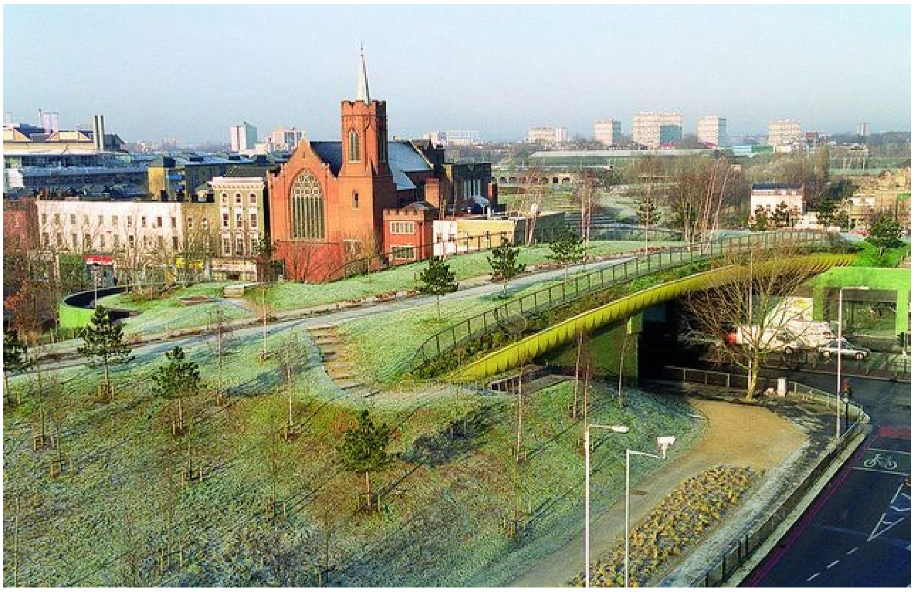
1. identifying the core forests,
2. generating a highway suitability map,
3. identifying the network service areas,
4. plotting the network paths.

A brief overview of each of these steps is provided in the following pages.

*A wildlife bridge in Banff National Park, Canada. Image: (MacDonald & Banff National Park n.d.).*

*Red crabs on Christmas Island climb a wildlife bridge.*
*Image: (Bray & Swell Lodge n.d.).*

*The wildlife bridge in Scotney, Kent. Image: (Chadwick 2018).*

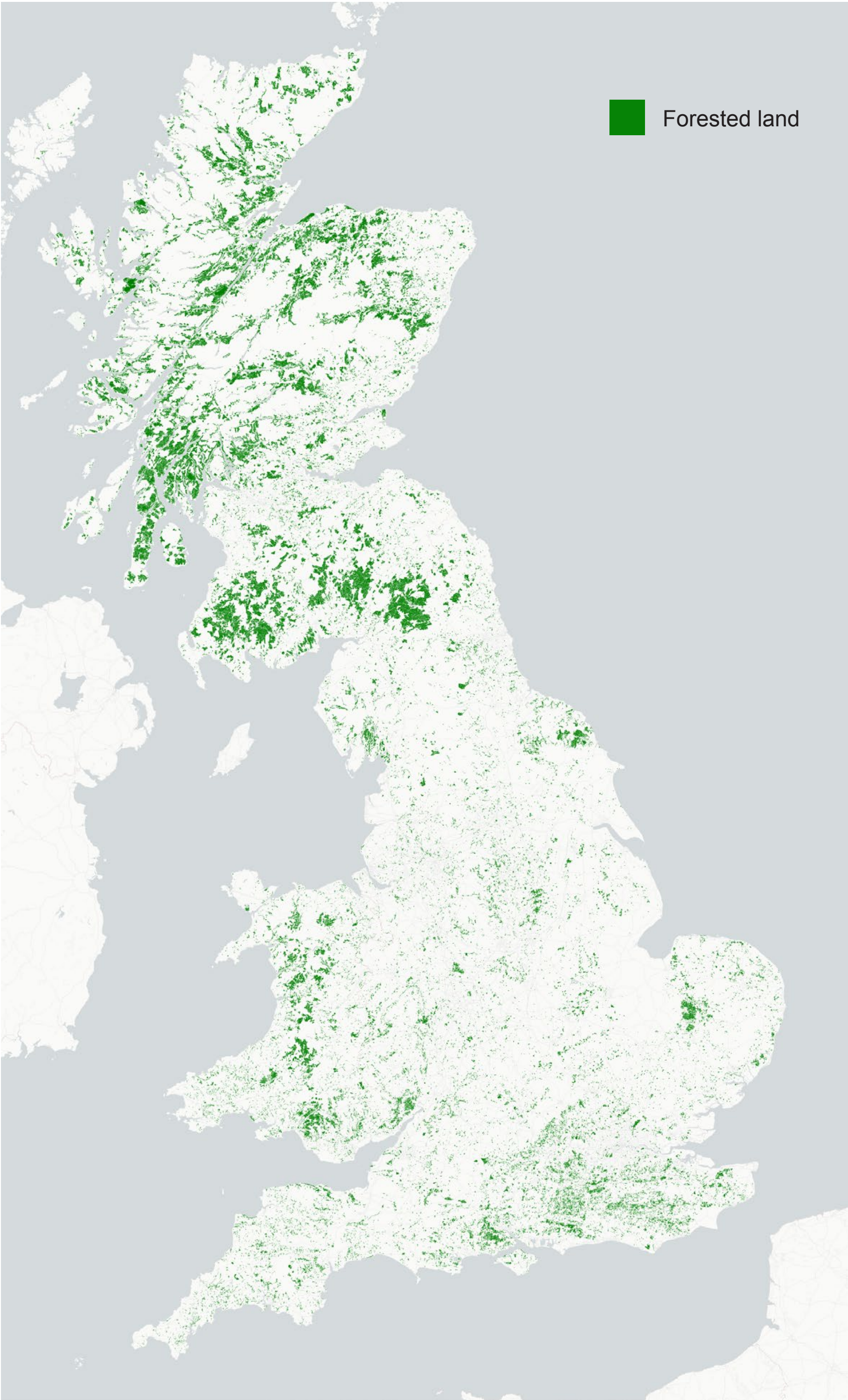


*The wildlife bridge in Mile End Park, London. Image: (Tower Hamlets Council 2011).*


*UK motorways in 2016.*

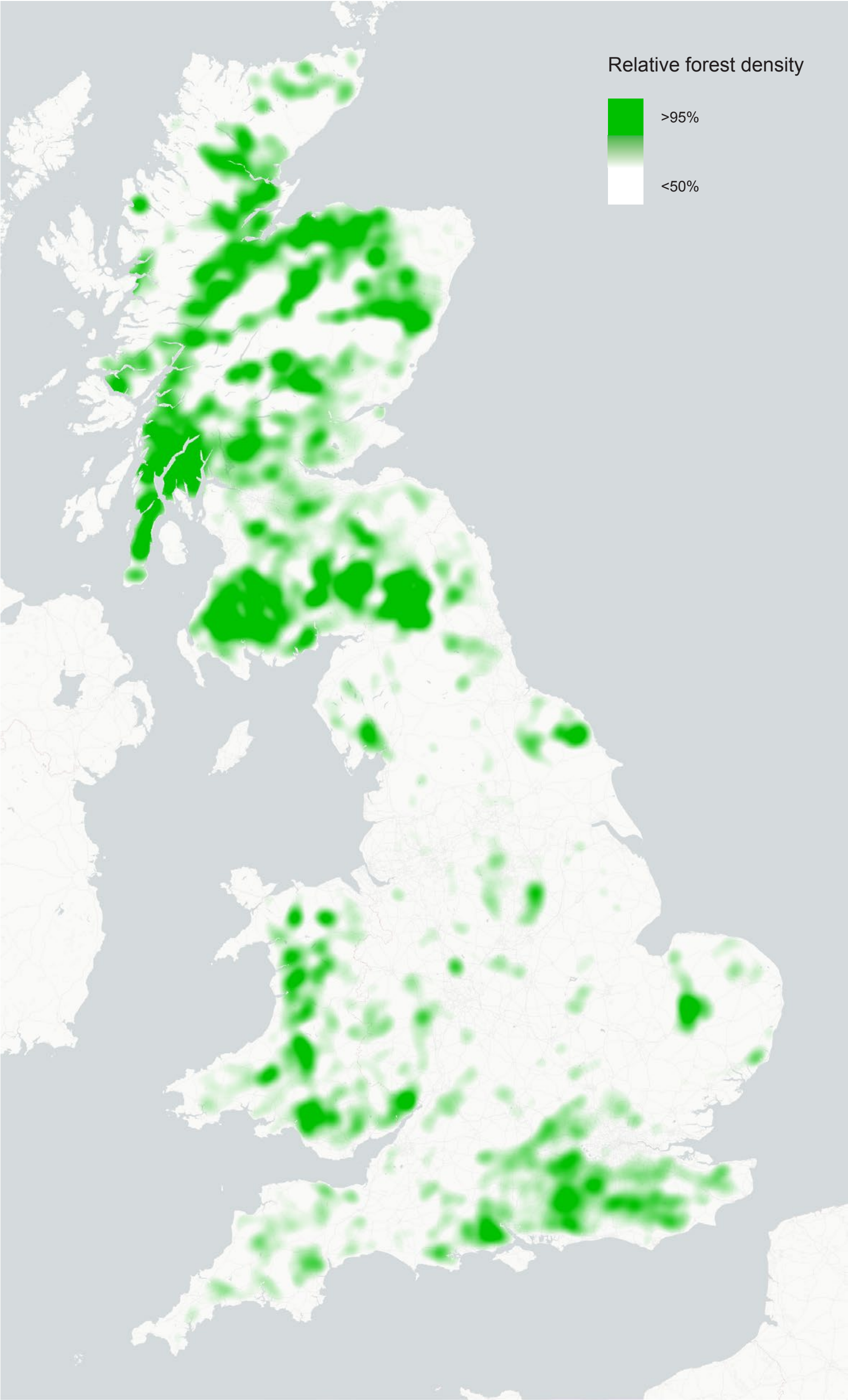
*Basemap from OpenStreetMap. © Crown copyright and database right [2021] Ordinance Survey [100021242].*

## 1. Identifying the core forests



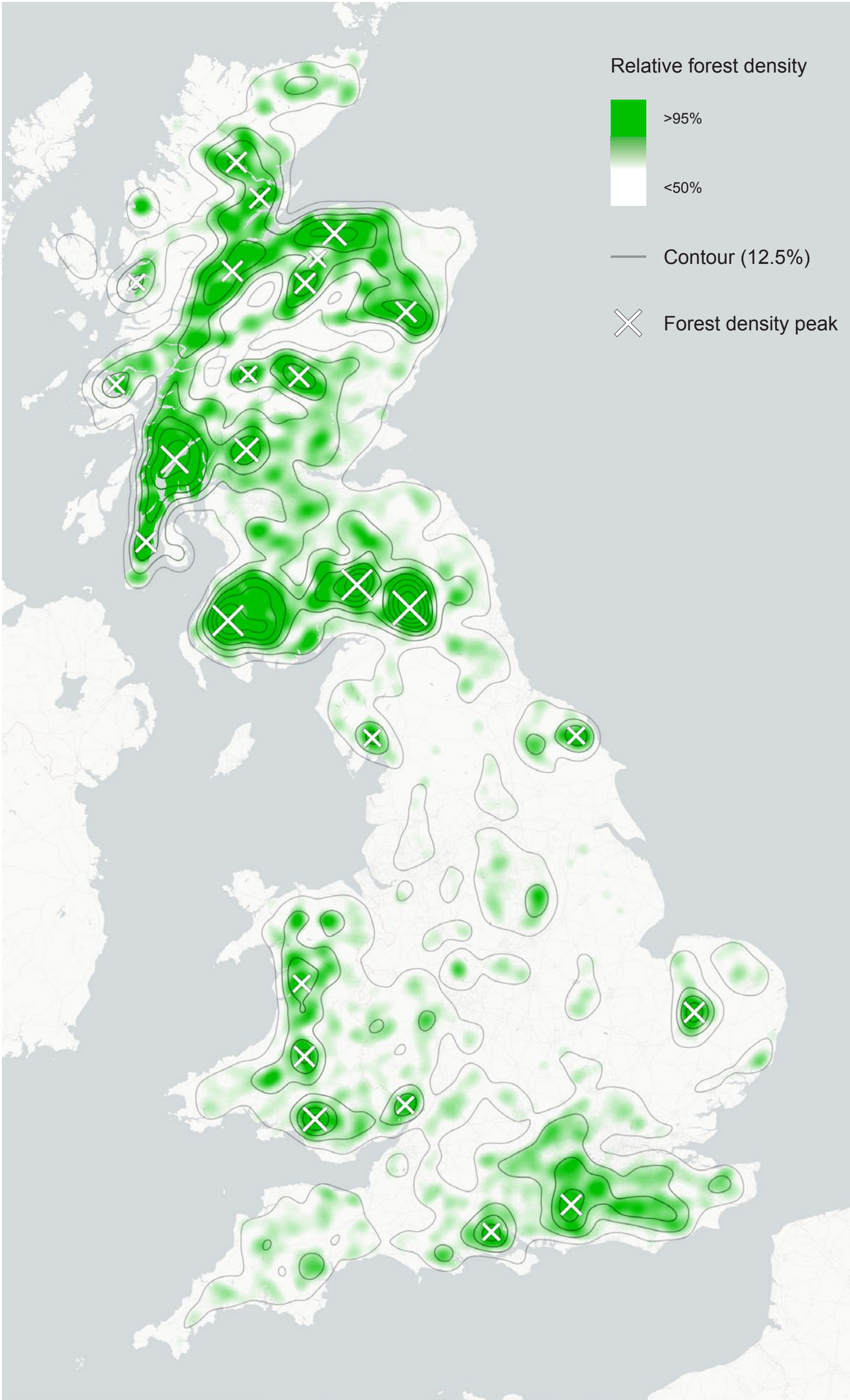

*Forest cover in Great Britain (NFI 2018). Basemap: (CartoDB).*

To identify core forests, we used NFI data describing areas of mature tree cover, rather than land legally designated as a forest (which would include felled timber plantations).




*Relative forest density across Great Britain. Basemap: (CartoDB).*

To understand this data at the national level, we generated a heatmap which describes how much of the land within a 10 km radius of each pixel is forested, in terms of relative density.

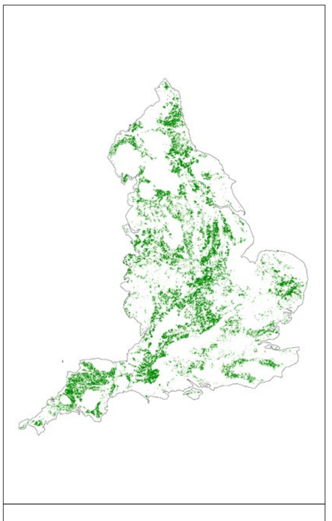



*Forest density peaks in Great Britain. Larger markers indicate higher relative density. Basemap: (CartoDB).*

We then generated contour lines for the heatmap at every 12.5% increase in relative density. From this, we determined areas of peak forest density, which represented our core forests.

## 2. Generating a highway suitability map

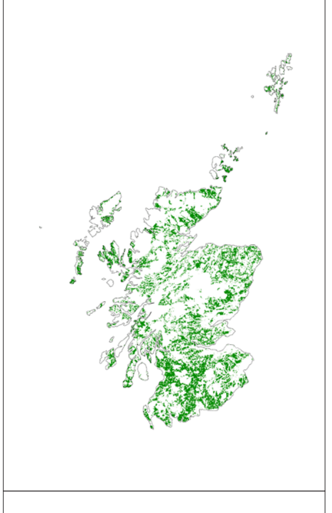
There are currently no datasets indicating suitable land for afforestation for the entirety of Great Britain. We, therefore, combined three separate studies covering England (commissioned by the UK Government), Scotland, and Wales (commissioned by their respective devolved governments). Each study had a different, albeit similar, description of suitable land:



***England***

*Data from Forestry Commission & the Centre for Ecology and Hydrology; via Carbon Brief*

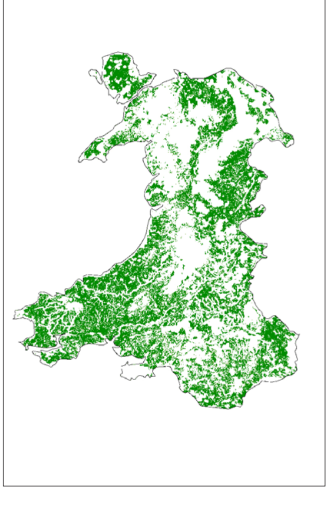
*Green indicates "low risk area for woodland creation". Low sensitivity is defined as areas that do not fall into certain categories such as higher quality agricultural land, special conservation areas and deep peaty soils, as well as not being close to protected areas (Carbon Brief 2020).*



***Scotland***

*Data from Woodland Expansion Advisory Group; via Carbon Brief*

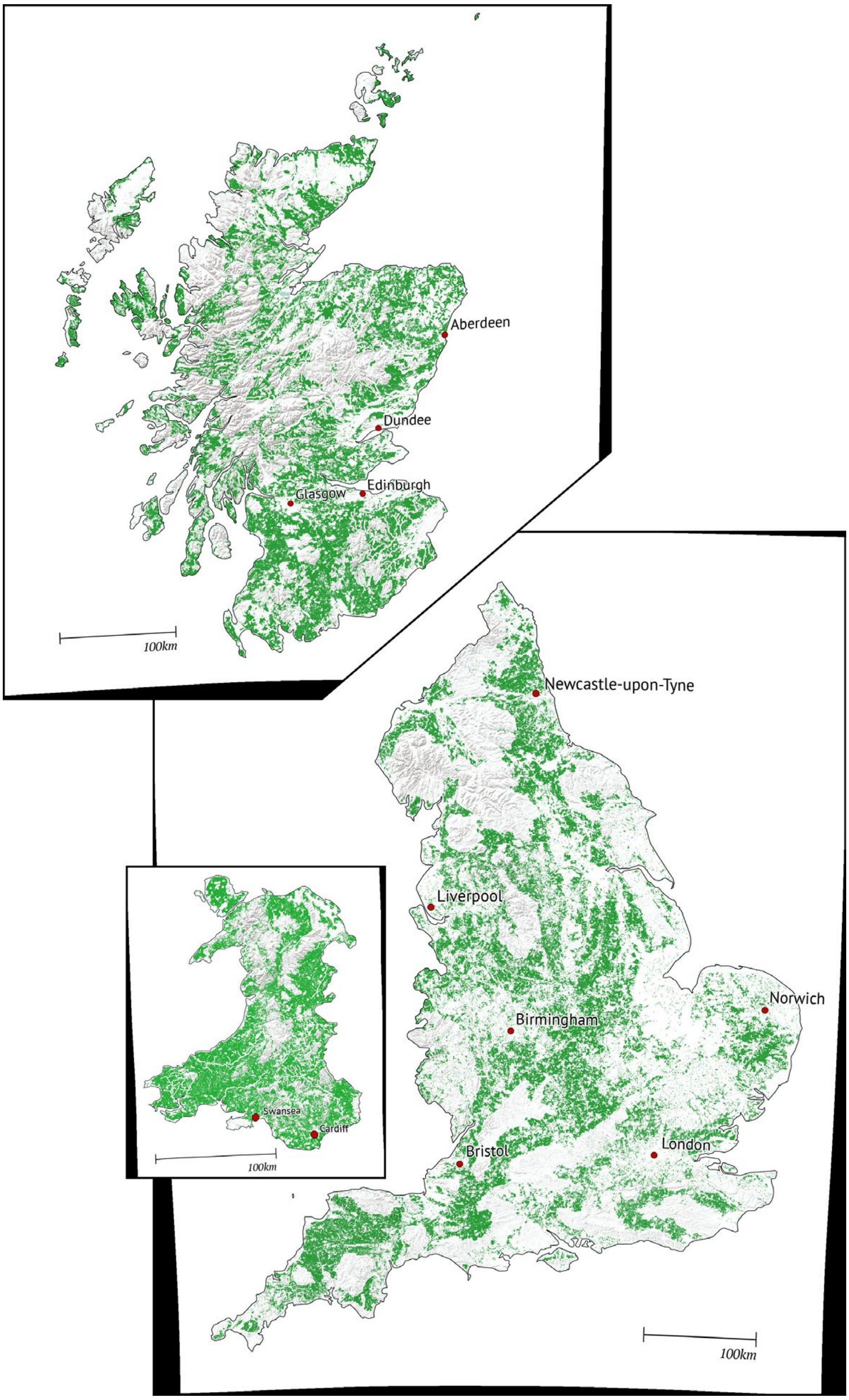
*Green indicates land in Scotland "most likely to have potential for woodland expansion", taking into account the quality of land for agriculture, its suitability for woodland, the presence of priority habitats and the presence of deep peat (Carbon Brief 2020).*



***Wales***

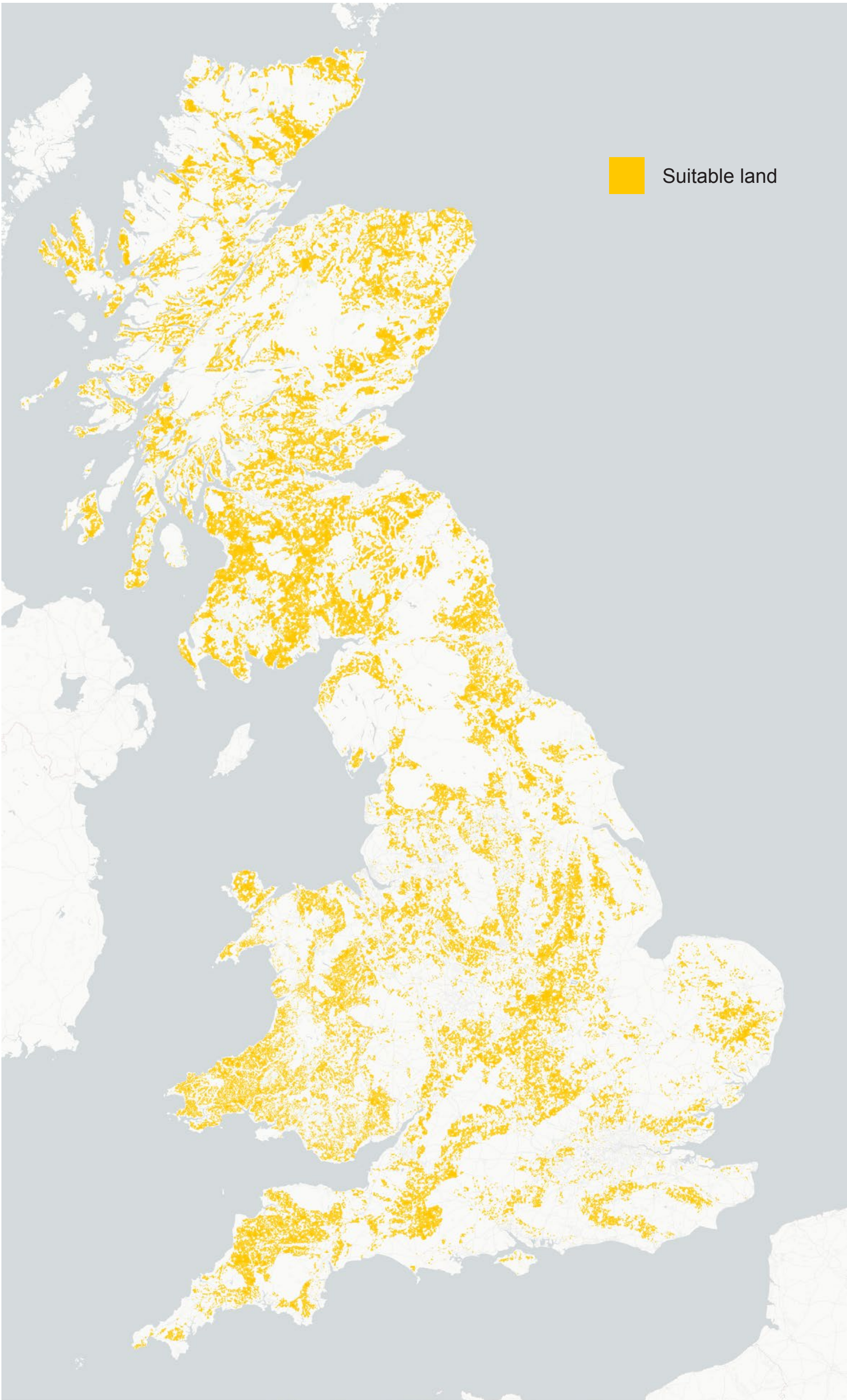
*Data from Welsh Government; via Carbon Brief*

*Green indicates "potential opportunities in Wales afforestation and reforestation'" taking into account Sensitive areas to woodland creation, such as areas of deep peat, or scheduled ancient monuments (Carbon Brief 2020).*



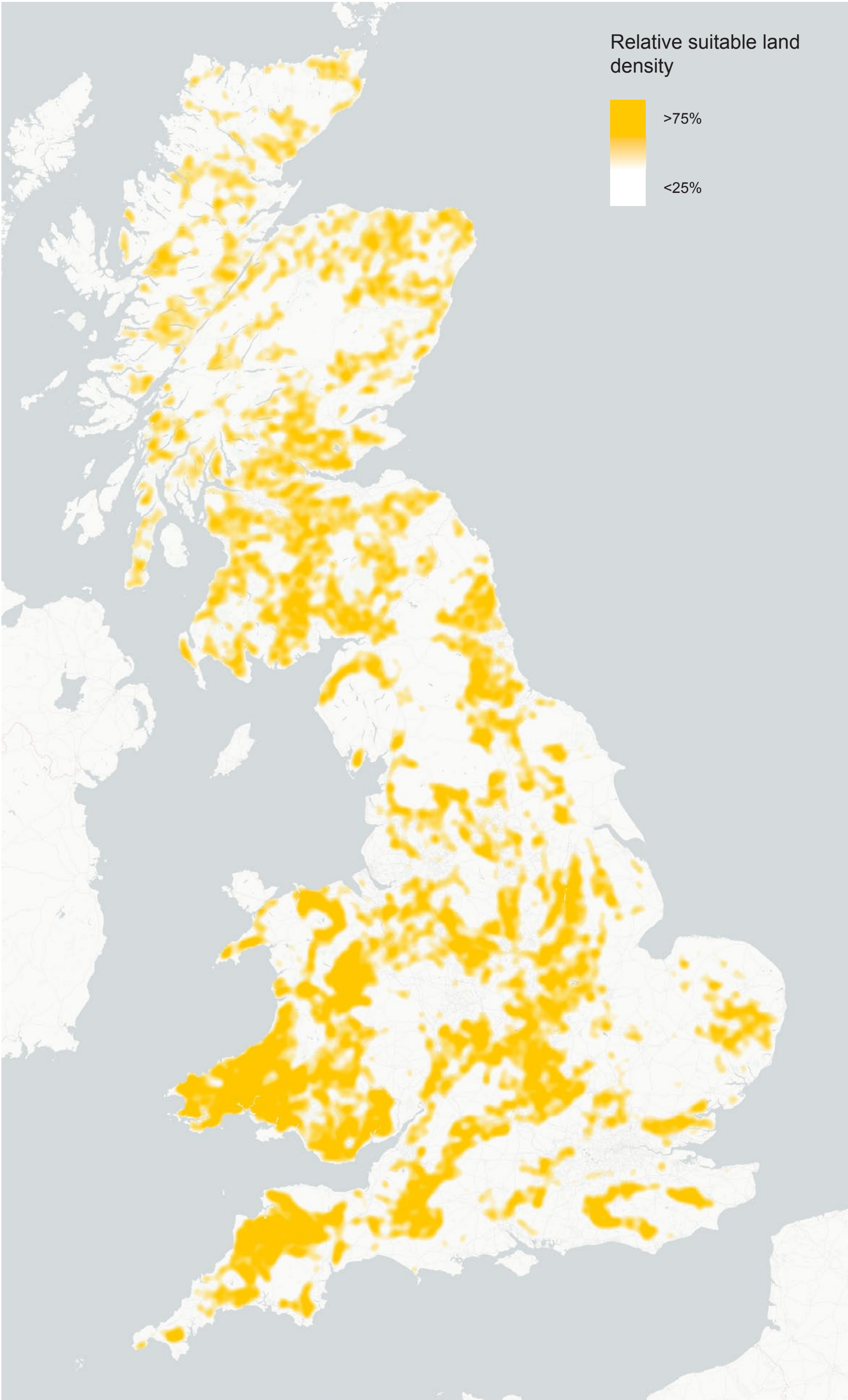

*Georeferencing in progress for the three datasets. Original images: (Carbon Brief 2020).*

These datasets are currently unpublished and were only available as high-resolution image previews. We first georeferenced these images by aligning them to the boundaries of Great Britain.




*Land in Great Britain suitable for afforestion. Basemap: (CartoDB).*

We then extracted the green pixels from each map and stitched them together to create a composite dataset. As we previously used green to indicate forest cover, we here represent suitable land in yellow.

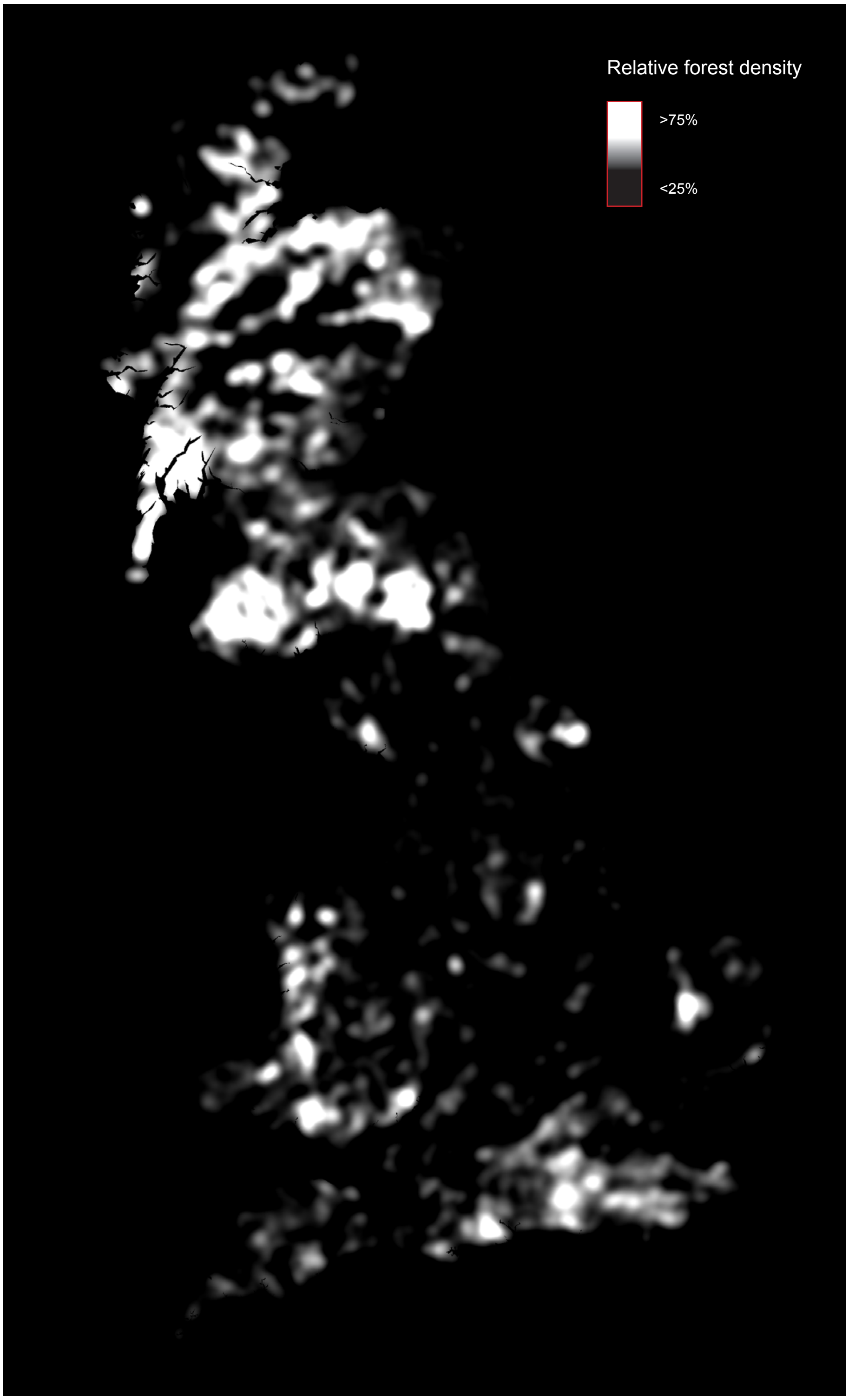



*Relative suitable land density across Great Britain. Basemap: (CartoDB).*

Then, as before, we generated a heatmap from this data. The resulting map describes how much of the land within a 10 km radius of each pixel is suitable for afforestation, in terms of relative density.

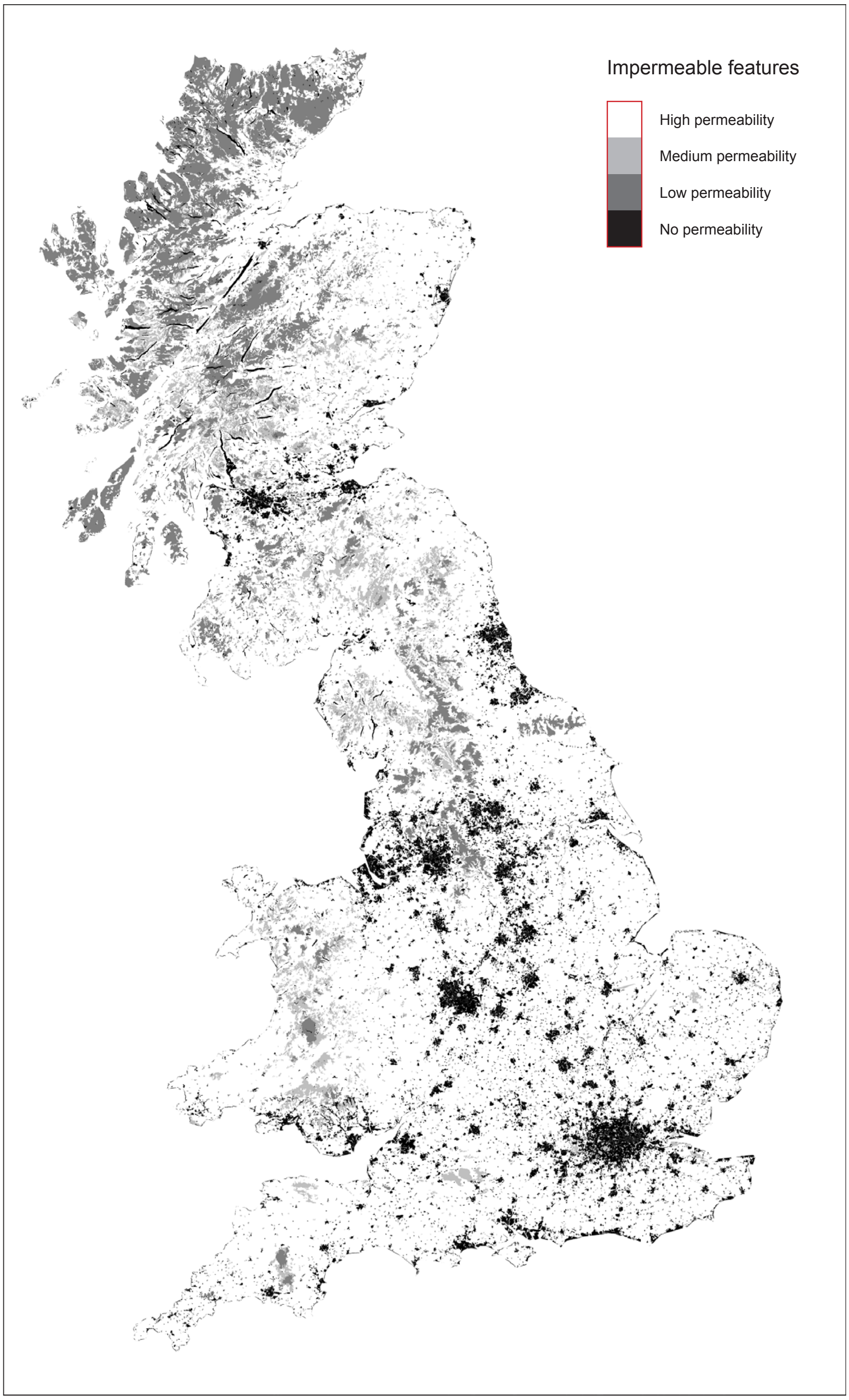

*Relative suitable land density across Great Britain, greyscale.*

Next, as highly forested land is logically deemed unsuitable for afforestation, we had to combine the two datasets to produce a highway suitability map.




*Relative forest density across Great Britain, greyscale.*

We started by converting the maps to greyscale to harmonise their colour spaces.




*Layer mask of impermeable and protected lanscapes.*
*Data: (Copernicus 2018).*

To re-introduce some of the detail lost by generating heatmaps, we created an opacity mask describing areas of impermeable land (e.g. water bodies, urban spread, bare rock, peat bogs).

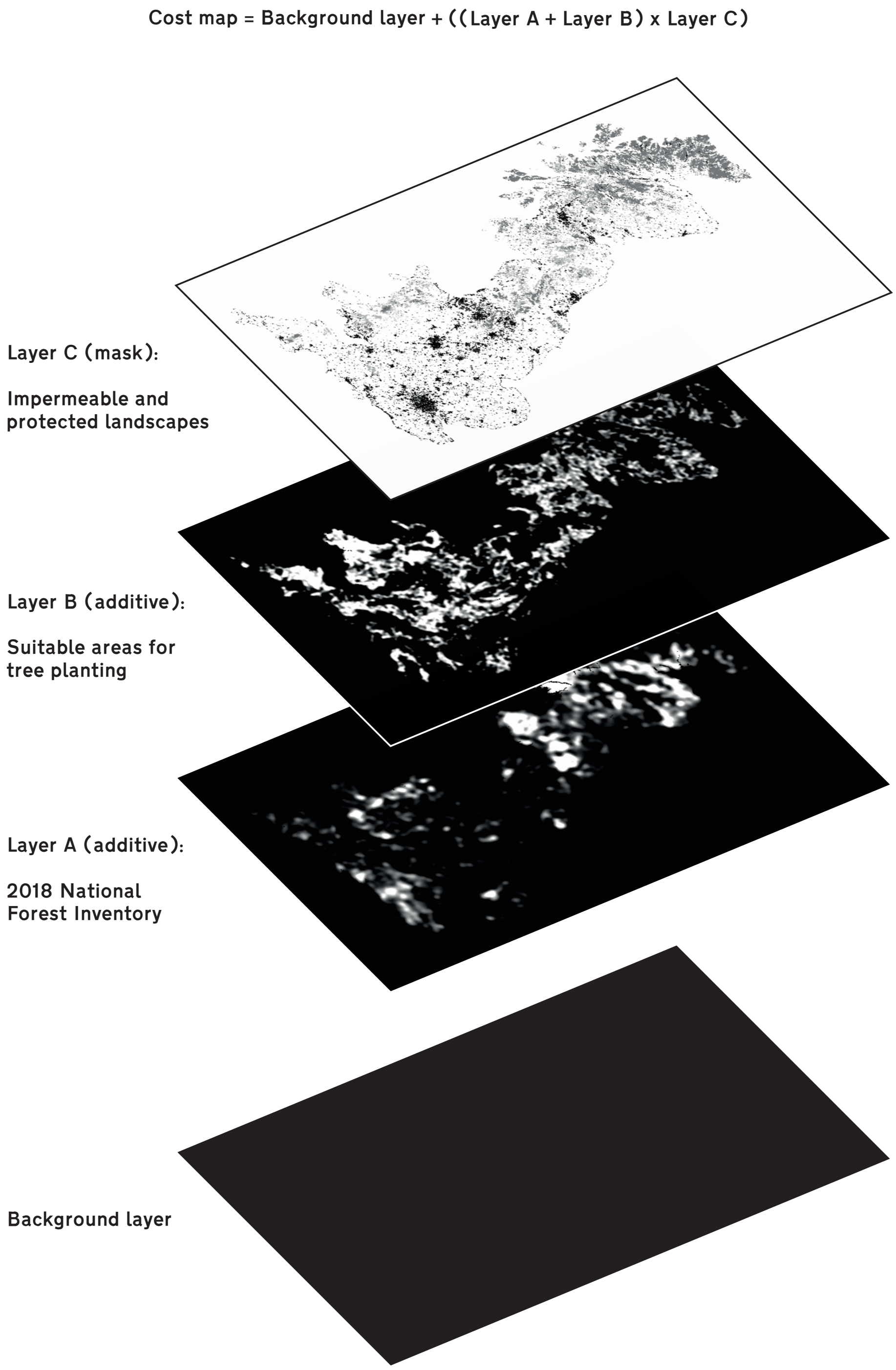
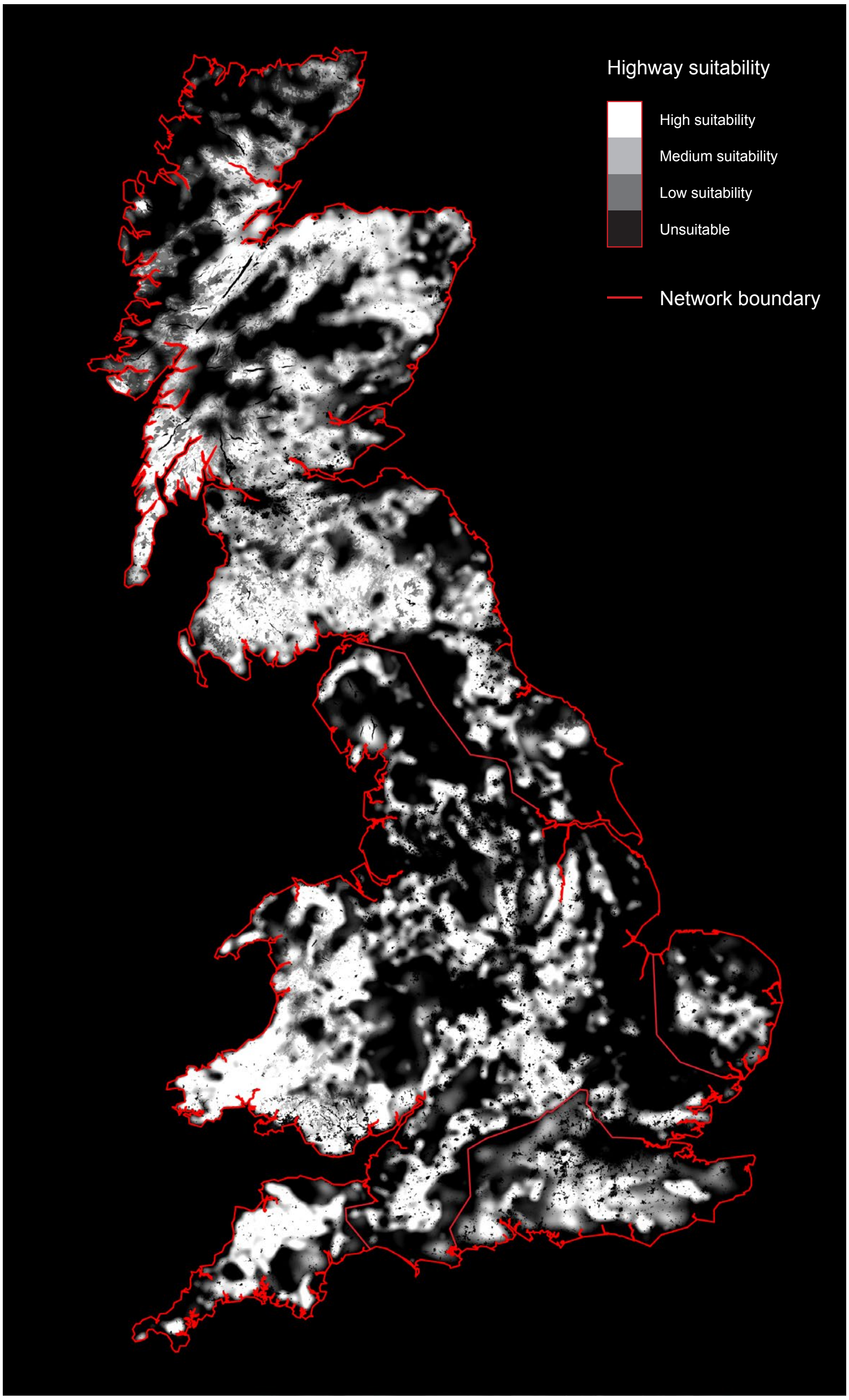



*Illustration of the image composition process.*


*The forest highway suitability of Great Britain.*

After combining the three layers, we obtained a complete forest highway suitability map. In this map, the brighter the area, the more suitable it is for the forest highway to pass through.

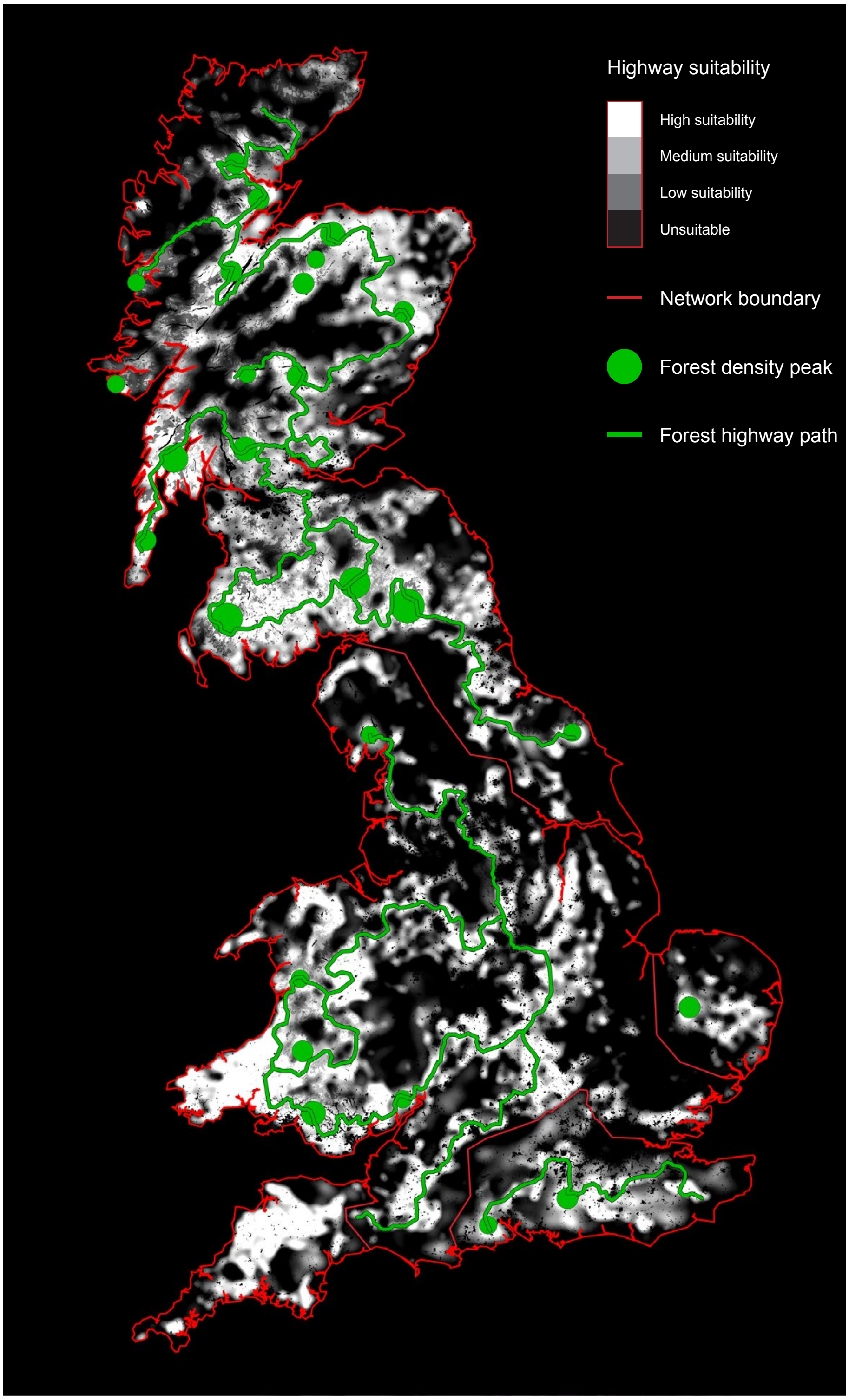
## 3. Identifying the network service areas




*The forest highway suitability of Great Britain, with key impassable network boundaries marked in red.*

The suitability map highlighted impassable boundaries between suitable areas. It became apparent that several small networks would be required, rather than one all-encompassing network.

## 4. Plotting the network paths




*A proposed path for the Great British Forest Highway, presented with the geospatial data informing its design.*

We plotted three networks to connect the core forest zones while remaining within the bounds of suitable areas. It resulted in the design proposal presented in this document.

## Planting strategy

The primary purpose of the UK Government's tree planting goals - a minimum net increase of 4% forest cover by 2050 (CCC 2018) - is to offset anthropogenic greenhouse gas emissions. As such, it would be easy to decide which tree species to plant based on the rate of their carbon uptake alone. This appears to be the implicit preference of the CCC who base their afforestation planting strategy on using 60% of non-native Sitka Spruce, which is famously fast-growing, and only 40% of native beech (Carbon Brief 2020). It is vital that we do not do this.

We stand with the Woodland Trust (2020) in their recommendation that the majority of tree cover expansion should be delivered with native tree species. Extensive research demonstrates that, while forests of diverse native species are slow-growing, they can sequester twice as much carbon as monoculture plantations in the long term; they are also more resilient to disease, pests and the pressures of climate change (Carbon Brief 2018).

We also consider the planting of native tree species as an important method for increasing the 'embeddedness' of the forest highway within its host landscapes. Biological research finds host specificity relationships between plants and fungi within mycorrhizal networks to be increasingly "cryptic" (Simard et al. 2012). Invasive species have also been observed using mycorrhizal networks to divert nutrients away from native species (Awaydul et al. 2019). In light of these findings, we hypothesise that native tree species are better suited to mesh into the mycorrhizal networks of core forests without harming existing plant and fungi populations.

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# Conclusion

## Areas of consultation

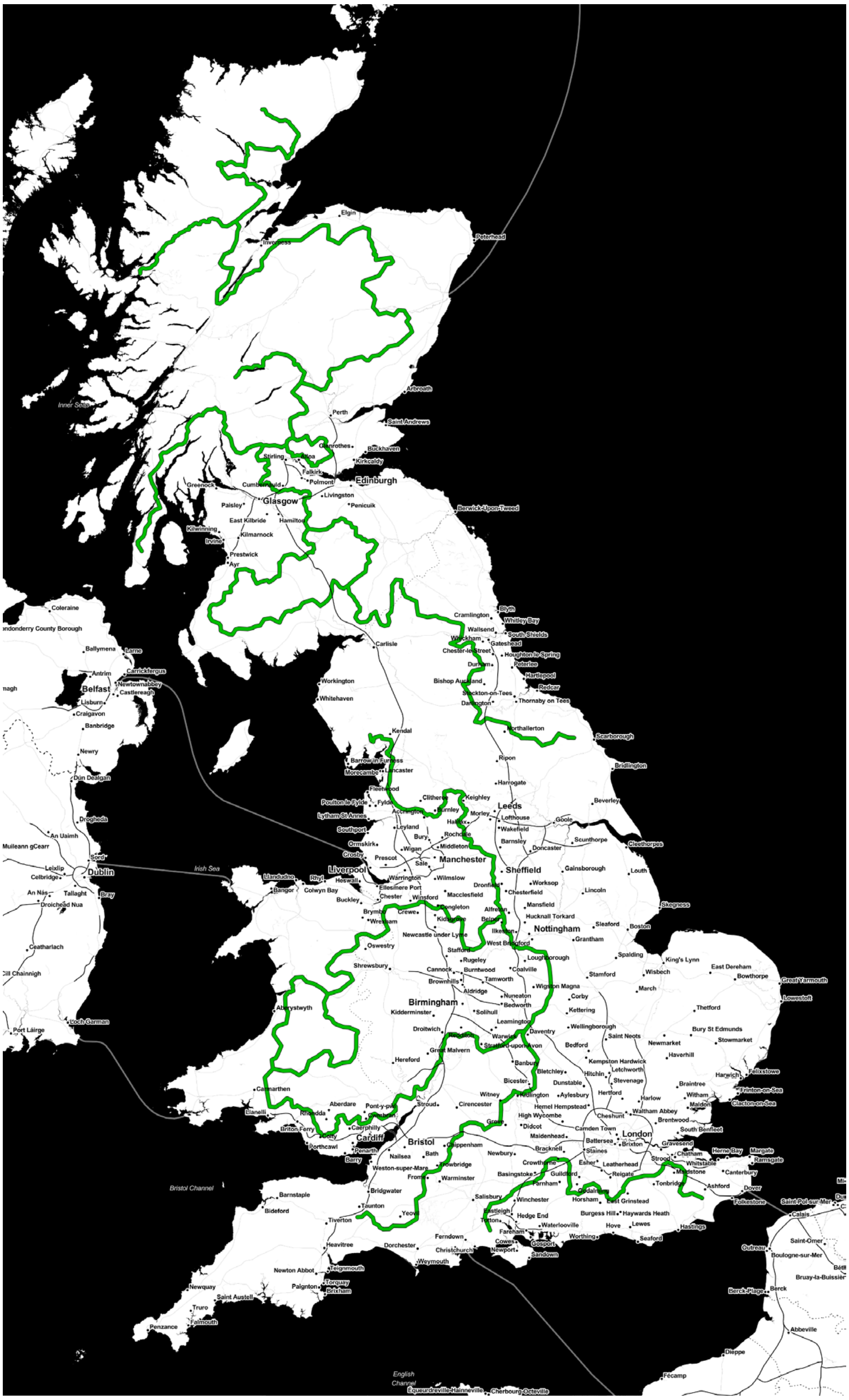
We welcome feedback on all aspects of this proposal. However, we seek specific feedback on a number of key questions:

- In centring the needs of the forest, which stakeholders have been overlooked in the design of the forest highway?
- How might communities connect their local forests to the infrastructure of the forest highway?
- How might the Great British Forest Highway be actively managed in a forest-centred manner after planting?

## How to respond to the consultation

This is a public consultation to which anyone with an interest may respond. The UK Government invites the contribution of evidence, ideas and recommendations in response to the plans described in this document.

Responses should be sent to <add email address here> by 19th March 2022.




*The proposed route for the Great British Forest Highway, with sizable urban settlements noted.*

*Basemap from Stamen.*

# Glossary of terms

## Afforestation

The creation of new woodland on land previously used for something else.

## Anthropocentric

Regarding humankind as the central or most important element of existence (OL 2021).

## Anthropogenic

Originating from human activity. Often used to describe environmental pollutants. e.g. “anthropogenic emissions of sulphur dioxide” (OL 2021).

## Biodiversity corridor

Vegetated areas that allow animals to travel between patches of habitat in a fragmented landscape (ForestrySA 2021).

## Biomass

The collective term for all organic matter. In plants this might be leaves, roots, wood, etc. In animals this might be flesh, feathers, fur, etc.

## Climate change

The observed and predicted changes in global climate patterns driven by the emission of greenhouse gases in human activities.

## Carbon sequestration

A process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form (OL 2021).

## Complexity

When multiple elements which are interacting in a disordered way result in robust organisation and memory (Ladyman et al. 2012)

## Connectedness

The state of being joined or linked (OL 2021).

## Earth Stewardship

Shaping the trajectories of social-ecological change at local-to-global scales to enhance ecosystem resilience and human well-being (ESA 2021).

### Ecosystem services

Benefits provided by ecosystems that contribute to making human life both possible and worth living (UKNEA 2012).

### Embeddedness

The quality of being firmly and deeply ingrained in place (OL 2021).

### Geospatial analysis

The gathering, display, and manipulation of data and imagery which describes a geographic location (TechTarget 2014).

### Greenhouse gases

Gases, such as carbon dioxide and methane (among others) that prevent heat from the sun leaving in the Earth's atmosphere.

### Green paper

A preliminary report of government proposals that is published in order to provoke discussion (OL 2021).

### Hectare

A unit of measurement of area commonly used in land management domains. 100 hectares is equal to 1 square kilometre.

### Heterogeneous

Diverse in character or content (OL 2021).

### Human-centred design

A movement in design centred around building empathy with the people being designed for (Design Kit 2015). Typically, these methods involve end-users having meaningful agency during the design process.

### Infrastructure

The basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise (OL 2021).

### Mycorrhizal network

A fungal network that grows among different plants will link these plants to each other; the network may connect individuals of the same or different species (Pringle 2009).

## Net zero emissions

An overall balance between the greenhouse gases emitted into the atmosphere (eg. burning fossil fuels) and the greenhouse gases removed from the atmosphere (eg. carbon capture, mass forestation).

## Non-human-centred design

An emergent movement in design that seeks to challenge anthropocentric perspectives in design. It asks designers to consider humans and non-humans (plants, animals, technological agents, etc.) as equal stakeholders during the design process.

## Raster data

Spatial data that uses a grid of pixels to hold information. Common examples include images and continuous datasets (e.g. temperature, elevation).

## Reforestation

The replanting and replenishment of degraded woodland.

## Resilience

The capacity to recover quickly from difficulties; toughness (OL 2021).

## Socio-ecological system

A system that includes societal (human) and ecological (biophysical) subsystems in mutual interactions (Harrington et al. 2010).

## Vector data

Spatial data that is comprised of points, lines, or polygons. Commonly used for discrete data (e.g. political boundaries, forested land).

## Wildlife bridge

Artificial structure over road or rail infrastructure which reconnects severed habitats or provides some wildlife function (Natural England 2015). Also known as an ecoduct.

## Wildlife Corridor

A strip of natural habitat connecting populations of wildlife otherwise separated by cultivated land, roads, etc (OL 2021).

## Glossary of abbreviations

**CBD**

Convention on Biological Diversity

**CCC**

Climate Change Committee

**DfT**

Department for Transport

**EEA**

European Environment Agency

**ESA**

The Ecological Society of America

**ESRI**

Environmental Systems Research Institute

**FAO**

Food and Agriculture Organization of the United Nations

**FOEI**

Friends of the Earth International

**IPCC**

Intergovernmental Panel on Climate Change

**NFI**

National Forest Inventory

**OL**

Oxford English Dictionary

**UNFCCC**

United Nations Framework Convention on Climate Change

**UKNEA**

UK National Ecosystem Assessment

**UKRI**

UK Research and Innovation

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There are also some creative inspirations that need to be acknowledged for their influence on this document:

The visual language and written content of this document was inspired by a number of green papers and websites published by the UK Government. In many places, words and phrases from the following documents have been directly sampled from these sources and remixed to create the content of this document.

1. Cabinet Office. (2011). Justice and security green paper.

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In addition to these governmental sources, the form and style of this document was heavily influenced by the following publications by PostRational, a fictional consultancy company:

7. PostRational. (2018). Exhibit MO: A case study in reconstructive resilience. Published in: Stir to Action Magazine.

8. PostRational. (2018). Fatberg & the sinkholes: A report on the findings of a journey into the United Regions of England. Published in: Economic Science Fictions.

The archetypal names given to characters (the Ecologist, the Planner, and the Politician) were inspired by the names of the characters in the book Annihilation by Jeff VanderMeer.

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And finally, thank you to Florian Payen for his design of the Politician’s signature, all of the proof-reading, and all of the support given during this project

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MA Material Futures
Semester 1: Non-human-centred design

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